Doctoral Dissertation

Vulnerability, Impact and Adaptation to Climate Change: Livelihoods of Chepang Community in the Rural Mid-Hills of Nepal

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We hereby recommend that the dissertation by Ms. Luni PIYA entitled "**Vulnerability, Impact and Adaptation to Climate Change: Livelihoods of Chepang Community in the Rural Mid-Hills of Nepal**" be accepted in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY**.

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Dedicated to my first learning institution, my parents:
Iswar Kumar Shrestha and Mana Maya Shrestha
Without the firm academic foundation that you have built for me right from my childhood, I could have never achieved this academic milestone today

Summary of the dissertation

Occurrence of climate change is no longer a contested issue. Whilst many researches have focused on the biophysics of climate change, the social dimensions have been neglected at least until recently. This research focuses on the socio-economic aspects of climate change. Such types of studies are more important for policy implications compared to the bio-physical studies as factors like temperature and rainfall are beyond the immediate influence of the policy makers. Climate change is a global phenomenon; however its manifestations, impacts, adaptation capacities, preferences, and strategies vary locally. Effective planning for climate change adaptation requires an assessment of local vulnerabilities, adaptation practices, and preferences so as to bridge the gap between community needs at the micro level, and policy processes at the macro level. Even at the local level, the poorest rural communities relying dominantly on natural resources for their livelihoods are the ones who are the most vulnerable to the adverse impacts of climate risks. In order to gain relevant policy insights to help such communities cope with the climate risks, it is important to capture the ground level realities of the livelihoods of these communities.

In this direction, this study focuses on the Chepang community, one of the highly marginalized indigenous nationalities of Nepal. Although their native area is surrounded by the major highways, feeder roads into the area are few. Literacy rate among this community is low, which has hampered their representation in the administrative and political spheres. As a result, despite being geographically near to Kathmandu, they are still marginalized from the mainstream of development of the country. Chepang thus qualify as an appropriate representative of the marginalized people in Nepal. Subsistence rain-fed agriculture, livestock, forestry and wage laboring form the major livelihood sources for this community. This study aims to analyze the livelihoods of Chepang community from the

perspectives of vulnerabilities, impacts and adaptation to climate change and extreme events.

More than 95% of the total Chepang population resides in Chitwan, Makwanpur, Dhading and Gorkha districts. To ensure representativeness of the sample selected, all the four districts have been covered by this study. One Village Development Committee (VDC) from each district is selected based on the dominance of Chepang population. This study is based on the primary data collected by household survey conducted in two phases: February-March 2010 and May-June 2011; and covers 221 Chepang households. This study also uses secondary weather data of monthly minimum temperature, maximum temperature, and rainfall over the period 1975-2008 obtained from the Department of Hydrology and Meteorology (DHM) in Nepal.

Analysis of the livelihoods portfolio of the Chepangs identify eleven different sources of livelihoods: agriculture, livestock, wage laboring, forestry, salaried job, skilled non-farm job, remittance from abroad, petty business, transfers (old age allowance), honey, and handicrafts. Agriculture is the major activity adopted by all the households, followed by forestry, livestock, and wage laboring. It was found that all households tend to diversify the livelihoods sources. Income is comparatively higher from salaried job, skilled non-farm job and remittance, however most of the households are constrained from adopting these remunerative sources owing to interlinked factors comprising of low education – landholding - livestock holding; lack of citizenship certificates - land registration certificates; and unfavorable land policies. It is important for the policy makers and development agencies to recognize the complementary relationship among farming, forestry, and non-farm livelihood strategies in sustaining their livelihoods.

How the local people perceive the ongoing climate change determines how they formulate strategies to cope with those changes. The perceptions of the community regarding changes in rainfall and temperature over the last decade were collected by the household survey, which was then cross-checked with the recorded data. Average minimum and maximum temperature and total rainfall data for the time period of 1975-2008 was considered. Trend analysis of historical climate data was done for two time-periods: long-run of 34 years (1975-2008) and short-run of 8 years (2001-2008). The analysis of community perception was focused for the last decade since longer time frame would be difficult for the respondents to remember and be subjected to recall bias. Nearly one-third of the respondents are able to perceive the changes in line with the recorded data, meanwhile there are many respondents who do not perceive any changes.

The determinants of household perceptions were analyzed by univariate probit model. Access to information, and extension services (as indicated by ownership of radio and membership in groups) are the most important factors facilitating perceptions of both temperature and rainfall changes. Cultivation of cash crops also facilitates perceptions of rainfall significantly. On the other hand, formal education and engagement in non-farm income sources reduce the ability to perceive the climatic changes. Priority must be placed on the dissemination of relevant information at the community level and updating the educational curriculum to include the issues related to climate change. Climate related studies at a micro-scale in rural areas of Nepal are hampered by the lack of climate data. Establishment of local hydrological stations and training the community to obtain daily readings would generate datasets on local climate, and also facilitate awareness and adaptation.

The vulnerability analysis was done based on indices constructed from selected indicators for exposure, sensitivity, and adaptive capacity. Historical changes in climate variables and occurrence of extreme climatic events are taken as indicators of exposure. The temperature and precipitation at the household level was interpolated for 32 years

(1977-2008) from the station level data (49 temperature stations and 218 precipitation stations) using the latitude-longitude-altitude information of the households by ordinary kriging method. Livelihood impacts of climate disasters and share of natural and non-natural sources to the total household income were taken as the sensitivity indicators. Adaptive capacity of a household is taken to be the property of the five livelihood asset-categories viz., physical, human, natural, financial, and social as given in the sustainable livelihoods framework. The indicators are weighted using stepwise Principal Component Analysis. The weighted indicators were aggregated to calculate the final index. Inter-VDC analysis of the vulnerability index indicate that exposure is most dominant determinant of vulnerability in a locality. Inter-household analysis of vulnerability indicate that poor households with low adaptive capacity are vulnerable anywhere, irrespective of where they are located. Out of the three components, only adaptive capacity is under the immediate influence of policy makers. Improving household adaptive capacity can also help in reducing sensitivity. Therefore the major policy focus must be to improve the adaptive capacity while ensuring the post-disaster emergency relief measures for localities with higher exposure. The poorest households should be the primary target of any interventions.

The most commonly reported climatic hazards are landslides, droughts and hailstorms. Respondents opine that droughts have become more frequent, and short-duration droughts during maize-growing season coupled with uncertain timing of rainfall have hampered maize cultivation. Hailstorms have been occurring frequently over the last few years during the April-May that hampers pears, oranges, and maize. Most of the respondents mark the late onset of post-winter rain, thereby delaying the maize-sowing and consequently the millet transplantation after maize harvest. The adaptation options reported are undertaken in response to these climate vagaries.

The adaptation practices adopted by the Chepang households are varietal selection, adjusting sowing time, collecting wild edibles, soil conservation practices, wage laboring, non-farm jobs, construction of water collection pond, cash crop, rearing livestock, and depending on community for assistance. Adaptation practices are categorized according to the fivefold classification based on risk pooling across space, time, assets, households, and market; and measured in terms of adoption rate. A single adaptation practice can serve more than one particular risks and it is difficult to isolate the adaptation practices devised solely in response to climate risks. Adoption rate is compared with adaptive capacity across the four study sites. Results show that balanced possession of all five asset categories is necessary to translate adaptive capacity into adaptation actions. There is thus a need for integrated development activities that aim to promote a balanced growth with more focus on financial capital, human capabilities, social networks, and infrastructure.

Multivariate probit model was used to analyze the factors influencing the households" choice of adaptation practices. Perception of rainfall changes, size of landholding, status of land tenure, distance to road, access to productive credit, information, extension services, and skill development trainings are all influential to enable households to deviate away from traditional coping strategies and adopt suitable practices to adapt to climate vagaries. Agricultural extension services coupled with trainings and climate related information dissemination is important to facilitate perception as well as adaptation in the community. Investment in improved practices must be promoted by the provision of micro-credits, with special focus on remote areas and small landholders.

Finally, the issues of livelihood vulnerabilities and adaptation to climate change are intricately related with the issues of sustainable development. It is thus necessary to mainstream climate change within the development activities and policies.

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Luni PIYA
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Acronyms and Abbreviations

AE	Adult Equivalent
ANOVA	Analysis of Variance
AR4	Fourth Assessment Report
CBO	Community Based Organization
CBS	Central Bureau of Statistics
CCDN	Center for Community Development Nepal
CCODER	Center for Community Development and Research
CDM	Clean Development Mechanism
CEEPA	Centre for Environmental Economics and Policy in Africa
CEN	Clean Energy Nepal
CH_4	Methane
CO_2	Carbon Dioxide
CO_2-eq	Carbon Dioxide Equivalent
DFID	Department for International Development
DHM	Department of Hydrology and Meteorology
et al.	et alii
FAO	Food and Agriculture Organization
FORWARD	Forum for Rural Welfare and Agricultural Reform for Development
GCM	Global Circulation Model
GELs	Global Environmental Leadership Education Program for Designing a Low Carbon World
GHG	Green House Gas
GLOF	Glacial Lake Outburst Flood
HH	Household
HHH	Household Head
HiCEC	Hiroshima International Center for Environmental Cooperation
IAAS	Institute of Agriculture and Animal Sciences
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
ISET-N	Institute for Social and Environmental Transition-Nepal
Km	Kilometer
KP	Kyoto Protocol

LAPA	Local Adaptation Plan of Action
LI-BIRD	Local Initiatives for Biodiversity Research and Development
LSU	Livestock Unit
masl	Meters above sea level
MDI	Manahari Development Institute
mm	millimeter
MNL	Multinomial Logit
MOAC	Ministry of Agriculture and Cooperatives
MOE	Ministry of Environment
MOPE	Ministry of Population and Environment
MVP	Multivariate Probit
n	Number of Households
N_2O	Nitrous Oxide
NAPA	National Adaptation Programme of Action
NCA	Nepal Chepang Association
NCCSP	Nepal Climate Change Support Programme
NCVST	Nepal Climate Vulnerability Study Team
NEFIN	Nepal Federation of Indigenous Nationalities
NFDIN	National Foundation for Development of Indigenous Nationalities
NGIIP	National Geographic Information Infrastructure Programme
NGO	Non-Governmental Organization
NIRS	Nepal Integrated Research System
NORAD	Norwegian Agency for Development
NPC	National Planning Commission
NRs.	Nepali Rupees
NTFP	Non-Timber Forest Product
^0C	Degree Centigrade
PASW	Predictive Analytics Software
PCA	Principal Component Analysis
RCM	Regional Circulation Model
SAPPROS	Support Activities for Poor Producers of Nepal
SAR	Second Assessment Report
SD	Standard Deviation
STATA	Data Analysis and Statistical Software

TAR	Third Assessment Report
TU	Tribhuvan University
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US$	United States Dollars
VDC	Village Development Committee
WHO	World Health Organization

Chapter 1. Background of the study

1.1 Introduction

Climate change is happening and its occurrence is no longer a contested issue. It is unequivocal that the Earth‟s climate system is warming and this fact is confirmed by the rising sea levels, melting glaciers and snow covers, retreating Arctic ice sheet, warming ocean and increasing global average air temperature. Science has given enough proof that the current phenomenon of global warming is not entirely a part of the natural cycles, but rather human activities are responsible for most of the warming seen over the last 50 years (IPCC, 2007a). Only the models that incorporated both natural and anthropogenic forcing better simulated the past trend of rising land and ocean temperatures, which has thus provided a stronger evidence of human influence on climate (Hegerl et al., 2007). Anthropogenic emission of Carbon Dioxide (CO_2) from the combustion of fossil fuels and land use change, and Methane (CH_4) and Nitrous Oxide (N_2O) emission from agricultural activities are the major greenhouse gases (GHGs) held responsible for the global warming. Even if the GHG emissions are held constant at the 2000 level, temperature is projected to increase at the rate of $0.1^{o}C$ per decade for the next two decades. The rate of warming will of course be higher with higher rate of GHG emissions. This will have adverse impacts on every sector like water availability, food production, terrestrial ecosystems, coastal ecology, and health (IPCC, 2007b; Rosenzweig et al., 2007). Climate Change is a global phenomenon, however its manifestations and the impacts are entirely local. For instance, for the same degrees rise in temperature, impacts felt by countries in Northern Europe will be entirely different from the risks that have to be faced by island countries like Tuvalu. Climate change has glaring inequities (Mearns and Norton, 2010) in terms of its causes and impacts – while the richest countries and the richest people are the ones responsible for emitting most of the GHGs, the poorest countries and the poorest people are the ones most vulnerable to the adverse impacts of global warming and subsequent climate change.

With the establishment of Intergovernmental Panel on Climate Change (IPCC) in 1988 and publication of the first assessment report by IPCC in 1990, research interest in human induced climate change has been growing continuously (Le Treut et al., 2007). Global warming and associated climate change is now a cross cutting issue and is a research interest in every academic discipline. Climate science has thus been progressing rapidly contributing to the better understandings of the biophysical processes related with climate change and its impacts. Sophisticated technologies has now made it possible to trace the temperatures back to several hundreds of years by examining the ice cores, and complex models have successfully projected the climatic variables for upcoming decades with increasing accuracy. Models have been continuously improving and projections of future climate change at the continental scale have been possible with greater certainty. However uncertainties remain. Certain climatic processes like cloud feedback is yet to be completely understood. Models have not been able to simulate or project climate at a finer spatial scales compared to the global and continental scales, and projecting precipitation with equal confidence as temperatures is still a challenge for the scientists (IPCC, 2007a). Furthermore, future climate change and its impacts remain uncertain because it depends on the types and quantity of GHGs humans will continue to emit, which itself is very uncertain. Nevertheless, climate science has improved and is improving continuously. Whilst a lot of researches have focused on understanding the biophysics of climate change, its impact on the biophysical and ecological environment, and projecting future directions of climate change, „the human and social dimensions of climate change have been woefully neglected in the global debate – at least, until recently" (Mearns and Norton, 2010, p. 2). However, several literatures in the recent years have highlighted that human-environment interactions determine the degree of impacts felt by a system, and that the impact of the same climatic phenomenon might be felt differently by different people, even within the same geographical location, depending upon various social, economic, policy, and institutional factors (Mearns and Norton, 2010; Vincent, 2004; Cutter et al., 2003; Adger and Kelly, 1999). The socio-economic aspects of climate change will be the main topic of discussion in the upcoming chapters of this dissertation.

1.2 Statement of problem and research rationale

Natural climate variability has always been a challenge to human livelihoods. Human-induced climate change has lent a complex new dimension to this challenge. There are plenty of evidences that the natural climatic variability, compounded with climate change will adversely affect millions of livelihoods around the world (Chambwera and Stage, 2010; Assan et al., 2009; IPCC, 2007c; Siva Kumar et al., 2005; Adger et al., 2003; Ziervogel and Calder, 2003). The rural communities in the developing countries are expected to be affected more due to their extensive dependence on climate sensitive livelihood options, and limited adaptive capacity to adapt to the changes for various inherent socio-economic, demographic, institutional and policy trends (UNFCCC, 2009). Nepal, with its fragile geography, predominantly natural resource based livelihoods, and low level of adaptive capacity due to higher incidence of poverty, is placed among the most vulnerable country to Climate Change (Oxfam, 2009). Nepal is already a country vulnerable to natural disasters particularly floods and landslides. With an increased intensity in monsoon risks, the risk of flash flooding, erosion, and landslides will be increased. The adverse impacts of Climate Change will definitely play a significant role in exacerbating the vulnerability, existing poverty and inequalities in least developed countries like Nepal.

Climate change is a global phenomenon; however its manifestations and impacts vary locally, so do the adaptation capacities, preferences, and strategies. Effective planning for climate change adaptation programming requires an assessment of local vulnerabilities, practices, adaptation options and preferences so as to bridge the gap between community needs and priorities at the micro level, and policy processes at the meso and macro level. Micro-level studies should form the inputs for formulating relevant policies at the meso and macro level (Burton et al., 2006). In the case of Nepal, trend analysis of historical temperature and precipitation data reveal that there are huge spatial variations within the country, with many micro-climatic pockets that show very different climatic trends even within a small geographical area (Practical Action, 2009). Thus, researches done with the national level data fail to capture the location specificity of smaller areas. This calls for the need of detailed explorations of impacts, and adaptation strategies at the micro level. Attempts have been made to study the vulnerabilities, impacts and adaptation strategies at the local level in Nepal (Jones and Boyd, 2011; Onta and Resurreccion, 2011; Ghimire et al., 2010; Regmi, 2010; Bouma et al., 2009; Oxfam, 2009; Sharma, 2009; Gautam et al., 2007a; Gautam et al., 2007b). These studies are all, except one, based on qualitative assessments. This study will supplement these literatures with an in-depth analysis of the vulnerabilities, impacts and adaptation issues by integrating quantitative analysis with qualitative information obtained from primary field survey.

Even at the local level, poor and marginalized communities tend to be those most vulnerable to climate change and the least able to cope with weather-related disasters because of lack of access to information and resources to reduce their risks. The IPCC fourth assessment report (AR4) points out that marginalized communities primarily depending on natural resources in developing countries are comparatively more vulnerable to climate change and the same communities are more constrained in undertaking adaptation strategies to minimize the adverse impacts due to a multitude of barriers (Adger et al., 2007). In this direction, this research focuses on the Chepang community, one of the highly marginalized indigenous nationalities[1] in Nepal, as the study population. In Nepal, indigenous nationalities represent the marginalized section of the country both spatially as well as socio-economically. Not only do the majority of indigenous people reside in the geographically remote parts of the country, but also their socio-economic and human development indicators lie far below the national average. Based on the Nepal Living Standards Survey 2003/04, hilly indigenous people (besides Newar and Thakali[2]) have higher poverty incidence of 43% compared to the Tarai indigenous people having poverty incidence of 33% (NIRS, 2006). The Chepang community has been categorized as one of the highly marginalized indigenous nationalities from the hills by National Federation of Indigenous Nationalities (NEFIN) and National Foundation for the Development of Indigenous Nationalities (NFDIN). Although their native area is surrounded by major highways of the country (Figure 3.3), feeder roads joining the area to the highways are very few. The geographical remoteness is further compounded by constant landslides along the walking trails during the rainy season and poorly developed infrastructures like limited communication facilities, electrification, bridges, health centers, and schools. Literacy rate among this community is very low, which has hampered their representation in the administrative as well as political spheres. As a result, despite being situated geographically quite near to the capital city Kathmandu (Figure 1.1 and Figure 3.3), they are still marginalized from the mainstream of development of the country. Chepang thus qualify as an appropriate representative of the marginalized group of people in Nepal and is thus selected as the population for this study. Chepangs rely on rain-fed subsistence

[1] According to the National Foundation for Development of Indigenous Nationalities Act 2002, the term indigenous nationalities refer to tribes or communities having their own mother language and traditional rites and customs, distinct cultural identity, distinct social structure and written or unwritten history (NIRS, 2006).
[2] Newars and Thakalis are the only two indigenous nationalities falling under the advanced category.

agriculture and forest resources for their livelihoods. They occupy small parcels of land that can barely produce food enough for the family. They live in the areas most in risk to floods and landslides and are more reliant on local natural resources such as forests and water and would therefore suffer the most from drying up of local water resources and changes in vegetation cover. Even small changes to rainfall patterns can have devastating consequences on their crops. They are vulnerable to extreme weather events; and often have poor access to information and lack resources to help them cope with and recover from weather-related disasters. Their vulnerability is further compounded by geographic isolation poorly served by roads and other infrastructures, and often isolated by landslides and floods. Studies related to the impacts of climate change should focus on the poor and marginalized communities because they are the most vulnerable and the least able to cope with the impacts of climate change. There is a need to highlight the impacts of climate change on the livelihoods of these vulnerable communities so as to draw the attention of the government and development agencies to this issue. The current study is an attempt towards this direction. The study will contribute to raise the issues of impacts and community-based adaptations to climate change in the academic discussions and draw the attention of responsible institutions.

Action on climate change adaptation and mitigation in Nepal are hampered by a lack of technical capacity and low awareness and prioritization of climate change at all level. Nepal is the last signatory countries to the United Nations Framework Convention on Climate Change (UNFCCC) to complete the National Adaptation Program of Action (NAPA) process. Many key ministries like Ministry of Agriculture and Co-operatives and Ministry of Water Resources are unaware of the implications of the Climate Change and are implementing only a very few, nascent activities. There is very little coordination among the different ministries and the Ministry of Environment, the focal body for climate change issues. The government"s participation in international negotiations has been erratic and there is little coordination with other governments in the region. At the district level, key government staffs are often not aware of climate change and the predicted impacts on agriculture, disasters, and marginal communities despite the role they could play in supporting adaptation. This study will have policy implications by making suitable recommendations, both short-term response to changing weather patterns as well as long term and sustained adaptation strategies.

1.3 Chepangs: The study community

Along the Mahabharata range, in the remote and steep terrains bounded to the South of the Trishuli River (Prithvi Highway), North and West of the Rapti River (East-West Highway and Tribhuvan Highway respectively), and East of the Narayani River (Mugling-Narayangarh Highway), lies the traditional area of the Chepangs: one of the indigenous nationalities of Nepal. In the administrative division of the country, their traditional area falls in the West of Makawanpur district, Northeast of Chitwan district, and South of Dhading district. There is also quite significant population of Chepangs to the north of Trishuli River in the Southeast of Gorkha District, believed to have migrated from their traditional region (Rai, 1985). Although major highways of the country surround their traditional area, a large part of Chepang settlements are still untouched by motorable roads and feeder roads joining their settlements to the highways are very few. According to the population census 2001, the total Chepang population is 52,237 constituting 0.23% of the total population of Nepal (CBS, 2003a). Of the total Chepang population, 40.67% lives in Chitwan district, 29.39% in Makwanpur district, 20.82% lives in Dhading district, and 5.25% lives in Gorkha district; the four districts thus form the home to more than 95% of the total Chepang population (CBS, 2008). Majority of the Chepangs live in the hilly

Village Development Committees (VDCs[3]) of these four districts namely Kabilas, Chandibhanjyang, Dahakhani, Darechowk, Kaule, Shatikhor, Siddhi, Korak, Lothar, and Piple VDCs in Chitwan district; Manahari, Raksirang, Kankada, Khairang, Dadakharka, Bharta, Kalikataar, and Sarikhet-Palase VDCs in Makwanpur district; Jogimara, Gajuri, Mahadevsthan, Pida, Dhusa, and Benighat VDCs in Dhading district; and Taklung, Makaising, Tanglichowk, Bhumlichowk, and Ghyalchowk VDCs in Gorkha district. Brian Hodgson was the first scholar to write about the Chepangs in 1848. In the last three decades, many anthropological and sociological studies have been done on the Chepangs (Riboli, 2000; Gurung, 1995; Gurung, 1994a; Gurung, 1994b; Neis, 1989; Rai, 1985). Few quantitative studies have been done on the socio-economic aspects of the Chepangs (FORWARD, 2001a; FORWARD, 2001b; Gribnau et al., 1997).

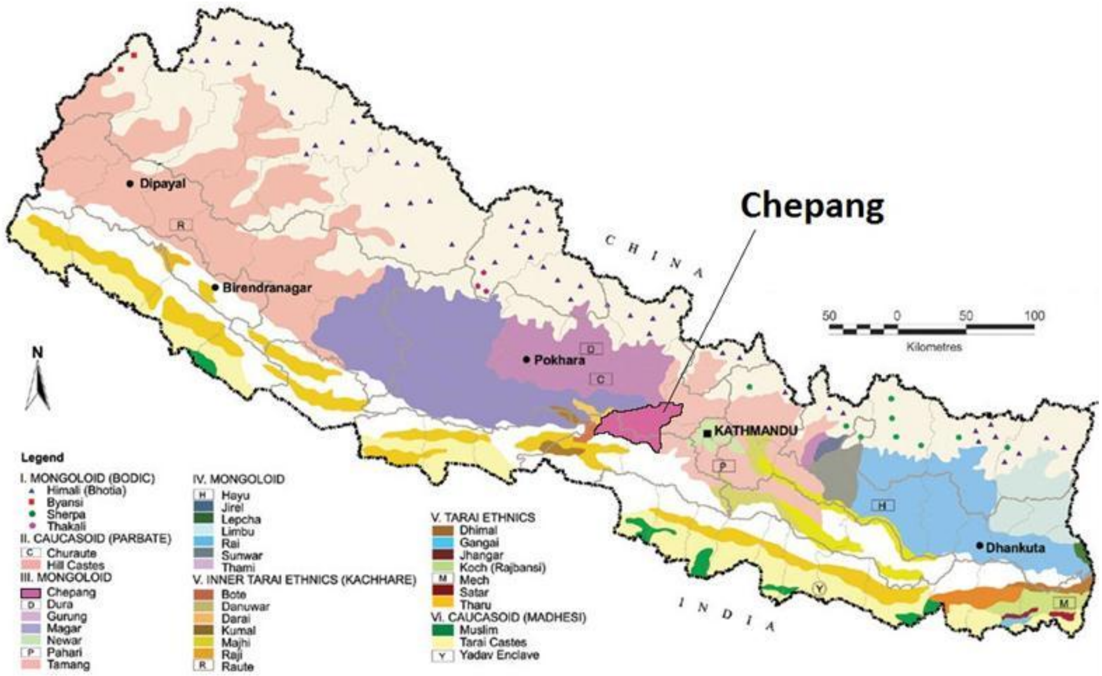


Figure 1.1 Ethnographic map of Nepal
Source: Gurung et al., 2006; cited by Turin, 2007

The 59 indigenous nationalities in Nepal are classified into five groups comprising of endangered, highly marginalized, marginalized, disadvantaged, and advanced group (See Appendix 1). This classification is based on a composite index comprising of

[3] VDCs are the lowest administrative tiers in Nepal, composed of 9 wards.

variables like literacy rate, housing, land holdings, occupation, language, graduates, residence, and population size. The indigenous nationalities are further classified into mountains, hills and tarai based on the geographical location where they form a majority. Chepangs fall under hilly and highly marginalized indigenous nationalities, together with Baramu, and Thami. Despite their traditional area being located very near to Kathmandu valley (see Figure 1.1 and Figure 3.3), they have been sidelined from the mainstream of national development, thereby making them highly marginalized.

Poverty, illiteracy, lack of food self-sufficiency, food insecurity, and lack of resource ownership are some of the common characteristics of the Chepangs. Ignorant of administrative requirements and official procedures many Chepangs are still devoid of citizenship certificates. Chepangs dwell in marginal land, usually in the steep slopes. Chepangs have been the owners of their land since time immemorial. However, due to their practice of *khoriya* cultivation in olden days in place of organized agricultural methods, they do not have legal ownerships of lands they have been using. Even in cases where they have official title to their private lands, the little land that they have is poor and infertile. Farming is often practiced in marginal land, and is not enough to provide for them for the whole year. During the lean period, Chepangs depend on forests to gather wild edibles like tubers, yams, and fruits (Aryal et al., 2009; Bastakoti and Kattel, 2008; Gribnau et al., 1997; Gurung, 1995). However, control over and access to forest resources has been severely restricted due to unfavorable state policies, which in turn threaten their traditional livelihoods (Upreti and Adhikari, 2006).

Often described as guardians of the forest, Chepangs are believed to be until the last 100-150 years ago a semi-nomadic hunter / gatherer group ranging the forests of Nepal as described by Brian Hodgson in his 1848 article to be “living entirely upon wild fruit and the produce of the chase” (Hodgson, 1874, p. 45). It is supposed that agriculture is comparatively a newer phenomenon for them (Bhattarai et al., 2003; Gribnau et al., 1997; Gurung, 1995). Nearly a century after Hodgson, a comprehensive study about Chepangs by Rai (1985) reported that though Chepangs still practiced a good deal of hunting and gathering, agriculture formed the mainstay of their livelihood, and they practiced *khoriya* or shifting cultivation. Under this system, a patch of land was cleared in the forest and cultivated for three continuous years before the soil became exhausted. It was then left fallow for seven years; meanwhile they cleared and cultivated other patches of land. However, their access to forest was severely restricted due to the introduction of new government policies, most notably the enactment of Private Forest Nationalization Act in 1957, under which all the forests that had been used from the past under the traditional rights were included under the government ownership. This put a restriction in the hunting and gathering activities, thereby negatively affecting the traditional system of the Chepang livelihoods. Chepangs had no legal ownership of land where they practiced *khoriya*, and most of them remained as uncultivated patches within the forest area, which was now under the government ownership. Cadastral survey conducted in the Chepang area in early 1970s only registered lands that were permanently cultivated as private properties, thereby failing to recognize *khoriya* patches as land suitable for registration. Enactment of Forest Act 1993 further strengthened the government ownership of forests, and introduction of community and leasehold forestry banned all the hunting and cultivation activities within the forest area. Restrictions on hunting, gathering, and clearing of forest patches for *khoriya* cultivation led to the transition of their livelihoods to sedentary agriculture. They mostly grow maize, millet, buckwheat, black gram, soybean, and mustard in upland and *khoriya*; they also cultivate rice, wheat, and vegetables if they own lowland or irrigated upland. However, only a small percentage of Chepang households are fully food self-sufficient. Though agriculture forms the mainstay of their livelihoods, Chepangs still depend upon forest resources to a large extent and the contribution of wild and uncultivated edible plants play an important role in their subsistence economy. Beside gathering, Chepangs also depend upon livestock, wage laboring, collection and sale of NTFPs, skilled and salaried jobs, handicrafts, and remittance for cash income. Most of their cash income is spent in procuring food. During the time of their food deficit, Chepangs have to depend on the other communities like Bahuns, Chhetris, and Newars for loan, which they pay back by selling goats, black gram, soybean, or other forest products like NTFPs, and honey (FORWARD, 2001b; Gribnau et al., 1997).

1.4 Research Objectives

This study aims to analyze the livelihoods of Chepang community from the perspectives of vulnerabilities, impacts and adaptations to climate change. The following five specific objectives will be pursued to fulfill the general objective:

1) To analyze the livelihoods activity portfolio of the Chepangs.

2) To explore the perceptions of the community regarding climate change and the factors determining their ability to perceive those changes.

3) To measure the vulnerability of the study households to climate change.

4) To examine the impacts of climate change on the livelihoods of the Chepang community, and

5) To assess the adaptation strategies adopted by the study community and the determinants of household adaptation choices.

Chapter 2. Literature review

2.1 Climate Change in Nepal

Climate change is a global phenomenon and Nepal is not an exception to it. Nepal shares only 0.025% of the total global GHG emission (Oxfam, 2009). In 1996, the GHGs equivalent emitted by one American was equivalent to that emitted by 269 Nepalese (CEN, 2003). On the other hand, Nepal is one of the countries that are the most vulnerable to the vagaries related to climate change. Rugged topography; geologically fragile hills and mountains; livelihoods predominantly dependent on natural resource based sources like agriculture and forests; limited institutional capacity; and low level of infrastructure and technological development add to the gravity of the problem (Regmi and Adhikari, 2007). Although Nepal is a signatory of the UNFCCC and the Kyoto Protocol (KP), the government of Nepal addressed the issues of climate change in its policy documents only in the tenth periodic plan (2002–2007). Thereafter, the government committed in the Three Year Interim Plan (2007-2010) to promote carbon trade by participating in the Clean Development Mechanism (CDM). Alternative energy and forest management was recognized as the potential resources for carbon trading (NPC, 2007). Climate Change was explicitly mentioned only in the current Three Year Plan Approach Paper (2010–2012) with objectives of promoting green development, making development activities climate friendly, mitigating the adverse impacts of climate change, and promoting adaptation (MOE, 2010). The government also passed the Climate Change Policy 2011 last year.

Delay in the prioritization of climate change in the national plans and policies is also demonstrated by the fact that Nepal was the last among the signatory developing countries to the UNFCCC to submit NAPA only in September 2010. A parallel Local Adaptation Plan of Action (LAPA) has also been developed and approved in November 2010 to promote a bottom-up approach of adaptation activities based on the location-specific priorities (Jones and Boyd, 2011). Recently the government of Nepal received a grant of 1.8 billion Nepali Rupees (approximately 22.5 million US$) for implementing local level adaptation project, which the government is planning is spend in the fourteen least developed districts in the Mid- and Far-Western regions of Nepal under the programme Nepal Climate Change Support Programme (NCCSP). The NAPA and Climate Change Policy 2011 has provision to spend 80% of the international grants received for climate change adaptation for local adaptation activities (Ghimire, 2012). The community forest users groups in various districts of Nepal have also started to earn revenue for their role in carbon sequestration from international donor agencies like Norwegian Agency for Development (NORAD) (Acharya, 2012; Tripathi, 2011).

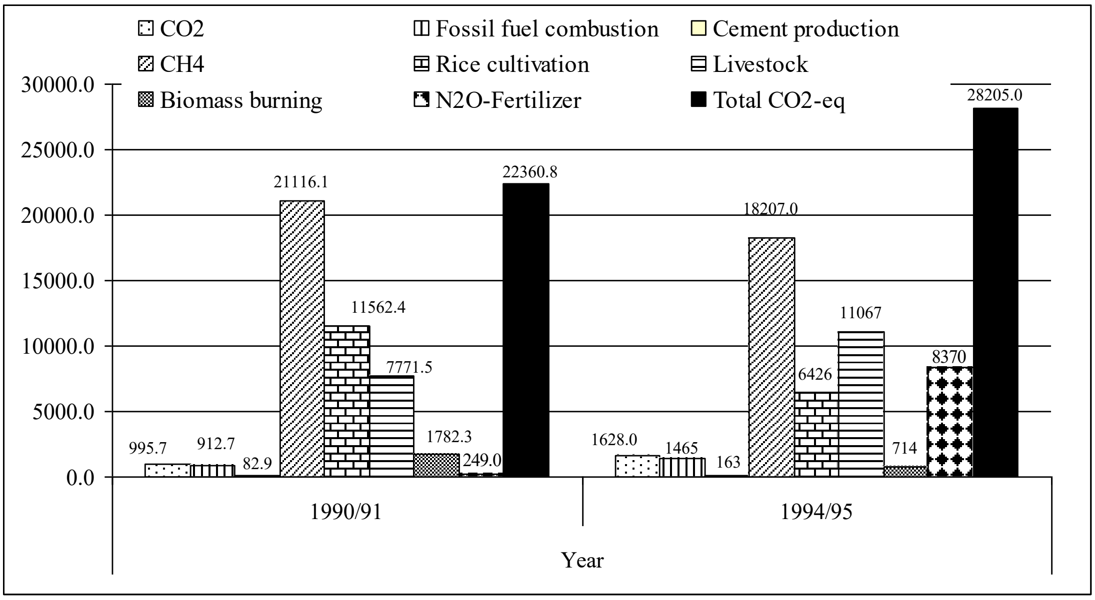


Figure 2.1 GHGs emission from different sectors in Nepal (1990/91-1994/95, CO_2-eq in '000 ton)
Data source: IPCC, 2007a; MOPE and UNEP, 2004; DHM, 1997 (cited in Dhakal, 2001)
Figure source: Maharjan, et al., 2012

The government of Nepal has prepared only two GHG inventories till date, the first in 1990/91 and the second in 1994/95. Between 1990/91 and 1994/95, there was 63.5% increase in CO_2 emission with an annual growth rate of 13.1%. Carbon Dioxide Equivalent (CO_2-eq) emission between the two inventory period increased at an annual rate of 5.8%

(Figure 2.1), with agriculture contributing a significant 69% of total CO_2-eq emission, followed by land use change and forestry contributing around 21% in 1994/95 (MOPE and UNEP, 2004; Dhakal, 2001). Per capita CO_2 emission between 1990 and 2004 grew at an annual growth rate of 9.3%, which is very high compared to neighboring countries like India (3%), China (4.4%), and Bangladesh (4.4%) (UNDP, 2007).

Climate change related studies in Nepal are further restricted due to the limited availability of weather data. There are 166 stations around the country that record rainfall and only 44 stations that record temperature. Weather data is available only for the last three to four decades for most of the stations. Historical analysis of temperature for the period 1977 to 1994 shows that the annual mean temperature in Nepal is growing at the rate of 0.06°C annually (Shrestha et al., 1999) while for the period of 1976 to 2005, it was found to be growing at an annual rate of 0.04°C (Practical Action, 2009). However, the temperature trend varies spatially and seasonally across the country (Figures 2.2, 2.3, and 2.4). The same study by Practical Action reports that maximum temperature is increasing faster than the minimum temperature at 0.5°C and 0.3°C respectively; the rate of temperature increase is found to be greater at higher altitudes (Figures 2.3). According to the same report, winter temperature shows a decreasing trend in certain pockets of the Tarai (the southern plains) due to the cold waves and resulting foggy conditions in winter along the Northern Gangetic Plain including the Tarai of Nepal.

Analysis of historical precipitation trend in the country shows that precipitation is highly variable across the country both spatially and seasonally. Precipitation is very erratic with large interannual variations, thereby resulting in no significant trend of precipitation over the years. Historical trend analysis of temperature and precipitation shows that there are many microclimatic pockets scattered spatially along the country and the weather trend varies significantly even within small geographical area (Practical Action, 2009). It is difficult to make a single conclusion for the whole country, thereby necessitating studies at a micro-spatial scale.

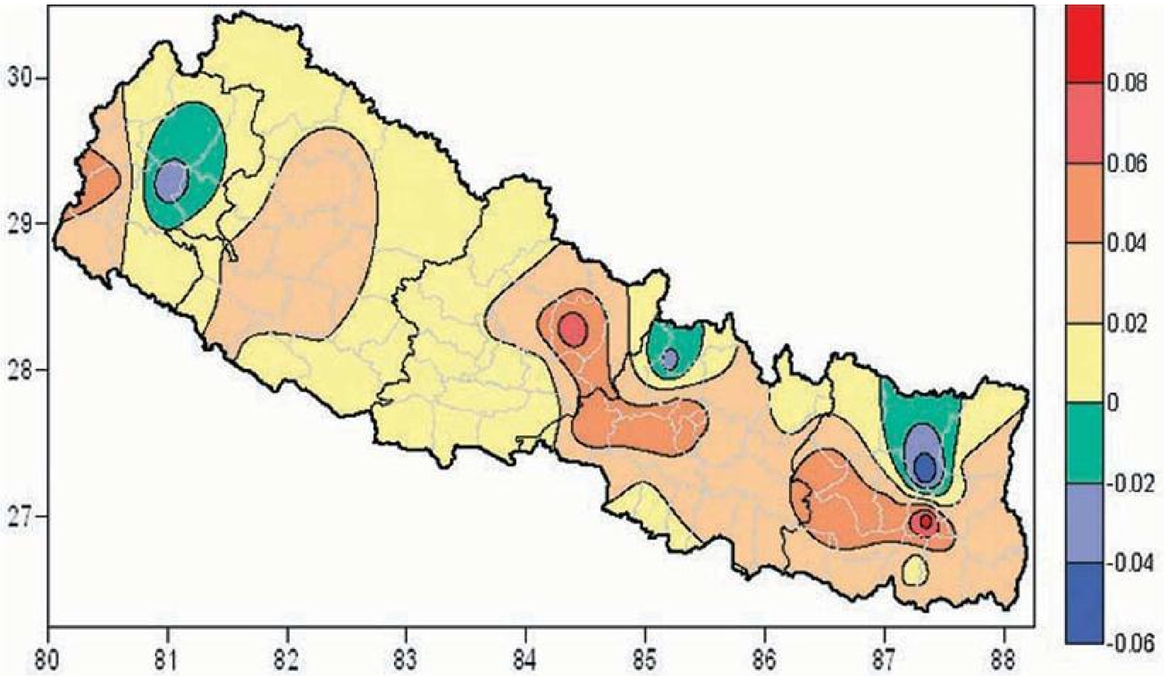


Figure 2.2 Spatial variation of annual mean temperature trend (1976 - 2005) (^oC/year)
Source: Practical Action, 2009

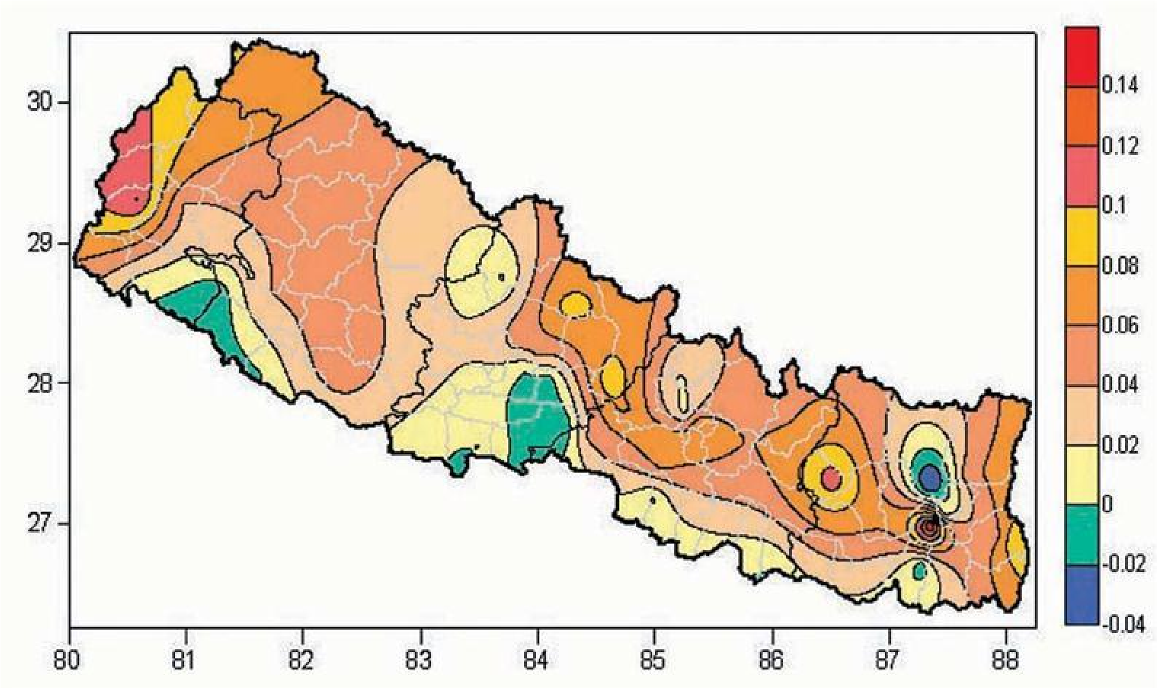


Figure 2.3 Spatial variation of average annual maximum temperature trend (1976 – 2005) (^oC/year)
Source: Practical Action, 2009

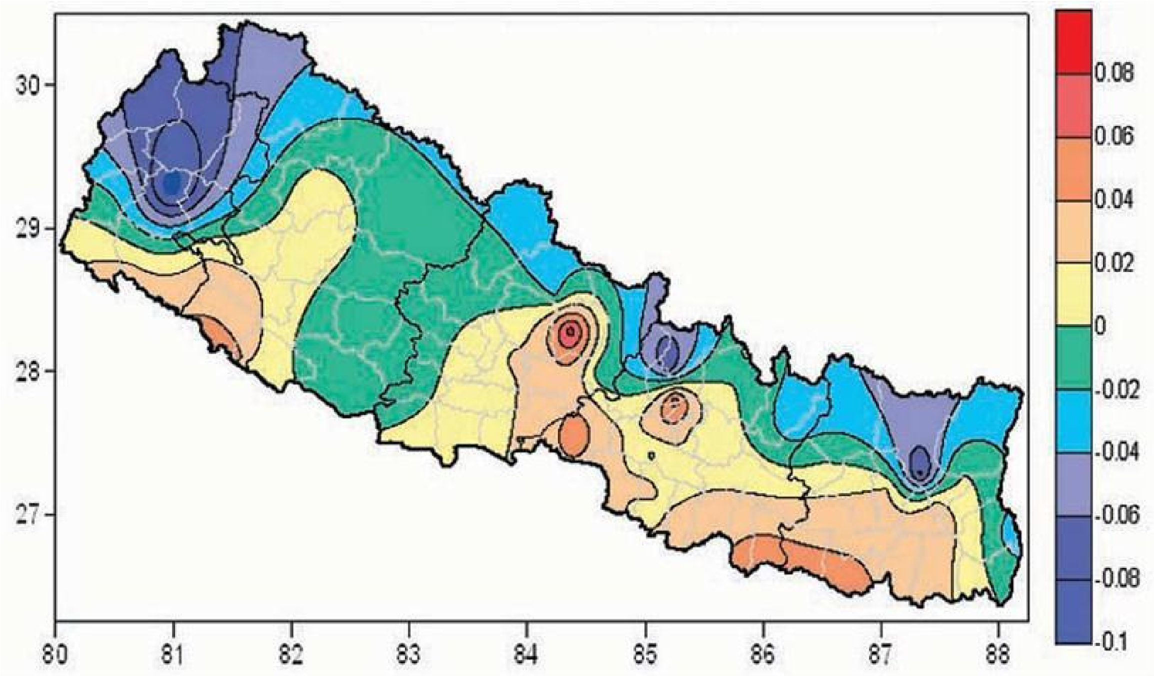


Figure 2.4 Spatial variation of average annual minimum temperature trend (1976 – 2005) (°C/year)
Source: Practical Action, 2009

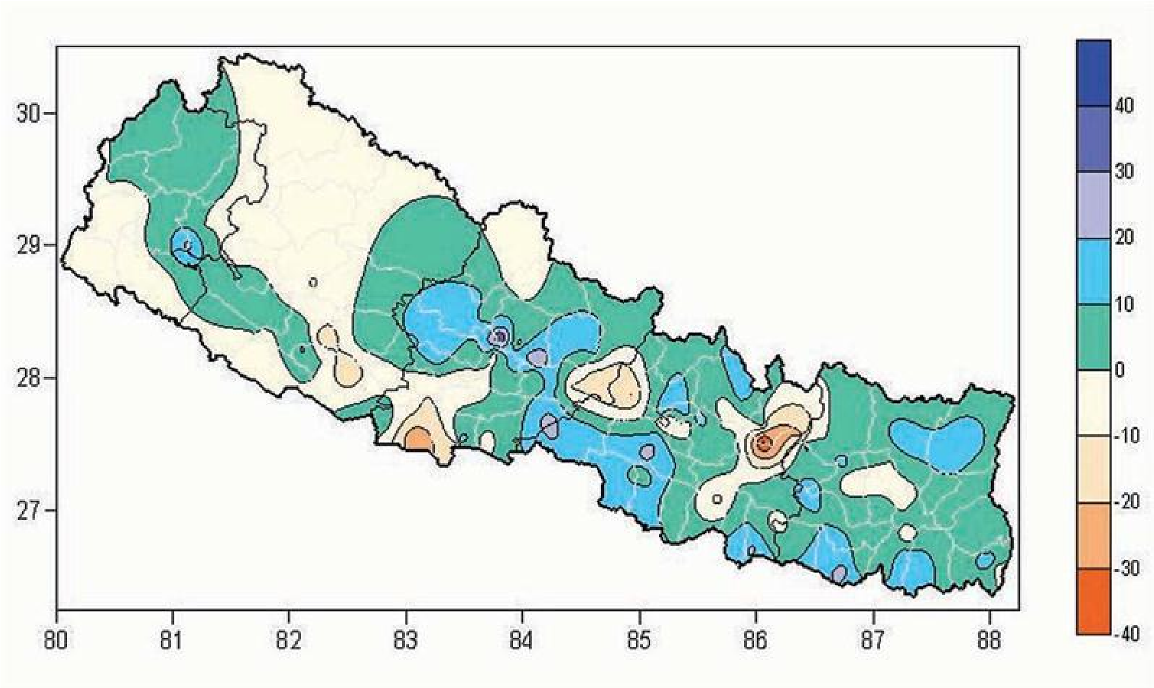


Figure 2.5 Spatial variation of average annual rainfall trend (1976 – 2005) (mm/year)
Source: Practical Action, 2009

Future projections of temperature for Nepal by Global Circulation Model (GCM) and Regional Circulation Model (RCM) show an increase in average annual temperatures by 3°C to 4.7°C by the end of this century. In general, temperature projections are higher for winter compared to summer (Table 2.1). Temperature projections also vary spatially, with highest projections for Western Nepal, and lowest for Eastern Nepal (NCVST, 2009; Agrawala et al., 2003). GCM projections for precipitation by Agrawala et al. (2003) shows overall increase in mean annual precipitation across the country (Table 2.1); whereas GCM and RCM estimates by NCVST (2009) projects both increase and decrease in the annual mean precipitation with no clear trends (Table 2.2). Monsoon and post-monsoon rainfall are predicted to increase while winter rainfall is projected to decrease indicating that monsoon rain is going to be more intense while the winters will be even drier. Heavy rainfall events with maximum downpour within a short period of time is increasing in frequency over the recent years (Baidya and Karmacharya, 2007); with the maximum 24-hour rainfall occurring in the foothills of Siwalik and Mahabharata range (Practical Action, 2009).

Table 2.1 GCM estimates of temperature and precipitation in Nepal

Year	**Mean temperature increase (^{o}C)**			**Mean precipitation increase (mm)**		
	Annual	**Winter**	**Summer**	**Annual**	**Winter**	**Summer**
Baseline average	-	-	-	1433	73	894
2030	1.2 (0.27)	1.3 (0.40)	1.1 (0.20)	71.6 (3.8)	0.6 (9.9)	81.4 (7.1)
2050	1.7 (0.39)	1.8 (0.58)	1.6 (0.29)	104.6 (5.6)	0.9 (14.4)	117.1 (10.3)
2100	3.0 (0.67)	3.2 (1.00)	2.9 (0.51)	180.6 (9.7)	1.5 (25.0)	204.7 (17.9)

Source: Agrawala et al., 2003
Note: Figures in parenthesis indicate standard deviation

Table 2.2 Precipitation projections for Nepal (GCM and RCM estimates)

Year	**Annual mean**	
	Multi-model mean	**Range**
2030	0%	-34 to +22%
2060	+4%	-36 to +67%
2090	+8%	-43 to +80%

Source: NCVST, 2009

NAPA has identified six major areas impacted by Climate Change in Nepal, viz., agriculture; water resources; climate-induced disasters; forests and biodiversity; health; and urban settlement and infrastructure. Erratic precipitation, increasing droughts, and changes in the local rainfall patterns have impacted the agricultural sector of the country. Occurrence of drought in 2005 is reported to decrease the production of paddy and wheat by 2% and 3.3%

respectively in that year. Similarly, it has been reported that rice production in Eastern Tarai decreased by 27-39% in 2006 due to drought in that area (Regmi, 2007). In the same year, the country as a whole experienced 21% and 3% decline in rice and millet production respectively due to which Nepal experienced negative food balance in 2006, the first time after 1999 (MOAC, 2006). Malla (2003) reports that there is an initial possibility of yield increase for rice, wheat, and maize in all ecological regions of Nepal owing to the rise in temperature and CO_2 fertilization. However, temperature rise above 4^oC will reduce the rice and wheat yields in the Tarai where temperature is already quite high. Although Hills and Mountains might still experience increases in yield thereafter, decrease in soil fertility and nutritional value of crops is more likely at higher temperatures.

One of the highlighted climate change impacts is the melting of snow in the Himalayas thereby increasing the threats of glacial lake outburst floods (GLOFs), which causes destructions of settlements, agricultural lands, infrastructure, human lives and properties. According to United Nations Environmental Programme (UNEP), out of the total 2,323 glacial lakes in the Himalayas within the Nepalese territory, 20 glacial lakes have the threats of outbursts due to the consequences of global warming. MOPE and UNEP (2004) reports that 1^oC increase in temperature can result in the disappearance of 20% snow and glacier in mountains above 5,000 meters; and the estimations of reductions in snow for 2^oC, 3^oC, and 4^oC rise in temperatures are 40%, 58%, and 70% respectively.

Several studies reveal that the duration of monsoon rainfall have been decreasing over the last few years; however the total amount of average national monsoon rainfall has increased, which means monsoon rainfall is getting intense. Because of such changes in the rainfall patterns, the problem of flashflood and landslide has been increasing in the wet season whereas drought is becoming harsher in the dry season (Gautam et al., 2007a; Gautam et al., 2007b; Pokhrel, 2007; Vidal, 2006). Intensive rainfall and subsequent floods and landslides cause severe damage on livelihood assets claiming lives and properties.

Temperature increase has been reported to cause an upward shift in flora and fauna in Nepal (Malla, 2007). As reported by MOPE and UNEP (2004), if the CO_2 concentration is doubled from the existing level, 3 out of the 15 types of forests in Nepal as categorized by Holdridge model will disappear. Specifically, it is reported that the tropical wet forest and warm temperate rain forest will disappear, and the cool temperate vegetation will be converted into warm temperate vegetation thus affecting the forest biodiversity.

Temperature increase has also impacted the human health. Mosquitoes, previously found only in the Tarai and Mid-Hills have been reported to appear in the High-Hills. As a consequence, the vector borne diseases like malaria are now moving at higher altitudes and 7 out of 13 Mountain districts of Nepal were classified as the malaria prone districts in 2006 (WHO, n.d.). In addition, incidence of previously unseen vector borne diseases like kalaazar and dengue has been frequently reported in the Tarai districts. Alternate heat and cold waves during summer and winter seasons have also emerged as livelihood threats in the Tarai settlements in the recent years. In the year 2002, 60 cases of fatalities were recorded in the Tarai due to the extreme temperatures.

With almost negligible contribution to the global GHG emissions, Nepal has very less to offer in the mitigation of GHGs. However, since the impacts of climate change are already quite significant, adaptations must the priority for the country. NAPA has identified both short-term and long-term prioritized adaptation options for each of the thematic areas mentioned above. It aims to mainstream the adaptation processes within the goals and priorities of the national development plans, putting more emphasis on dissemination of information, skills, and technology to the vulnerable communities and increasing their adaptive capacity through livelihoods support, improved governance, collective responses, improved delivery services, access to technology, and finance (MOE, 2010).

2.2 Review of the socio-economic dimensions of climate change with focus on rural livelihoods in the developing countries

The study of socio-economic aspects of climate change began rather recently (Mearns and Norton, 2010); although climate change studies gained momentum after the publication of first assessment report by IPCC in 1990, much of the earlier studies were more focused on the biophysical aspects. Undoubtedly, such studies have contributed immensely in understanding the physical processes of climate change and its impacts on biophysical systems such as sea level rise, crop production, glacial melts, and so on. It was only a decade later that the social aspects of climate change gained interest among the researchers. Over the last decade, emphasis has been given to put people or communities in the center of analysis, in contrast to the earlier studies putting hazards in the focus. These researches have highlighted the importance of local level analysis (against a larger scale global, regional, or national level analysis) and bottom-up approaches of analysis. The following sections present a review on various socio-economic aspects of climate change studies with a focus on the rural livelihoods in the developing countries.

2.2.1 Conceptualizing vulnerability to climate change

Vulnerability is the susceptibility of a system to disturbances determined by exposure to perturbations, sensitivity to perturbations, and the capacity to adapt (Nelson et al., 2010a). Cutter et al. (2009) defines vulnerability as the susceptibility of a given population, system, or place to harm from exposure to the hazard and directly affects the ability to prepare for, respond to, and recover from hazards and disasters. Both these definitions agree that vulnerability refers to the susceptibility to harm, rather than the measure of harm itself, which may be due to exposure to threats or drivers of change.

The Second Assessment Report (SAR) of the IPCC defines vulnerability as the extent to which climate change may damage or harm a system; it depends not only on a system‟s sensitivity but also on its ability to adapt to new climatic conditions (Watson et al., 1996). IPCC TAR refined its earlier definition of vulnerability as „the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC, 2001). IPCC AR4 is consistent with the definition of vulnerability given by TAR.

The definition given by IPCC SAR views vulnerability as the „end point" of a sequence of analyses starting with projection of future climate trend, development of possible climate scenarios, studying the biophysical impacts of such climate changes, identification of adaptive options, and finally any residual (adverse) consequences that remain after adaptation define the level of vulnerability (Kelly and Adger, 2000). Most climate change studies have often followed the end-point analysis in assessing the vulnerability which conceptualizes vulnerability as the impact on the system after a hazard incident. Such analysis puts hazard in the center of analysis focusing on the climatic drivers such as temperature, precipitation, and extreme climatic events which cannot be influenced by policy makers, at least in the short-run. It tends to rely on projections using biophysical models which itself has a lot of uncertainties (Nelson et al., 2010a). In the recent years, climate change studies have recognized that vulnerability is not only defined by the characteristics of the hazards, but rather by the emergent property of human-environmental systems that enable them to cope with changes, thereby linking vulnerabilty to their adaptive capacity (Vincent and Cull, 2010; Vincent, 2004; Adger and Kelly, 1999; Adger, 1999). This approach puts vulnerability as the „starting point" of analyses, a state that exists within a system before it encounters a hazard, therefore refers to the present day vulnerability. In this approach, vulnerability is determined by the existing capacity to respond to that hazard. Such differences in the approach have led to the coining of the terms „Biophysical" vs. „Social" vulnerability (Vincent, 2004; Brooks, 2003). End-point analyses tend to view vulnerability as a linear impact of hazards, referring to the exposure and sensitivity of natural environments to projected changes in climate, therefore referring to the biophysical vulnerability. This approach is often criticized for taking humans as passive receivers of hazards, failing to account for the interactions of humans to cope with such hazards. In the starting point approach, emphasis is placed on "social vulnerability" concerning more with the social system. Social vulnerability approach recognizes that the physical phenomena are mediated by the particular human context in which they occur. While biophysical studies have contributed to our understanding of the physics of climate change and its impact on biophysical environments; it has less implications on policy making since variables like temperature and precipitation are not under the immediate control of the policy makers. Social vulnerability studies focuses on the analysis of drivers of current adaptive capacity, thereby providing insights on the type of information required to prioritize adaptation. Such types of studies are more relevant to policy makers as it focuses on the socio-economic drivers like poverty, and access to resources that are under their direct influence. The school of thought focusing on the social vulnerability led to the understanding that the impact of hazard is modified by the existing socio-economic and institutional factors in a community, thus the vulnerability of a social system to a particular hazard is not the same for all the community members (Ford and Smit, 2004; Vincent, 2004; Adger, 1999).

Though theoretically, social and biophysical approaches to vulnerability studies present two divergent schools of thoughts, social vulnerability assessments cannot be complete without taking hazards into considerations since vulnerability is always hazard specific. Some studies have therefore, tried to form a compromise between the two approaches by considering an integrated approach for vulnerability assessments, combining socio-economic factors (adaptive capacity) with exposure and sensitivity to give a complete picture of vulnerability (Nelson et al., 2010b; Gbetibouo and Ringler, 2009; Cutter, 1996).

2.2.2 Measuring social vulnerability to climate change

Initiation of the studies of social dimension of climate change can be attributed to Adger (1999) who studied vulnerability to climate change in coastal communities in Vietnam. Adger (1999) borrows the concept of entitlements from Nobel Laureate Amartya Sen, and proposes the infrastructure of entitlement as a measure of social vulnerability. Measurements of poverty incidence, inequality and institutional settings have been used as proxy indicators to assess the social vulnerability in a coastal village in Vietnam. It was found that the vulnerability at the community level is affected by the broader institutional changes at the sub-national or national level. Adger opines that vulnerability is location specific and the indicators cannot be generalized to other localities or cannot be aggregated from one level to the other. This concept has further been consolidated in his subsequent works (Kelly and Adger, 2000; Adger and Kelly, 1999).

Various other approaches have been put forward to measure social vulnerability to climate change at the regional, national, or subnational level. Cutter et al. (2003) apply the hazard of place model proposed by Cutter (1996) to create a social vulnerability index for the United States based on county level socio-economic and demographic data. This model attempts to synthesize the geographical contexts with the socio-economic factors of vulnerability. However, this model does not include the climate variables or climatic extremes as a factor. Vincent (2004) chooses proxy indicators of the determinants of vulnerability based on expert judgment, and comes up with weighted aggregate index at the national level for various African countries so as to facilitate comparison of vulnerability across the countries.

Many of the later studies have focussed on household level data to analyze vulnerability. Deressa et al. (2009a) employed the „vulnerability as expected poverty" approach given by World Bank (Hoddinott and Quisumbing, 2003) to measure the vulnerability of households to climate extremes in the Nile Basin of Ethiopia. This approach is based on the estimation of probability that a household will fall below a given standard of minimum daily consumption requirement or a standard poverty line, or the probability that it will remain below the minimum standard level if it is already there. Using a combination of socio-economic data and frequency of extreme climate events to estimate the probability of being vulnerable, it was found that the farmers" vulnerability was extremely sensitive to the minimum consumption requirement or poverty line and also on the agro-ecological setting.

Vincent and Cull (2010) takes vulnerability as a function of the possession of five livelihoods assets under the sustainable livelihoods framework given by Department of International Development (DFID, 1999) to construct a household vulnerability index and facilitate inter-household comparison so as to assess the impacts of vulnerability reduction projects and to target the neediest households within community.

A more integrated framework encompassing all the components of vulnerability as defined by IPCC viz., exposure, sensitivity and adaptive capacity has been followed by Gbetibouo and Ringler (2009) and Nelson et al. (2010b). These studies cover all the three components of vulnerability viz. exposure, sensitivity, and adaptive capacity as given by IPCC and adopts rural livelihoods framework developed by DFID (1999) and Ellis (2000) to measure the adaptive capacity. Both studies integrate biophysical models with household survey data to assess the vulnerability at the sub-national level. Nelson et al. (2010b) demonstrate that using biophysical modeling alone, without incorporating the socio-economic determinants (adaptive capacity) leads to entirely erroneous results, thereby giving wrong message to the policy makers.

2.2.3 Local perceptions in climate change researches

The importance of local perceptions in understanding the local level changes of climatic variables and manifestations of climate change was recognized rather late. There has been some studies conducted over the last decade on perceptions of climate change at country level (Leiserowitz, 2007), or at local level in developed countries (Patino and Gauthier, 2009; Leiserowitz, 2006) as well as developing countries in Africa (Deressa et al., 2011; Gbetibouo, 2009; Maddison, 2007) and Asia (Chaudhary and Bawa, 2011; Byg and Salick, 2009; Vedwan, 2006; Dahal, 2005; Vedwan and Rhoades, 2001). In Asia, all these studies are conducted among the Himalayan communities of India, Nepal, and Tibet, probably because much of the attention in Asia has been received by the melting glaciers in the Himalayas (IPCC, 2007b). In Nepal, though few other studies on the local perceptions of climate change have been conducted in the hills and low-lying plains (Tiwari et al., 2010; Bhusal, 2009), the findings from such studies are yet to be circulated widely.

The view of local communities about the ongoing changes in climate, its causes and impacts can be entirely different from what science has explained about climate change. Byg and Salick (2009) report that Tibetans in Yunnan province give spiritual reasons like angering of mountain gods as the causes of disruption in the climate patterns. Very often, the understanding of climate change by rural communities is a function of micro-level livelihood practices and is conditioned by the knowledge of crop-climate interaction. For instance, the apple growers in the Northwestern Himalayas of India notice changes in temperature and rainfall only for the apple growing period (Vedwan, 2006). Their perceptions of changes in snowfall in the area are very much linked to the various growth stages of apple; like late snowfall is easily noticed by the farmers because amount of snowfall is very important to determine the fulfillment of chilling requirements to break the winter-dormancy in apples. Similarly, shift in rainfall hampers the color development of apples and thus is remarkably mentioned by these farmers. However, once apples are harvested in September, changes in any of the climate variables are rarely reported (Vedwan and Rhoades, 2001). It is thus very important to first understand how local people understand the climate and how climate interacts with their livelihood activities. Unless adaptation policies and related projects address the local perceptions, it cannot be expected that the community will agree to and adopt the recommended practices. Furthermore, since rural communities are the ones who have closely observed the local climatic patterns, local knowledge can provide important insights into the phenomenon that has not yet been noticed or researched by the scientists. Patino and Gauthier (2009) demonstrate that local perspectives can be combined with scientific climate scenarios to draw policy recommendations from the community through participatory vulnerability mapping.

Many local level studies capturing the perceptions of local communities have been conducted in African countries in the recent years (Deressa et al., 2011; Mertz et al., 2009b; Gbetibouo, 2009; Nhemachena and Hassan, 2007; Maddison, 2007). These studies triangulate the local perceptions with the meteorological records, which show that majority of the local people are capable to follow the ongoing changes. Not all the members in the community, however, follow such changes. All the studies cited above show that there are some members in every community who do not perceive any changes in climate. Within those who perceive changes, not all of the perceptions match the meteorological records. Attempts have been made to understand the characteristics that differentiate the members who perceive the changes from those who do not perceive any changes across the rural communities in Africa (Deressa et al., 2011; Gbetibouo, 2009; Maddison, 2007). It has been noted that both individualistic and general characteristics affect ability to perceive. While individualistic factors like age and household size do not have much policy implications, others like gender differences, education, and farming experience have important policy relevance. Among other factors, access to information, social networks, infrastructure like distance to market, and engaging in non-farm income sources are found to determine the ability to perceive changes in temperature and rainfall. Furthermore, there are factors specific to agriculture like farm income, farm extension services, nature of farming (subsistence or commercial), soil quality, and access to irrigations that affect perception of climate change. Such type of analysis is important as it helps to characterize those members who have the ability to perceive changes in climatic variables versus those who cannot, thereby highlighting the factors that need to be addressed in order to facilitate perceptions and finally adaptations to climate change at the local level. The limitation of the above cited literatures is that they analyze determinants of the ability to perceive some changes in temperature and rainfall, regardless of whether the perceptions are in line with the meteorological data or not. As stated before, even among those who perceive some changes, not all are in line with the recorded data. There is thus a need to separate those who can perceive the changes in the same direction as recorded in the meteorological stations versus those who cannot do so. Furthermore, there is dearth of quantitative studies on the factors determining the community perceptions in the South-Asian or Nepalese context.

2.2.4 Approaches in analyzing adaptive capacity

A wide variety of literatures on adaptation to climate change can be found. As summarized by Smit and Wandel (2006), these studies can be categorized into four types. The first category uses hypothetical adaptation practices to calculate how much the negative impacts of climate change can be moderated, offset or mitigated. The literature under second category, like Adger et al. (2005) analyzes a set of adaptation practices in terms of cost-benefit ratio or cost effectiveness. However these two categories do not study the actual ongoing adaptation practices. Another group of literature gives a relative measure of the adaptive capacity based on an index developed from some pre-selected indicators by scoring, rating, or ranking in order to direct adaptation efforts to the area where the adaptive capacity is the least (Vincent, 2007; Adger and Vincent, 2005). Such studies are used for comparative studies of adaptive capacity for different nations, regions, or communities. The last group of studies follows the bottom-up approach by investigating the existing community level practices in order to identify means of implementing adaptation initiatives or enhancing adaptive capacity. These studies focus the analysis on the ways in which system experiences changes and decision-making processes that promote adaptation or improve the adaptive capacity (Ford and Smit, 2004). This research makes use of the insights gained from the last two types of adaptation related literatures.

The substantial works on adaptive capacity is done after the publication of IPCC TAR in 2001, which identified adaptive capacity as a component of vulnerability. IPCC defines adaptive capacity as the ability of a system to adjust to climate change including variability and extremes to moderate potential damages, to take advantages of opportunities, or to cope with the consequences (McCarthy et al., 2001). Assessment of current adaptive capacity of a system provides useful insights on the existing potential of the system to cope with climate disasters and also point out the shortcomings which need to be addressed to improve the adaptive capacity of the systems before such events occur. Many of the initial studies have focused on the adaptive capacity at the national level (Haddad, 2005; Adger and Vincent, 2005; Brooks et al., 2005; Adger et al., 2004; Yohe and Tol, 2002) and few of the latter studies have been focused at the subnational level (Jakobsen, 2011; Nelson, et al., 2010; Gbetibouo and Ringler, 2009). The earlier national level studies are aimed at comparative assessment of adaptive capacity at the national level to identify the countries with lowest adaptive capacity, thereby assisting in the adaptation related investment decisions under the United Nations Framework Convention on Climate Change (UNFCCC). The subnational studies are done with the objective of identifying the regional variations within the country, thereby facilitating specific target-group oriented resource allocations. While explorations of the adaptive capacity at the national level is important to make comparison across nations, such studies is lesser relevant at the sub-national and local level as it does not capture the processes and contextual factors that influence adaptive capacity at the level where adaptation ultimately takes place. Vincent (2007) demonstrates that the indicators of adaptive capacity cannot be generalized across scales. Indicators of adaptive capacity at the national level are unrepresentative at the sub-national or local scale. Thus, exploring the local context is important to gain insights into local constraints and opportunities.

All of these studies have contributed to form a conceptual basis for defining adaptive capacity by throwing an insight on the possible social and economic indicators of adaptive capacity. They conclude that many of these variables are not quantifiable and can only be qualitatively described. The earlier studies select the indicators of adaptive capacity based on subjective judgments while the latter ones promoted selection of indicators based on some theoretical underpinnings. Nelson et al. (2010b) and Gbetibouo and Ringler (2009) utilize the sustainable livelihoods framework to analyze adaptive capacity and opine that the adaptive capacity of a household is the emergent property of the assets possessed. These studies confirm that possession of diversified set of assets enables the households to choose from various livelihoods options and switch from one strategy to another during the times of stress. Thus households with diversified assets and livelihood activities have higher adaptive capacity.

While Adger et al. (2004) identifies that the current adaptive capacity is the best proxy for future adaptive capacity, Brooks et al. (2005) seeks to validate the indicators through correlation with past disaster events. Haddad (2005) makes a comparative assessment of national level adaptive capacity and empirically demonstrates that the ranks of countries changes drastically when socio-political goals of national governments are taken into considerations. Adger and Vincent (2005) and Vincent (2007) provide an analysis of the uncertainties in adaptive capacity. These studies point out four types of uncertainties while measuring adaptive capacity viz., determining the driving force behind adaptive capacity, selection of indicators and their quantification, functional relationships of the indicators with adaptive capacity and the changes in adaptive capacity over time. The first study illustrates the existing uncertainties with the help of indicator based adaptive capacity index constructed for countries in Africa; the latter uses the indices for both national level for African countries, and household level for a village in South Africa to highlight the uncertainties in adaptive capacity at different scales. They conclude that the drivers of adaptive capacity might be similar, but the indicators cannot be generalized across scales. Some studies analyze the adaptive capacity of a system as a component within vulnerability analysis (Nelson et al., 2010b; Gbetibouo and Ringler, 2009). Nelson et al. (2010b) takes adaptive capacity as an emergent property of the possession of diversified set of assets, so that the households have more options to choose from, and can switch among the choices during the periods of stress. Gbetibouo and Ringler (2009) also implicitly follow the concept of asset possession as the measurement of adaptive capacity. Both these studies are indicator based measurements of adaptive capacity.

2.2.5 Studies of community based adaptation practices

Realizing the importance of assessing the actual adaptation practices being undertaken at the community level and analyzing the underlying factors that determined the community capacity to undertake adaptation actions, the IPCC AR4 of the Intergovernmental Panel on Climate Change (IPCC) focusses the adaptation chapter in documenting and analyzing the ongoing adaptation practices and highlights the constraints to effective adaptation especially in developing countries posed by physical, technological, financial, informational, social, and cultural barriers (Adger et al., 2007). The number of literatures documenting and analyzing the ongoing practices of climate change adaptation among the rural communities in developing countries have been increasing ever since (Deressa et al., 2011; Below et al., 2010; Onyeneke and Madudwe, 2010; Chambwera and Stage, 2010; Gbetibouo, 2009; Pokharel and Byrne, 2009; Oxfam, 2009; Barbier et al., 2009; Mertz et al., 2009a; Mertz et al., 2009b; Bhandari and Gurung, 2008; Regmi et al., 2008; Nhemachena and Hassan, 2007; Adger et al., 2007; FAO, 2007; Gautam et al., 2007a; Gautam et al., 2007b).

Below et al. (2010) reviewed adaptation practices by small-scale farmers from 16 countries and came up with 104 different practices broadly categorized under five headings: farm management and technology; farm financial management; diversification on and beyond the farm; government interventions in rural infrastructure, the rural health care services, and risk reduction for the rural population; and knowledge management, networks, and governance. Nhemachena and Hassan (2007) categorize these practices into two broad groups - diversification and management practices, under which practices like crop diversification, mixed crop-livestock farming systems, using different crop varieties, planting different crops, changing planting and harvesting dates, mixing less-productive - drought-resistant - and high-yielding water sensitive crops, diversifying from farm to non-farm options, using more irrigation/ground water/watering, and using soil and water conservation techniques are included. The community-based practices reported by other studies are also similar to these. The local coping strategy database managed by UNFCCC is an excellent collection of ongoing adaptation practices all over the world, with most of the cases coming from rural farming communities in developing countries. The database consists of around 200 cases for nine different types of hazards like drought, aridity, shift in season, erratic rainfall, extreme hot and cold, etc. The adaptation practices has been categorized into 21 different strategies like appropriate crop selection, alternative cropping methods, post-harvest management, soil conservation, natural resource management, rain water harvesting, and so on. Explorations of the ongoing adaptation practices among the rural communities reveal some very important features of adaptation to climate change. Firstly, these adaptation practices are not entirely new in the community; such practices have been ongoing in the community since a long time. Traditional soil conservation practices like mulching and terracing have always been there in the community. Secondly, adaptation practices that are suitable to address the adverse impacts of climate change may not be necessarily implemented only in response to climate change related risks. Investment in livestock, for example, may be a decision taken by a farmer to increase the household income rather than in response to increasing droughts or shifting seasons. Nevertheless, it serves to improve household income and to compensate for the crop losses caused by droughts or unfavorable shifts in the seasons. Thirdly, even planned adaptation activities are not always undertaken as a response to climate change alone, but embedded with other development projects like soil conservation, land-use planning, etc. Fourthly, adaptation activities may sometimes conflict with the development priorities. For instance, in the face of recurrent droughts or decreasing rainfall, farmers may switch back to the indigenous varieties of maize that are drought tolerant. This practice will possibly be in conflict with the development priorities of promoting hybrids to increase crop yields. However, farmer may perceive the risk of crop failure to be greater than the risk of food shortage, thereby favoring indigenous varieties to hybrids.

While the documentation of the adaptation practices has been done quite well, the factors affecting the household adaptation choices is comparatively less studied. Analysis of the factors that enable or constrain households from undertaking a particular adaptation practice is important to provide relevant policy implication. Most of researches on determinants of adaptation choices among the rural farming communities have been done in the context of Africa (Below et al., 2012; Deressa et al., 2011; Deressa et al., 2009b; Gbetibouo, 2009; Seo et al., 2009; Hassan and Nhemachena, 2008; Kurukulasuriya and Mendelsohn, 2008; Maddison, 2007; Nhemachena and Hassan, 2007) and fewer studies have been conducted in other continents (Jones and Boyd, 2011; Onta and Resurreccion, 2011; Bouma et al., 2009; Seo and Mendelsohn, 2008a). The analyses done in various African countries have shed light on the factors that enhance or limit the ability of households to adapt to climate change and related vagaries. The adaptation choices by households in a particular locality is determined not only by the climate variables (e.g. rainfall, temperature) or geographical features (e.g. soil, slopes), but also by household socio-economic characteristics (e.g. age, sex, education, occupation, income structure); farm characteristics/infrastructures (e.g. subsistence or commercial farm, irrigation, market); social, institutional, and governance factors like information, extension, credits, organizational memberships, caste hierarchy, gender equity; and finally by the way climate change is perceived by the community. Caste hierarchy and gender restrictions have been found to act as a barrier for the socially marginalized groups within a locality to access certain institutions and adopt the adaptation options that are easily accessible for the so-called higher castes (Jones and Boyd, 2011; Onta and Resurreccion, 2011). The roles of local institutions in structuring the risks and vulnerabilities, creating an incentive framework and mediating external interventions in facilitating adaptations have been highlighted by Agrawal (2010). Bouma et al. (2009) conclude that while market and institutional access are important determinants of the effectiveness of adaptation strategies, equity and governance factors finally determine the level of access of various social groups to the market and institutions.

2.3 Contribution of the study to the existing literatures

As already indicated, there is dearth of studies related to the livelihood impacts of climate change done in Asia and even fewer in Nepal. Few notable studies conducted on the Nepalese context are mostly qualitative descriptions, usually based on general reconnaissance of a particular area or based on group discussions (Maharjan et al., 2011; Regmi, 2010; Tiwari et al., 2010; Sharma, 2009; Pokharel and Byrne, 2009; Bhusal, 2009; Bhandari and Gurung, 2008; Regmi and Adhikari, 2007; Dahal, 2005; Dhakal, 2001). Further, most of the climate change studies conducted at local level in Nepal have been conducted by the development agencies working with those communities so as to use the information for future designing of their project activities (Oxfam, 2009; Bhandari and Gurung, 2008; Regmi et al., 2008; Gautam et al., 2007a; Gautam et al., 2007b). Yet few other studies have analyzed the role of gender, caste, market and institutions in facilitating adaptation (Jones and Boyd, 2011; Onta and Resurreccion, 2011; Bouma et al., 2009). This study builds on these literatures by conducting a holistic analysis of the livelihood implications of climate change utilizing data obtained by group discussion as well as semi-structured household surveys; and undertakes a combined approach of qualitative and quantitative approaches in data analysis.

This study utilizes information from a number of studies conducted over the last decade focusing on the socio-economic aspects of climate change among the rural communities in various African countries and builds the analytical framework based on these studies (Chapter 3). These studies have comprehensively focused in documenting the community perceptions and ongoing adaptation practices in the community; and further proceeds to analyze the factors determining perceptions and adaptation decisions. All of these studies uses the long term trends of recorded data to triangulate the community perceptions. This study analyses the trends of recorded temperature and rainfall for both long term as well short term to empirically show that community perceptions tally more with the short term trends rather than the long term trends (Chapter 5). The previous studies analyze the determinants of perceptions without differentiating the perceptions of rainfall and temperature and also giving no considerations to the directions of perception to match the recorded trends. This study addresses these issues while analyzing the determinants of perceptions. Also, none of the earlier studies have made a quantitative comparison of adaptive capacity with the corresponding adoption of adaptation practices. This study contributes to the existing literature by making a quantitative comparison of the adaptive capacity with the adoption of adaptation practices to highlight the components of adaptive capacity that play a major role to enable the households to translate their capacity into actual practices (Chapters 6 and 8). Furthermore, the earlier studies have failed to integrate the community perceptions within the adaptation framework. One earlier study has considered the ability to perceive changes, without giving due considerations on whether the perception is line with the recorded data or not, and also does not differentiate between the perceptions of temperature and rainfall changes. This study takes a step forward to integrate the community perceptions in the adaptation framework, considering the ability to perceive the ongoing changes in line with the recorded data, and also differentiating the perceptions of temperature changes from the perceptions of rainfall changes. The analysis is Chapter 8 shows that the implications of perceptions of rainfall changes on adaptation choices are quite different from the implications of perceptions of temperature changes.

Chapter 3. Analytical framework and research design

3.1 Conceptual framework of the study

This study adopts the rural livelihoods framework proposed by DFID as the conceptual framework. The indicators for each of the components in the conceptual framework have been chosen to suit the context of the research. This framework is a holistic approach to understand rural livelihoods, and is applicable across any geographical areas and social groups. It recognizes the main factors affecting rural livelihoods, and the interrelationships among them. Furthermore, it links the micro with the macro, in other words, links people with policies. The foremost strength of this framework is that it is people centered, that is it puts households/communities at the core, and focuses on the inherent strengths or potential of these people, rather than focusing on the needs. This framework starts the analysis with the inherent potential and then proceeds to analyze the existing constraint to realize this potential (DFID, 1999).

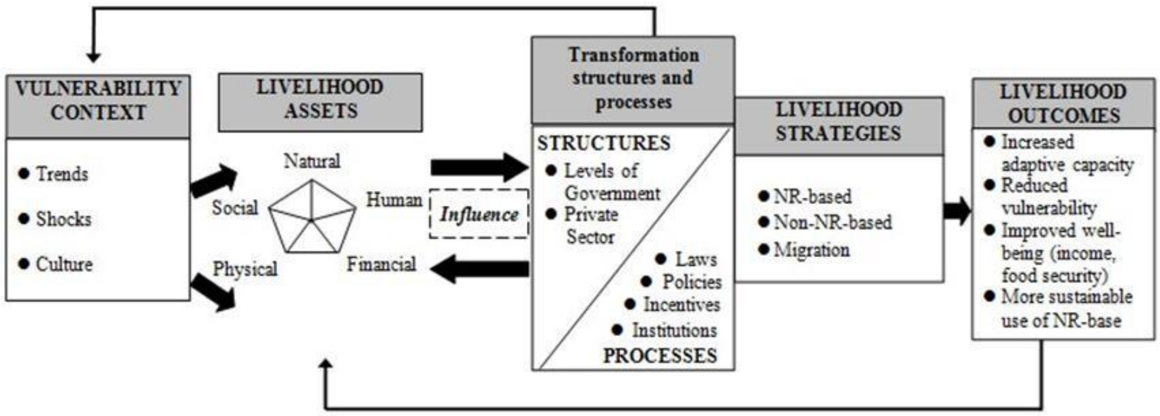


Figure 3.1 Conceptual framework of the study
Source: DFID, 1999; Carney, 1998

3.1.1 Components of the framework

The most widely accepted definition of livelihood is the one given by Chambers and Conway (1992, p. 6): "a livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living". This definition of livelihood has been followed by many academicians and development practitioners

(Ellis, 2000; DFID, 1999; Carney, 1998; Scoones, 1998). Ellis (1999, p. 2) defines livelihood as “the activities, the assets, and the access that jointly determine the living gained by an individual or household”. Both of these definitions agree that livelihood is about the ways and means of „making a living‟. Another feature that both definitions share in common is that livelihood deals with the assets available, and how they are utilized.

The concept of livelihood assets has been given differently by different authors. Chambers and Conway (1992) define it as assets of two types, viz., tangible (resources and stores), and intangible (claims and access). On the other hand, Scoones (1998) has identified four different types of livelihood resources as natural capital, economic/financial capital, human capital, and social capital. In addition to Scoones, this framework has identified one more capital, i.e. the physical capital. The asset pentagon is at the core of this conceptual framework and it depicts how these livelihood assets are utilized as a means to achieve positive livelihood outcomes. Human capital is the skill, knowledge, ability to labor and good health possessed by the members and is the most important of all capitals as it is indispensable to make proper utilization of other resources. Social capital denotes the social resources like horizontal or vertical networks, membership of formal institutions and informal safety nets upon which people depend for their livelihoods. For instance, during the times of stress like drought, communities like Chepangs have to depend on either borrowing from the neighbors, or credit from the shopkeepers, or loans from the moneylenders, which are all informal safety nets existing in the society. Memberships in community based formal organizations like local saving and credit cooperatives also serve as social capital to which the community can turn to during the time of needs. Natural capitals are the natural resource stocks from which resource and services useful for livelihoods are derived. For rural communities everywhere, natural resources like land, forest, water and biodiversity form the basic source of their livelihoods.

Physical capital includes basic infrastructure like roads, schools, communication facilities, etc. and the producer goods like tools and equipment needed to facilitate production. Infrastructures like schools can be important in educating people to raise awareness about climate change; while communication facilities can help in disseminating climate relevant information like weather forecasting, which facilitate rural communities to formulate appropriate responses against climate variability (Ziervogel and Calder, 2003). Financial capital includes both stocks (savings, insurance, credits) and flows (regular income, salary, pension, remittances) that facilitate consumption as well as production. This capital is more versatile as it can be converted to into other types of capital; however it is the one least available to the poor, the reason why other capitals are so important to them (DFID, 1999). These five types of capitals determine the adaptive capacity of the households/community. Households having greater diversity of assets possession will have higher adaptive capacity as it will facilitate diversification of livelihoods strategies (Ellis, 2000; Ellis, 1999) so that households can switch between these assets and strategies at the times of stress (Nelson, et al., 2010b).

In the due course of making a livelihood, people have to cope with stresses and shocks termed vulnerability context in the framework. These vulnerabilities influence on the management and utilization of resources, and on the choices made. Vulnerabilities may be created by long term trends in factors like population, prices, and agriculture production; or by shocks like natural disasters. While trends are more predictable, shocks are less predictable and come suddenly causing more damages. Certain vulnerability context may also be created by cultural factors, for example, cultural constraints for women in Bangladesh restricted them to move out of their houses during the times of flood and those who left the house were unable to swim in contrast to their brother or other male members in the family, thereby making them more vulnerable to floods (Demetriades and Esplen, 2010).

Structure and processes refer to the institutions, organizations, policies, and legislation that shape livelihoods. It operates at any level from household to international arena. Structures are composed of public and private organizations - Government bodies, community based organizations (CBOs), and non-governmental organizations (NGOs) - that set and implement legislations and provide services necessary for livelihoods. Processes include policies, legislations, traditional institutions, and cultural norms, which in turn determines how the structures and individuals operate. Policies determine the access to and control over capitals, which in turn determine the livelihood strategies and the returns from them. In case of Chepangs, policies like Private Forest Nationalization Act 1957 restricted their access to forest resources, thereby impacting upon their choice of forest based livelihood strategies.

Livelihood strategies are the diverse actions oriented towards meeting desirable needs, involving manipulations of livelihood resources and constructing regulatory mechanisms at different levels of society (Dharmawan and Manig, 2000). Households having more choices in livelihoods strategies will have greater ability to cope and adapt to shock and stresses. In rural areas of low-income countries, single livelihood strategy is not sufficient to eke out a living, therefore most rural households tend to diversify their livelihoods strategies combining both natural resource based and non-natural resource based livelihood options (Ellis, 1999; Ellis, 1998). As a result, besides farming, most Chepang households are found to depend on diverse income sources like off-farm wage works, non-farm activities, non-farm self-employment, and remittances. Finally, livelihood outcomes are the achievements or outputs of livelihood strategies.

3.1.2 Relationships among the framework components

Different components in the conceptual framework interact with each other in different ways. The direction of arrows in Figure 3.1 shows the direction of influence; however it does not always imply direct causality among the components. Firstly, there are interactions within the livelihood assets themselves. Possession of one asset may facilitate or disturb the proper utilization of other. For rural communities like Chepangs, legal ownership of land (natural asset) will facilitate to receive credits (financial asset) from the formal credit institutions by keeping the land as collateral. Similarly education and training (human asset) will increase their exposure to external institutions (social asset) and also help them to find non-farm jobs that give higher income (financial asset). On the other hand, absence of knowledge may limit the use of financial resources productively. Memberships of CBOs (social capital) facilitate sharing of knowledge, skills and information (human capital). Similarly, infrastructures like roads will provide markets for the agricultural produce thereby increasing their cash income (financial resources). Besides these interactions within the five assets, there are forward-backward influences and feedbacks among the components in the framework. The feedback loops are there between structures and process and vulnerability; and between and livelihood outcomes and assets.

Livelihood assets are linked with a two way arrow with structures and processes. Government policies are important to create assets (e.g. infrastructure), to determine the access to the resources through regulations, and determine how these resources will be utilized. For example, policies that facilitate credits based on group liabilities without the need to put land as collateral will help to increase the financial asset of the household, thereby increasing their investments and finally income. Similarly, as discussed before, policies related to land and forests will define the household"s access to these natural resources. On the other direction, structure and processes will also be directly influenced by the level of asset possession. Usually, individuals with greater asset possession having better social status will directly influence the policies and processes.

Structures and processes also directly influence the choice of livelihoods strategies. Policies to build roads or irrigation canals in a village may create opportunities for more remunerative livelihoods strategies by facilitating commercial agriculture. On the other hand, there can be certain restrictive policies like Private Forest Nationalization Act 1957 in Nepal that does not recognize the traditional rights of indigenous communities to land and forest and prevent them from using these resources freely. This will compel such communities to shift their livelihood strategies from farming or forestry to wage labor. Structure and processes also has a feedback loop with vulnerability context. Government fiscal policies determine the trend of economic variables like income, and health policies determine the population trend in the country, thus impacting the vulnerability context.

Livelihood strategies are also directly determined by asset possession of a household. For instance, non-farm skilled jobs require attainment of training or vocational education (human resources). Similarly, in order to pursue commercial agriculture as a livelihood strategy, households need to have access to irrigation infrastructure and market (physical assets). Greater the range of assets possessed by a household, the more options there will be to decide livelihood strategies. Higher asset possession will facilitate combinations among the assets to diversify livelihood strategies and also facilitate switching among the assets and the activities depending upon the requirements.

Next, the forward linkage between livelihood strategies and livelihood outcomes is very direct and clear. Household devise their livelihood strategies so as to achieve the best possible livelihood outcomes. The definition of desirable outcome depends on the context and household aspirations. Some of most commonly desired outcomes in the rural context are improved well-being in term of income as well as food-security, reduced vulnerability, better access to and sustainable use of natural resources, and so on. Finally, the feedback linkage between livelihood outcomes and assets is very important. Certain households may reinvest their cash income in buying lands (natural assets) or educating their children, which in turn will further lead to improved well-being of the household. Thus, the linkage between livelihood outcomes and livelihood assets is a virtuous circle, under which better livelihood outcomes will increase livelihood assets, which in turn will again lead to better livelihood outcomes, if other components of the framework work out favorably.

3.2 Analytical framework of the study

The analytical framework for this study (Figure 3.2) is based on the DFID sustainable livelihoods framework described in the previous section.

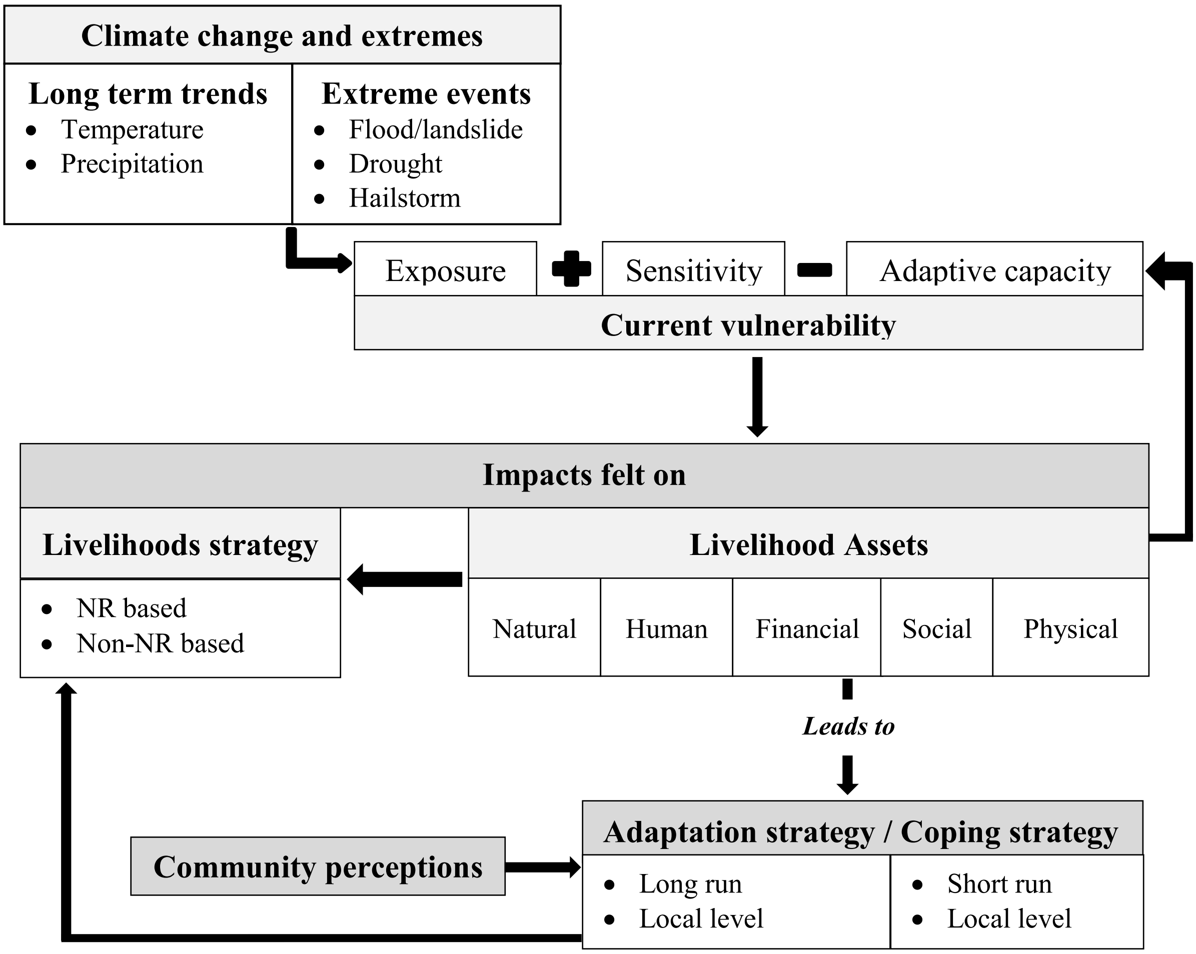


Figure 3.2 Analytical framework of the study

The components of the frameworks are basically similar; however these have been modified to suit the objectives of the study. A general description of the components has been already given in the previous section of this Chapter. This section will describe the modifications made in the components and the directions of influences; and also describe the sequence according to which the components of the analytical framework will be covered in various chapters of the dissertation.

Under the vulnerability context, the original framework only considers trends, shocks, and culture as components of vulnerability. Slightly modifying the vulnerability component to suit the context of climate change, vulnerability for this research will be composed of exposure, sensitivity, and adaptive capacity. Exposure, in turn, is determined by the long term trends of climatic variables and shocks in terms of extreme climatic events. For this study, trend of average maximum, minimum, and mean temperature will be considered for the period of 34 years from 1975 – 2008; similarly trend for a shorter period of last ten years will also be considered where necessary. Shocks have been described in our framework as the extreme climatic events occurring most frequently in the study area. Floods/landslides, droughts, and hails occurring over the last ten years has been considered. Descriptions of the trends and extreme events have been done in Chapter five, six, and seven of this dissertation as per the necessity.

Following the definition by IPCC, exposure and sensitivity, together with the adaptive capacity determine the overall vulnerability of the households. Sensitivity is the degree to which the livelihoods are affected by these shocks and stresses. Following Jakobsen (2011) and Nelson et al. (2010b), adaptive capacity is taken as a function of the livelihood assets possessed by the households. Diversity of livelihood assets presents households with multiple choices of livelihood activities and enables households to switch from one activity to another during the time of emergencies. A detailed description of the components of vulnerability has been covered in Chapter six. Vulnerability of the households has been analyzed using indicator based vulnerability index constructed from the indicators of exposure, sensitivity, and adaptive capacity.

The level of the vulnerability will determine the impacts felt by the households or community. Impacts of climate change will be felt in two major livelihood components: on the livelihood assets and on the livelihood activity portfolio, which as described in the previous section can be based on natural resources or other non-natural resources. The various livelihood activities or livelihood strategies formed by the combination of two or more livelihood sources, and returns from these activities portfolios are analyzed in the next Chapter.

The forward impact of vulnerability context on livelihood assets and activities is quite clear and direct. A new backward influence, not depicted in the original framework, between livelihood assets and vulnerability has been added in the analytical framework for this study. Since vulnerability to climate change is a function of adaptive capacity, which in turn is a function of livelihood assets; asset possession will also determine the vulnerability of the household/community. Shock like floods, for example, will have direct impact on landholdings (natural assets). If the household do not have alternative livelihood assets to draw upon for livelihoods, then the household will further be more vulnerable to future climate vagaries. The impacts of climate change on the livelihood assets and livelihood activity portfolio; and its subsequent implications on the vulnerability context will be dealt in Chapter seven.

In response to the impacts felt due the climate change and shocks, households will formulate short-term coping strategies for extreme events and long-term adaptation strategies for the changes in trends of climate variables. The adaptation strategies undertaken by the households will not only depend on their access to and possession of various livelihood assets, but also depend on their perceptions of the changes in climate variables. The perceptions and its determinants will be analyzed separately in Chapter five. The strategies adopted by the households at the local level and the determinants of the households" choices of adaptation strategies will be analyzed in the Chapter eight.

Finally, policy decisions at macro, meso, or micro level will be cross-cutting across many of the components in the framework. Policies will have direct impact on the access to livelihood assets as well as livelihood strategies. Furthermore, policies can have a feedback effect on vulnerability indirectly through its impact on livelihood assets, which in turn determine adaptive capacity, thereby affecting vulnerability. For example, policies to construct irrigation canals (physical assets) will increase the percentage of irrigated land and reduce the sensitivity of the households to climate change and variability, thereby decreasing the overall vulnerability. Policy impacts and implications will be discussed in all the chapters whenever applicable.

3.3 Study area

This study covers all four districts that form the native area of the Chepangs, i.e. Chitwan, Makawanpur, Dhading and Gorkha districts (Figure 3.3). As per the 2001 population census, nearly 95% of the Chepang population resides in these four districts. Of the total Chepang population, 40.7% reside in Chitwan district, 29.4% in Makwanpur district, 20.8% in Dhading district and 5.2% in Gorkha district (CBS, 2008). All four districts have been considered in this study to maintain the representativeness of the sample. As seen in the figure, the traditional area of the Chepangs only covers a small portion of these districts. Chepang settlements are situated along the geographically fragile and steep Mahabharat Hills within these districts. Few of the Chepang settlements in Chitwan and Makwanpur districts can be found at lower altitude of around 250 meters above sea level (masl). However, majority of the settlements are found at altitudes higher than 1,000 masl, ranging up to 1,920 masl represented by the Siraichuli peak located in Kaule VDC of Chitwan district, which is also the highest point along the whole of Mahabharata range. For the purpose of this study, one VDC from each district was selected based on the dominance of Chepang population.

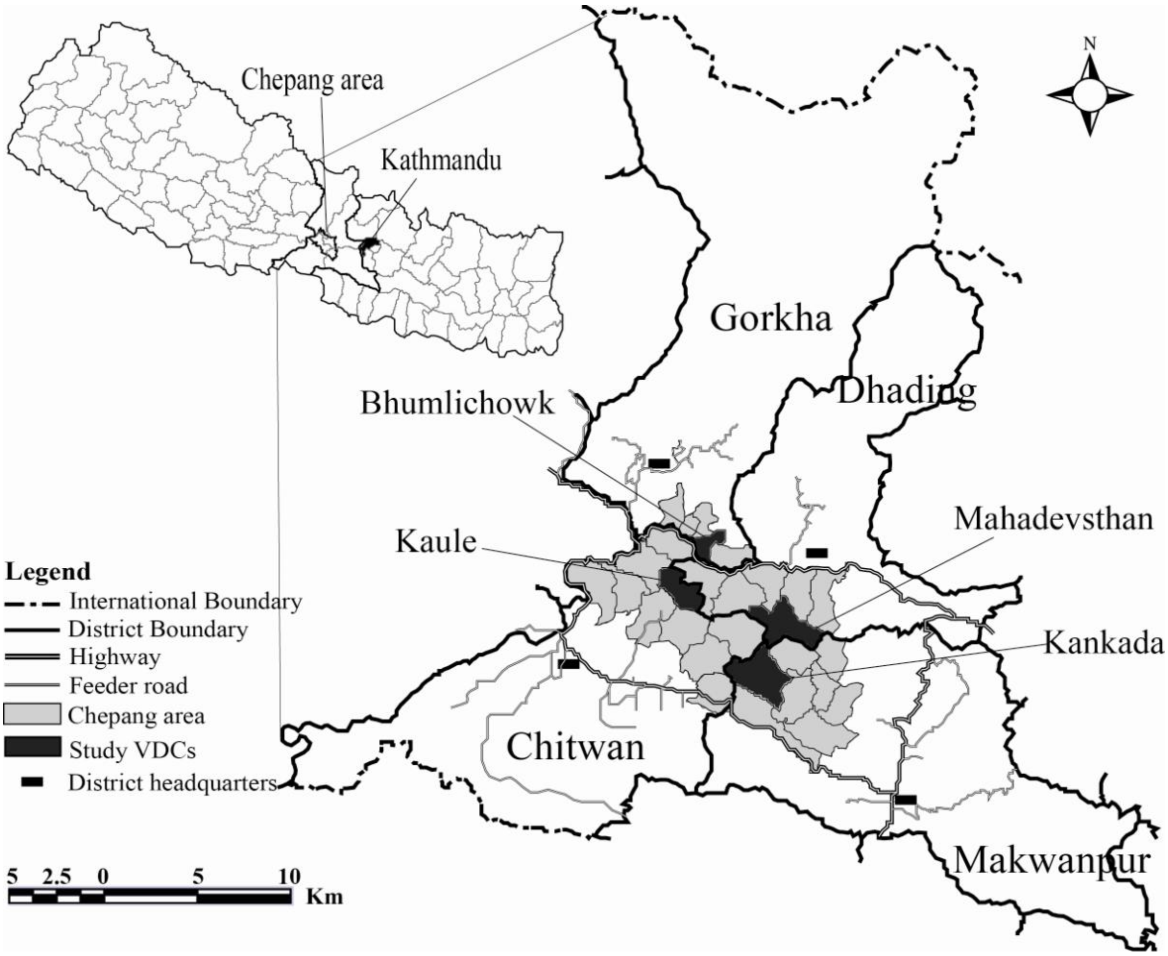


Figure 3.3 Research area

Kaule VDC was selected from Chitwan district. There are approximately 525 Chepang households in Kaule, with a population of 3,155. Chepang is the most dominant ethnic group in Kaule, forming 67.3% of the total population of the VDC (CBS, 2002a). Kaule VDC has been connected to the Prithvi Highway by an earthen road only in 2011. Around 2 hours ride through the narrow, winding roads along ridges of the hills is filled with adventure and thrill until you arrive at Hattibang in Kaule VDC. Kaule shares its border with Chandibhanjyang, Shaktikhor, Siddhi VDCs in Chitwan district; and Jogimara VDC in Dhading district. Altitude of Kaule varies from 810 to 1,920 masl (NGIIP, 2006a).

The highest point in the Mahabharata range, the Siraichuli peak, at an altitude of around 1,920 masl is situated in this VDC.

Kankada VDC from Makawanpur district is the VDC with the highest population of Chepangs in the district. There are approximately 675 Chepang households in Kankada with a population of 4,056; Chepangs are the most dominant ethnic group in Kankada, forming 52.3% of the total population in the VDC (CBS, 2002a). Kankada is a very remote VDC in Makwanpur, still untouched by transportation facilities. It shares its borders with Manahari, Raksirang, Khairang VDCs in Makwanpur district; Mahadevsthan VDC in Dhading district; and Lothar, Korak, and Piple VDCs in Chitwan district. Settlements in Kankada VDC are situated at an altitudinal range of 385 – 1,710 masl (NGIIP, 2006a).

Mahadevsthan VDC in Dhading district has around 310 Chepang households, having a population of 1857, accounting for nearly 30% of the total population in the VDC (CBS, 2002a). Chepangs are the second dominant ethnic group in the VDC after Tamangs. Mahadevsthan is linked to the Prithvi Highway by an earthen road up to Talti, from where Chepang settlements are accessible only on foot. Mahadevsthan shares its borders with Dhussa, Benighat, Gajuri, Pida VDCs in Dhading district; Kankada, Khairang, Dandakharka VDCs in Makwanpur district; and Lothar VDC in Chitwan district. Altitudinal variation in the VDC ranges from 550 to 1,930 masl (NGIIP, 2006a).

Bhumlichowk VDC was selected as the study site in Gorkha district. There are no VDCs in Gorkha where Chepangs are a majority; Bhumlichowk VDC has the largest Chepang population in Gorkha district. There are around 150 Chepang households in Bhumlichowk, with a population of 911; Chepangs are the second largest ethnic group in Bhumlichowk after Magars, forming 24.3% of the total population in the VDC (CBS, 2002b). It shares its border with Tanglichowk, Darbhung, and Ghyalchowk VDCs within the same district. Bhumlichowk is separated from the Prithvi Highway by the Trishuli

River. On the other side of the Trishuli River, the VDCs adjacent to Bhumlichowk are Darechowk VDC (Chitwan district) and Jogimara VDC (Dhading district). This VDC can be accessed only on foot after crossing the Trishuli River by a ropeway. Altitudinal variation ranges from 410 to 1,730 masl. The study VDCs are shown in Figure 3.3.

The Chepang settlements are situated up on hillsides. These settlements are sparse, and are connected by narrow foot-trails that run along the ridges. The topography of the settlements is very rugged, and from a distance the settlements are invisible due to forests and bushes. During rainy season, these trails are covered by bushes with plenty of leeches and constant danger of falling stones and landslides. One Chepang settlement is often separated from the other by rivulets flowing in the grove between the ridges so that in order to go from one settlement to another, one has to climb down the grove, cross the rivulet, and again climb up the ridge. During monsoon, the rivulets are flooded and the ridges are very slippery, so that movements across the settlements become very difficult.

3.4 Sources of data

3.4.1 Primary data

This study is based on primary data collected by household survey conducted in two phases. The household survey was used to generate quantitative data in a structured form that could serve descriptive analysis. The first phase of household survey was conducted in February-March 2010. Sixty randomly selected households from each VDC formed the sample for the household survey. It covered approximately 11%, 9%, 19%, and 39% of the total Chepang households in Kaule, Kankada, Mahadevsthan, and Bhumlichowk respectively (CBS, 2002a; CBS, 2002b). All the households covered by the survey were untouched by roads and not connected to the central electricity grid at the time of field survey. Settlements covered in Kaule VDC are Haattibaang, Taarsiling, Chhampuk, Lobaang, Metraang, Kaasinti, Tobaang, Bijok (Bijugaun), Syakhla, Daandar Daandaa, Kopthali, Kaarwaale (Kaarwaali) Tole, Thaaites, Chyamtaar and Beerpaati. These settlements are located at a walking distance of 4 to 6 hours from the Prithvi Highway. Settlements covered in Kankada include Maaisiraang, Bousiraang, Gajraang, Tekaaraang, Saakhaaraa, Panyuraang, Nyamsiti, Kundule, Bhaamsaati, Chaamanti, Gyangraang, Hattikhola and Devitaar, located at a walking distance of 3 to 6 hours from Manahari in East-West Highway. In Mahadevsthan VDC, Chepang settlements in Simthali, Furpejek, Baaraalaang, Daarang, Baangraang, Kalangaa, Chyuritaar, Jaipaal and Chingmaang were covered, lying at a walking distance of 2 to 4 hours from a place called Talti in the VDC. In Gorkha district, settlements of Hiklung, Thumka, Kyantung, Bhanjyang, and Lupraang (Nupraang/Numpraang) were covered lying at a walking distance of 2.5 to 4 hours from the Prithvi Highway. The first phase of the household survey was focused on the collection of data related to demographics, livelihood assets (landholdings, livestock holdings, savings, loans, education, training, membership to CBOs, infrastructure, physical assets, etc.), food production, livelihood activities, income from various sources, and expenditures. Besides the general livelihood information, this phase of field visit also focused on collecting information related to climate change and variability. Group discussions and key informants" interview (old community members) were carried out to obtain a timeline of climate related disasters like flood/landslides, droughts, and hails in the locality; also general perceptions of climate change, the locally observed indicators, and the impacts on livelihoods were assessed during the group discussions.

Based on the group discussions in 2010, interview schedule was designed and follow-up field visit was again made in May-June 2011. This time the same households covered in 2010 were revisited for gathering supplementary data. Out of the total 240 households covered in 2010 field survey, 58 households in Kaule VDC, 56 households in Kankada VDC, 54 household in Mahadevsthan VDC, and 53 households in Bhumlichowk

VDC could be revisited in 2011 survey; thus the final sample constituted a total of 221 households. In the follow-up survey of 2011, questions were focused on the perceptions of climate change, adaptation strategies adopted, and the impacts of extreme climate events (flood/landslides, drought, hail) on crop production and livelihood assets. Also, latitude, longitude, and altitude were recorded for all the households visited in 2011. A summary of field visits, altitudinal ranges of the VDC, Chepang population in the VDC, and the sample size covered is presented in Table 3.1.

Household survey was conducted using semi-structured interview schedule prepared in Nepali language. Masters and bachelor level students of agriculture, environmental science, and rural development were hired as research assistants/ enumerators to conduct the household survey. The aim of the survey, the purpose and use of the questionnaire were explained to the enumerators elaborately during the orientation. The researcher was together with the enumerators in all the research sites. The researcher and the enumerators visited each of the selected households and all interviews took place on the selected household"s premises. Each informant was first made aware of the objectives of the study. Probing was also done to further clarify the responses and triangulate the information given by the respondents. The time required to administer one questionnaire was nearly 2 hours.

Table 3.1 Altitudinal range, Chepang population, and sample size in the study VDCs

District and VDC	Altitudinal range of the VDC (masl)[a]	Chepang population in the VDC[b]	Sample size (number of Chepang households) surveyed	
			February – March, 2010	May – June, 2011 (final sample)
Chitwan – Kaule	810 – 1920	3155 (67.3)	60 (11.4)	58 (11.03)
Makwanpur – Kankada	385 – 1710	4056 (52.3)	60 (8.9)	56 (8.28)
Dhading – Mahadevsthan	550 – 1930	1857 (30.0)	60 (19.4)	54 (17.40)
Gorkha – Bhumlichowk	410 – 1730	911 (24.3)	60 (39.5)	53 (34.90)

Source: [a] NGIIP, 2006a; NGIIP, 2006b [b] CBS, 2002a; CBS, 2002b
Note: Figures in parenthesis indicate percentage of the VDC total

3.4.2 Secondary data

This study also uses secondary weather data of mean monthly minimum temperature, mean monthly maximum temperature, and total monthly precipitation obtained from the Department of Hydrology and Meteorology (DHM) in Nepal. Weather data from nine selected stations within the study districts for the time period of 1975-2008 is used to triangulate the community perceptions in Chapter 5. Temperature from 49 temperature stations and precipitation from 218 precipitation stations for the time period 1977-2008 used to interpolate the temperature and rainfall for the sample households in Chapter 6. The methodology is discussed in detail in the respective chapters.

3.5 Data analysis

The obtained data was entered and analyzed using Excel, Predictive Analytics Software (PASW), and Data Analysis and Statistical Software (STATA). Interpolation of temperature and precipitation at the household level was done in ArcGIS10. This study incorporates both qualitative and quantitative approach in data analysis. Qualitative arguments are complemented by descriptive statistics. Quantitative approach like binomial probit is used in Chapter 5; principal component analysis is adopted in Chapter 6; and multivariate probit in Chapter 8. This study also employs geospatial analytical tools like Moran‟s I test for testing spatial autocorrelation and ordinary kriging for interpolating temperature and precipitation at the household level. The detail methodology in case of quantitative approaches has been explained in detail in the respective chapters.

Chapter 4. Livelihood strategies of the Chepangs

4.1 Introduction

In the last two decades, development researchers have focused on understanding the different components of rural livelihoods in the developing countries (DFID, 1999; Carney, 1998; Scoones, 1998; Chkambers and Conway, 1992). Many studies have also focused on the analysis of livelihood strategies adopted by the rural people (Babulo et al., 2008; Adi, 2007; Shah et al., 2005; Thennakoon, 2004; Dharmawan and Manig, 2000). Livelihood strategy denotes the range and combination of activities and choices that people make and undertake – ways of combining and using assets – in order to achieve their livelihood goals (DFID, 1999). Livelihood strategies are often location specific because the opportunities or possibilities available for communities to undertake survival actions differ according to locations. „Rural livelihoods" often tend to be equated with „agricultural livelihoods", which fail to recognize the diversity of integrated livelihoods strategies that the marginalized rural households undertake (DFID, 2003). Therefore, a thorough understanding of the diversified livelihood strategies of the marginalized rural community is essential for formulating development programs and policies aimed at improving their livelihoods.

In Nepal, indigenous nationalities constitute 37.5% of the total population. Their socio-economic and human development indicators lie far below the national average (NIRS, 2006). The marginalization of the indigenous nationalities from the development mainstream has caught the attention of the development agencies and policy makers. Multi-sectoral development projects are required to improve the socio-economic status of these communities, and these should be based on a study, which has captured the ground realities of their socio-economic characteristics, and identified the issues associated with their livelihoods. With this background, this chapter will contribute to identify and analyze the major patterns of livelihood strategies adopted by the Chepang community, one of the highly marginalized indigenous nationalities of Nepal.

The chapter has been divided into five sections. Concepts of livelihood strategy from various literatures will be highlighted in the next section. The second section focuses on the methodology. Review of related literatures has been done in the third section; findings of the study will be discussed in the fourth section and the fifth section concludes the chapter.

4.1.1 Livelihood strategies: A conceptualization

Livelihood outcomes are determined by the livelihood strategies adopted by a household or an individual. Scoones (1998) has identified three broad clusters of livelihood strategies, namely agricultural intensification/extensification, livelihood diversification, and migration. Under the first strategy, agricultural intensification/extensification, communities gain most of their livelihood from farming either through intensification (more output per unit area through capital investment or increase in labor inputs) or through extensification (bringing more area under cultivation). Second livelihood strategy is livelihood diversification, which has been discussed in detail by Frank Ellis in his works (Ellis, 1999; Ellis, 1998). According to Ellis (1999, p. 2), livelihood diversification is defined as "the process by which households construct a diverse portfolio of activities and social support capabilities for survival and in order to improve their standard of living". Studies reveal that in rural areas of low-income countries, farming alone is not sufficient to eke out a living (Babulo et al., 2008; Adi, 2007; Barrett et al., 2001). As a result, most rural houses are found to depend on diverse income sources besides farming. It usually includes off-farm wage works, non-farm activities, non-farm self-employment, and remittances. The third livelihood strategy is migration, which may be voluntary or involuntary. Furthermore, according to Ellis (1998), migration may be seasonal (according to agricultural season), circular (according to cyclical labor demands in non-farm labor markets), permanent (usually rural to urban), and international. A household may pursue these three strategies singly or in combination together or in sequence.

The other two livelihoods analysis frameworks after Scoones were given by DFID (DFID, 1999; Carney, 1998) and Ellis (2000). Both these frameworks identify two broad types of livelihood strategies namely natural resource based and non-natural resource based. Natural resource based livelihood strategies in the rural areas of Nepal are primarily farming (composed of both agriculture and livestock), gathering from forest, and other non-farm activities like handicrafts. Non-natural based strategies include activities like non-skilled wage laboring such as working as porters, in stone quarries, road constructions, etc.; skilled non-farm jobs like tailoring, cooking in restaurants, carpet weaving, welding, house constructions, carpentry, etc.; and very few rural households may have salaried jobs, remittances (urban and international), petty business, and transfers such as pensions and old age allowances. A rural livelihood portfolio usually has a combination of two or more of these livelihoods strategies. According to Ellis (2000), the composition of this portfolio has specific policy implications. For instance, even within farming, a household farming for subsistence differs from a household pursuing commercial agriculture. Another policy implication is in the substitutability of the strategies. For communities like Chepangs, if the government wants to restrict the use of forest to conserve biodiversity, policies should be amended so as to substitute forestry based livelihoods with other livelihood options.

4.2 Methodology

This chapter is based on the data obtained from the first phase of household survey conducted in 2010. Semi-structured interview schedules were used that contained questions related to information about household members like age, sex, education, occupation, possession of citizenship certificates, etc.; types of landholding and crops produced, livestock raised, dependence on forest for food and commercial products, and income from various other livelihoods sources. All the questions in the household interviews were directed to receive information for the last one year. Information regarding the commonly adopted livelihoods strategies by the community was also collected through participatory methods like key informants" interview, and focal group discussions. The methodology was thus composed of a combination of participatory methods and small-scale sample surveys, which is likely to prove the most cost-effective means of determining the livelihood strategies of rural households (Malleson et al., 2008; Ellis, 1999; Ellis, 1998). The nature of the study is primarily qualitative, with some descriptive statistics to support the arguments. ANOVA was performed to test the mean differences among the study VDCs.

4.3 Literature review

Agriculture forms the major livelihood sources for most of the rural population in Nepal (CBS, 2003a). NIRS (2006) reports that the share of farm income is about 48% for all Nepal, while it is 51% for the group of hilly indigenous nationalities excluding Newars. Besides farming, non-farm income and remittances form the other two most important sources of income. Bhandari and Grant (2007) opine that agricultural production alone is not a viable livelihood option for rural communities in Nepal. Thus, diversification of livelihood strategies is a common strategy among the rural population. In their study conducted in Kaski district of Western Nepal, they identified three major categories of livelihood strategies viz., highly dependent on agricultural production, highly dependent on forest products, and highly dependent on employment income and other business. The last group of households was reported to have relatively higher security compared to the other two types of livelihoods.

There are few studies that analyses the livelihood strategies of the Chepang community. FORWARD (2001b) reports that the Chepangs have adopted „multi-pronged livelihood strategies" encompassing permanent agriculture and animal husbandry, slash and burn cultivation, wage labor, hunting and gathering practices, cottage industries and barter system. This study emphasizes that Chepangs have diversified their livelihood sources because no single source is sufficient for their livelihood all the year round. However, this study fails to give further information on the contribution of each livelihood sources singly or in combinations.

Agriculture is the major livelihood source for the Chepang households (FORWARD, 2001a; FORWARD, 2001b; Gribnau et al., 1997; Nakarmi, 1995). Since agriculture is not sufficient to provide food for the whole year, other subsidiary livelihood activities are undertaken for earning cash income. FORWARD (2001b) reports that, besides agriculture, wage laboring and livestock are the major source of livelihoods undertaken by 74% and 66% of the Chepang households respectively. In the same line, in a study done in Chepang community in Dhading district by Nakarmi (1995), it is reported that agriculture is the main occupation for 97% of the households while livestock raising, and cottage industries constituted other supplementary activities undertaken by 81% and 6% of the households respectively. These studies however fail to give the contributions of the livelihood activities in terms of income. In the same line, Aryal (2007) reports that agriculture is the primary source of livelihood for 98% of the Chepang households in Dhading district, while wage laboring was the primary source for the rest 2%. On the other hand wage laboring formed the secondary source of livelihood for 93% of the households. Besides these, other secondary livelihood strategies consisted of salaried jobs and petty business for 3% and 32% of the households respectively.

In a study done by Gribnau et al. (1997) in Chitwan district, it was found that Chepangs primarily depend on agriculture, besides which they also depend significantly on forest, small livestock especially goats, fruits and medicinal plants, wage labor, and taking loans. According to this study, field crops provide 24% of annual cash income for a Chepang household, while livestock, forest, and wage laboring respectively generates about 38%, 15%, and 14% of the annual cash income for a Chepang household in Shaktikhor VDC of Chitwan district. This study will contribute to dearth of existing literatures on livelihood studies of Chepang community by conducting an in-depth livelihoods study reporting the households involved in each livelihood sources, contribution of each sources to annual income of the households, and analyzing the combination of the livelihood sources by the Chepang households.

4. 4 Findings

4.4.1 Sources of livelihoods in the Chepang community

Eleven different sources of livelihoods were identified in the Chepang community viz., agriculture, livestock, wage laboring, forestry, salaried job, skilled non-farm job, remittance from abroad, petty business, transfers especially old age allowance, honey, and handicrafts. Agriculture, livestock, forestry, honey and handicrafts are natural resource based livelihoods sources, while the rest form non-natural resource based livelihoods sources. Agricultural income is comprised of the value of major cereal crops, legumes, oil crops (including *chiuri – Bassia butyracea*), and vegetables grown for own-consumption or for sale over the last one year; plus cash income earned from fruits, medicinal and aromatic plant growing in private lands. Income from livestock consists of two components: sale of live animals and livestock products either consumed or sold. Crops and livestock products used for own consumption were valued using the average of local market price and own reported values. Wage laboring includes the off-farm activities for which the households are paid on an hourly or daily basis. In the survey, wage laboring includes both agricultural and non-agricultural labor, for which the adult male members of the family migrate temporarily outside the village during the dry season when there are no agricultural activities to be done. Common wage laboring works includes working in stone quarries, limestone mines, road construction, portering, and so on. Another important source of livelihoods for the Chepang community is the forest. In this study, forest products collected either for human consumption or for sale were valued using market prices or own reported values. The commonly collected food items that were valued comprised of tubers, leafy vegetables, chiuri seeds for oil, and honey. While computing forest income, fodder and litter were not included due to the difficulties in their valuation. Furthermore, there were difficulties in valuating even the tubers and leafy vegetables, which the people collected in significant amounts almost all around the year; but which were never marketed. For such products, valuations were done using the value of nearest domesticated products like domesticated yam for wild tubers, domesticated leafy vegetables like broad leaved mustard for wild leafy vegetables. Salaried job comprises of monthly paid jobs like in teacher, peon, guard, Christian pastor, and assistants in garage, petrol pumps and shops. Skilled non-farm job included non-farm activities requiring some particular skills like carpentry, house-construction, sewing, knitting, driving, shoe-making, and welding. Another source of livelihood is remittance from abroad, usually laboring in India, Qatar, and Malaysia. Some households also depend on petty business like selling home-made liquor, bringing items like cigarettes, tobacco, matches, etc. from the market and selling in the village, and running traditional water mills. Few households also receive transfers from the government, most importantly old-age, and widow allowance. Next source of income for the Chepangs is income from domesticated honey bee; both sold as well as self-consumed amount was valuated for honey. Final source is the income from bamboo and wooden handicrafts like baskets and plough used for daily household purposes, and only the income from sold items were considered while computing income from handicrafts. Wage laboring, salaried jobs, skilled non-farm jobs and remittance usually involve temporary migration because there are very few earning opportunities at the local level.

Table 4.1 Gross annual income per household (NRs.[4]) from different sources

Source	Gross annual income/HH (NRs.)		
	n	**Mean**	**SD**
Agriculture	221 (100.0)	36,006.7	36,133.4
Livestock	178 (80.5)	11,148.8	13,046.1
Wage labor	158 (71.5)	28,384.0	20,954.8
Forest	201 (91.0)	4,980.9	7,340.3
Salaried job	23 (10.4)	68,076.5	36,270.2
Skilled non-farm job	27 (12.2)	40,577.8	34,895.6
Remittance abroad	7 (3.2)	81,142.9	73,274.4
Business	10 (4.5)	12,125.0	11,270.2
Government transfers	26 (11.8)	6,715.4	1,949.9
Honey	58 (26.2)	1,145.6	1,911.2
Handicraft	33 (14.9)	2,923.6	3,899.5
Total	221 (100.0)	86,497.5	58,232.0

Source: Field survey, 2010
Note: Figures in parenthesis indicate percentage

Table 4.1 shows the gross annual income that households derive from each of these livelihood sources. Agriculture forms the most important source of livelihood for all the households covered by the study. Besides agriculture, forest, livestock, and wage laboring also form important sources of livelihoods for the majority of the households (91%, 80.5%, and 71.5% respectively). Other sources of income were pursued by relatively lesser proportion of the households. Other three sources, i.e. salaried jobs, skilled non-farm jobs, and remittance are comparatively more remunerative as these sources have higher average annual income per household. However, very few households depend on these remunerative sources. The average annual income per household is the highest for remittance from abroad followed by salaried job and skilled non-farm job. The remaining income sources, i.e. business, government transfers, honey and handicraft are also pursued

[4] NRs. = Nepali rupees; 73 NRs. = US$ 1 (at the time of field survey)

by comparatively lesser households, and the mean annual income from these sources is also lower. Though average annual income from forest is low, it is an important livelihood source for the Chepang community as 91% of the households are depending on it, mostly for wild foods.

Households have one distinct source of livelihood, which it considers primary, to which more time is allocated, and from which more income is derived. As depicted in Table 4.2, agriculture is the primary livelihood source for the majority of sample households (43.89%), followed by wage laboring (31.67%). Although most of the households are dependent upon livestock and forest, it forms the primary source for very few households (4.52% and 2.71%). Highest gross annual income is derived by households having remittance as the primary source (NRs. 163,731.0), followed by salaried job (NRs. 139,746.0) and skilled non-farm job (NRs. 101,225.9). However, as already discussed, very few households are dependent on these remunerative sources.

Table 4.2 Gross annual income per household (NRs.) according to the primary source

Primary source of income	n	Gross annual income/HH (NRs.)	
		Mean	SD
Agriculture	97 (43.89)	90,035.5	63,089.7
Livestock	10 (4.52)	78,185.0	40,611.5
Wage labor	70 (31.67)	67,783.4	32,863.8
Forest	6 (2.71)	58,792.6	38,310.2
Salaried job	17 (7.69)	139,746.0	60,541.6
Skilled non-farm job	16 (7.24)	101,225.9	72,989.7
Remittance abroad	3 (1.36)	163,731.0	106,631.6
Business	2 (0.90)	48,296.1	23,042.2
Government transfers	1 (0.45)	10,012.8	-

Source: Field survey, 2010
Note: Figures in parenthesis indicate percentage

4.4.2 Spatial variations

Differences in location play an important role in determining the livelihood outcome, which is depicted by gross income in this study. From Table 4.3, it can be seen that farming is the mainstay of all the households‟ livelihood in all the VDCs. However, in

Bhumlichowk VDC, income from agriculture is significantly higher than in the other VDCs. This is because commercial agriculture especially tomato has been developed quite well in Bhumlichowk VDC; it is located at the nearest distance from the highway compared to other VDCs (Table 6.6); which is why they can easily dispose their products to the nearby markets in Hugdi, Fishling, and Mugling. Recently, gravity ropeway has been constructed in the VDC with support from Practical Action solely for the purpose of transporting vegetables which has facilitated them to transfer their vegetables easily up to the highway; which otherwise would have to be carried downhill by the people themselves. At the same time, irrigation facilities are better developed in Bhumlichowk; nearly 62% of households in Bhumlichowk own plots having sources of irrigation compared to only 22%, 7%, and 59% households in Kaule, Kankada, and Mahadevsthan respectively (Appendix 2). Besides, other VDCs lie far away from the road-head; and lack of irrigation and transportation facilities restricts commercial agriculture in those areas. Income from livestock and wage laboring, however, is similar across the four sites and not statistically significant.

Dependence on forest is significantly higher in Kankada; the remotest among the four VDCs. Income from skilled non-farm job is significantly higher in Bhumlichowk, again because of the proximity to the highway and market centers which gives them more chances to search for such kinds of jobs. Also, literacy rate is the highest in Bhumlichowk (Appendix 2), thereby enabling them to undertake skill development trainings. Income from handicrafts is significantly higher for Mahadevsthan VDC. Most of the household members in this VDC have traditional skills to weave bamboo baskets, and the nearby markets of Talti, Archale, and Bardanda have been developed as a kind of niche market for these bamboo handicrafts. Chepangs sell their baskets to the shopkeepers in these markets, from where the bamboo handicrafts are supplied to other areas by the wholesalers who come to the local markets to collect the handicrafts items from the local shopkeepers. Income from salaried job, remittance from abroad, petty business, government transfers, and honey is not significantly different across the four VDCs. The total average income is the highest in Bhumlichowk and the lowest in Kaule.

Table 4.3 Spatial variations in gross annual income per household (NRs.) from various sources

Source	Gross annual income/HH (NRs.)								P-value
	Kaule		Kankada		Mahadevsthan		Bhumlichowk		
	n	Mean	n	Mean	n	Mean	n	Mean	
Agriculture	58 (100)	15,379.9	56 (100)	35,135.4	54 (100)	29,389.7	53 (100)	66,241.9	0.00***
Livestock	46 (79.3)	11,765.2	46 (82.1)	10,748.5	41 (75.9)	8,617.5	45 (84.9)	13,234.4	0.42
Wage labor	44 (75.9)	29,804.5	35 (62.5)	28,488.6	39 (72.2)	24,794.1	40 (75.5)	30,230	0.65
Forest	43 (74.1)	3,451.4	56 (100)	7,018.3	50 (92.6)	4,219.5	52 (98.1)	4,783.8	0.08*
Salaried job	1 (1.7)	36,000	15 (26.8)	67,744	2 (3.7)	60,000.0	5 (9.4)	78,720.0	0.75
Skilled non-farm job	12 (20.7)	27,666.7	3 (5.4)	24,000.0	8 (14.8)	41,450.0	4 (7.5)	90,000.0	0.01***
Remittance abroad	1 (1.7)	50,000.0	-	-	2 (3.7)	145,000.0	4 (7.5)	57,000.0	0.68
Business	1 (1.7)	18,000.0	7 (12.5)	7,892.9	1 (1.9)	30,000.0	1 (1.9)	18,000.0	0.28
Government transfers	8 (13.8)	7,500.0	10 (17.9)	6,660.0	6 (11.1)	6,000.0	2 (3.8)	6,000.0	0.52
Honey	13 (22.4)	2,052.2	20 (35.7)	1,139.9	11 (20.4)	719.5	14 (26.4)	646.6	0.22
Handicraft	7 (12.1)	1,751.4	8 (14.3)	618.8	15 (27.8)	4,900.0	3 (5.7)	1,923.3	0.05**
Total	**58 (100)**	**59,103.2**	**56 (100)**	**90,891.1**	**54 (100)**	**74,209.6**	**53 (100)**	**124,353.8**	**0.00*****

Source: Field survey, 2010
Note: Figures in parenthesis indicate percentage
***, **, * denote significant at 1%, 5%, and 10% level of significance respectively

4.4.3 Diversification of livelihood sources in the Chepang community

It was found that most of the households depend on two or more sources for their livelihoods. Livelihood diversification is common among the Chepang community. Activity portfolio of the sample households was analyzed to observe the patterns of combination of livelihood sources. Six broad groups of livelihood strategies have been identified based on the number of livelihood sources the households depend upon. When all of the livelihood sources were considered separately, altogether 50 patterns emerged, which was very inconvenient for analysis. Therefore, for the purpose of analysis, agriculture and livestock are merged into „farming"; salaried jobs, skilled non-farm jobs, and remittance was kept under one category as „remunerative sources" as they gave higher returns; honey, handicrafts and allowances were grouped together as „others". Thus, altogether six different sources were considered, viz. farming, wage laboring, forestry, remunerative sources, petty business, and others. After doing so, 20 different patterns emerged, which is given in Table 4.4. Farming is the mainstay of the Chepang"s livelihood, as it forms one of the components in all the livelihood patterns. It can be observed that mean gross annual household income is the lowest for the group with only one livelihood source, and the income increases subsequently increases with the combination of more number of livelihood sources. Overall, the lowest income is NRs. 32,790 for the combination farming alone, and the highest is NRs. 168,905 for the combination of all six livelihood sources. From Table 4.4, it is evident that the annual income from the livelihood strategies having remunerative sources as one of the components is generally higher within each group, and also higher than the aggregate mean income for each group.

Among all the livelihood strategies, combination of three livelihood sources forms the most dominant livelihood strategy, out of which combination of farming, wage laboring, and forest is the most common diversification strategy followed by nearly 29% of the households. The next dominant strategy is the addition of others to the combination of farming, wage laboring and forest, undertaken by nearly 22% of the households. This shows that besides farming, wage laboring and forests are not simply alternative options, but are integrated into the livelihoods of Chepang community.

Table 4.4 Gross annual income per household (NRs.) according to livelihood strategies

Livelihoods activity portfolio	n	Gross annual income/HH (NRs.)	
		Mean	**SD**
One source			
Farming	2 (0.9)	32,790.5	17,635.8
Sub-total	2 (0.9)	32,790.5	17,635.8
Two sources			
Farming, forest	14 (6.3)	52,508.3	41,682.1
Farming, wage	4 (1.8)	67,261.0	36,048.4
Farming, remunerative	3 (1.4)	52,330.4	18,700
Farming, others	2 (0.9)	57,076.1	71,077.2
Sub-total	23 (10.4)	55,448.0	40,260.8
Three sources			
Farming, wage, forest	65 (29.4)	70,073.2	42,568.5
Farming, forest, others	17 (7.7)	72,335.3	46,351.2
Farming, wage, others	6 (2.7)	40,707.6	24,192.9
Farming, forest, remunerative	14 (6.3)	111,546.0	63,897.3
Farming, wage, remunerative	1 (0.5)	75,437.2	-
Sub-total	103 (46.6)	74,425.1	44,608.2
Four sources			
Farming, wage, forest, others	48 (21.7)	84,204.8	45,814.2
Farming, wage, forest, business	4 (1.8)	75,712.3	54,535.5
Farming, wage, forest, remunerative	14 (6.3)	139,237.9	55,352.6
Farming, wage, remunerative, others	1 (0.5)	62,250.0	-
Farming, forest, remunerative, business	1 (0.5)	107,023.1	-
Farming, forest, remunerative, others	10 (4.5)	115,553.5	54,229.2
Sub-total	78 (35.3)	97,677.2	46,943.5
Five sources			
Farming, wage, forest, business, others	2 (0.9)	127,073.3	850.3
Farming, wage, forest, remunerative, business	1 (0.5)	248,251.8	-
Farming, wage, forest, remunerative, others	11 (5.0)	165,377.6	104,092.9
Sub-total	14 (6.3)	165,825.1	81,908.8
Six sources			
Farming, wage, forest, remunerative, business, others	1 (0.5)	168,905.3	-
Sub-total	1 (0.5)	168,905.3	-
Total	**221 (100)**	**86,497.5**	**58,232.0**

Source: Field survey, 2010
Note: Figures in parenthesis indicate percentage

During the dry seasons, when there are few agricultural activities in the village, Chepangs undertake wage laboring to fulfill the consumption needs, for which they temporarily migrate outside the village for jobs like carrying loads, working in stone quarries, and road constructions. Chepangs depend on forest for collection of fodder, fuel, and commercial products. Apart from that, forest is an important source of wild edibles for the Chepangs especially during the lean periods. Despite being undertaken by majority of the households, income from the combination of farming, wage laboring and forest is lower than the aggregate average annual income. It is even lower when compared to other combinations of remunerative sources that is undertaken by much lesser households but has higher average annual income. This shows that the majority of Chepang community is dependent on less remunerative livelihood strategies earning comparatively lower returns. This is because of higher investment and vocational education required for the remunerative sources, which most of the Chepang households cannot afford.

This implies that the Chepang households are constrained from choosing more remunerative non-farm livelihood options, and are compelled to continue depending on the sources giving lesser returns. This is basically due to the lack of formal education, vocational training, citizenship certificates, capital for investment, and lack of non-farm opportunities. The average education of the heads of the sample households is very low (1.2 years). More than 64% of the household heads are illiterate, and nearly 30% of them have only attained either non-formal education or primary level education (Appendix 2). As a result of low level of education, they are unable to pursue salaried jobs, or go abroad for foreign employment as they are unable to follow the necessary official procedures required. In addition to low education, nearly 19% of the sample population does not possess citizenship certificates due to lengthy official process which is often difficult for illiterate community. Citizenship certificates are often issued from district headquarters far away from their settlements, which the Chepangs cannot afford easily. Lack of citizenship certificates means they are unable to issue passports for going abroad, claim allowances for senior citizens, buy and sell lands, open bank accounts, issue birth-death-marriage certificates, or obtain subsidized good and public services. Land is the most important asset for any rural community. However, most of the Chepang households only possess unirrigated upland and khoriya, which are less fertile compared to irrigated uplands and paddylands (Appendix 3). Irrigated paddylands are owned by only 35% of the sample households, and only 37% of the sample households have access to irrigation facilities. Furthermore, only 13.06% of the total cultivated land in the study area is irrigated (Table 6.6). Land can be used as a liability to obtain loans for investments in more remunerative options, but for that land need to be registered. However, more than 44% of the sample households are cultivating unregistered lands, partly because of lengthy official procedures, and partly because of faulty government policies which registered only permanently cultivated lands thereby excluding the lands under shifting cultivation practices. Unregistered lands cannot be used as liabilities to obtain loans for further investments. Livestock is the next important asset for Chepangs. However, most of the households belong to small-holders‟ category owning less that 5 livestock units, so that they rarely make extra income that can be saved or used for further investments. The livelihoods of Chepang community is thus constrained from choosing a more remunerative option by many interacting factors like low educational attainments, low asset possession, unfavorable government policies, lack of access to fundamental rights like possession of citizenship and land registration certificates. These constraints are often interlinked and interact with one another to constrain the livelihood choices of the Chepangs; for instance without citizenship certificates, they cannot issue passports and land registration certificates; or receive bank loans. Unregistered lands cannot be used as liabilities to obtain formal credits. Government policies do not recognize their lands for registration, and furthermore all the government official procedures related to issuance of citizenship certificates, registration of land, and borrowing formal credits are often too difficult for the illiterate community to comprehend. As a result there are fewer choices of less remunerative livelihood options for these households to choose from.

4.5 Discussion

Agriculture is the mainstay of the livelihood of the Chepang community. Beside agriculture, livestock, wage laboring, forest, salaried jobs, skilled non-farm jobs, remittance, petty business, honey, and handicrafts are the livelihood sources for this community. Agriculture, livestock, forestry, honey, and handicrafts are natural resource based livelihoods, while the others are non-natural resource based. Wage labor, salaried jobs, skill non-farm jobs, and remittance involved temporary out-migration by the male members of the households. Wage laboring forms a source of income for 71.5% of the households, which is quite near to 75% reported by FORWARD (2001b); while 94% was reported by Aryal (2007). Forest, another important source of livelihood for 91% of the Chepang households, however has not been given considerations by previous studies except for Gribnau et al. (1997), probably because the dependence is primarily for subsistence purposes and giving monetary values to the products is difficult. The remaining livelihood sources viz., salaried jobs, skilled non-farm jobs, and remittance were undertaken by relatively lesser households (10%, 12%, and 3% respectively). On average, farming contributes 52% of the total income, which exactly matches with 51% reported by NIRS (2006) for hilly indigenous nationalities. After farming, wage labor contribute 26.3%, forest 6.84%, salaried jobs 4.95%, and skilled non-farm jobs 4.88% of the gross annual income; while the others contribute less than 1.5% to the total (Appendix 4).

In terms of primary sources of income, agriculture forms a primary source for 43.89% of the households, while wage labor forms a primary source for 31.67% of the households. Remunerative sources altogether form the primary source for only around 16% of the households. However gross annual income per household is the highest for households having remittance as the primary source, salaried jobs ranking the second, and skilled non-farm jobs ranking the third. Farming and wage laboring, though primary source of many households, have lesser annual income. Remittance, salaried jobs, and skilled non-farm jobs are thus more remunerative income sources; however, very few households have the capacity to choose these sources for their livelihoods. Analysis of income portfolio of the households reveals 20 different combination strategies of various income sources. Among all the livelihood strategies, combinations having remunerative sources as one of the components has comparatively higher annual income than those depending on farming, wage laboring, and forest. Combination of farming, wage laboring, and forest is the most dominant livelihood combination strategy followed by 29% of the households; however, income from this combination is lower than other combinations having remunerative sources as a component. Thus majority of the Chepang households is dependent on less remunerative livelihood sources earning comparatively lower returns. This is because the livelihood choices of these households are constrained by multiple factors comprising of low education, low landholding, low livestock holding, lack of citizenship certificates, lack of land registration certificates, and unfavorable land policies. These factors are interlinked and interact with one another, thereby further constraining the Chepang households to choose more remunerative livelihood options.

4.6 Conclusion and policy implications

The fact that higher incomes are generated with the combination of more livelihood strategies leads to the conclusion that there‟s a need to promote diversification. Furthermore, emphasis should be placed on more remunerative income sources like salaried jobs and skilled non-farm job opportunities. However, advocating for diversification and promotion of skilled non-farm jobs does not imply that the agriculture and livestock sector can be overlooked. Since farming still forms the mainstay of the livelihood of the Chepang community, interventions in the agricultural and livestock sectors are still important. Furthermore, the fact that majority of the households draws some portion of their income from forest resources implies that forest is not just an alternative livelihood option, but is rather integrated into the livelihood of this community. The implication of this for policy is that the access of the Chepang community to forest resources should be ensured. It is thus important for the policy makers and development agencies to recognize the complementary relationship among farming, forestry, and non-farm livelihood strategies in sustaining the livelihood of the Chepang community.

Chapter 5. Climate change: Community perceptions and the determinants

5.1 Introduction

Changes in climate is certainly happening everywhere, but how the local people perceive it determines how they formulate strategies to cope with the changes in the short run and to adapt to the long term changes. In other words, it is necessary to realize that some changes are going on in order to take actions to adjust to those changes (Deressa et al., 2011). It has been well realized that most of the climate change projections using empirical models are unable to capture the micro-level specificities of climate change (IPCC, 2007a). No doubt, these studies have contributed immensely to understand the bio-physical processes and impacts of climate change at the global and regional level. The major limitations of these models are twofold: firstly, they cannot model the climate phenomena at the local scale, and secondly very few of them integrate the socio-economic variables which are of immediate relevance to policy makers. Although climate change is a universal phenomenon, its indicators and manifestations are entirely local, so are the adaptation choices, strategies, and practices. There has thus been increasing emphasis on the bottom-up approaches that climate change studies should be conducted at the local level where adaptations ultimately take place (Smit and Wandel, 2006).

This chapter analyzes how the Chepang community in the rural Mid-Hills of Nepal perceives the changes in temperature and rainfall and whether these perceptions match with the recorded data or not. Spatial autocorrelation of those responses is tested in ArcGIS10 to see if those response show clustering or dispersion and whether the spatial pattern is significant or just due to random chances. Further analysis is done to determine what characteristics differentiate those who can perceive the changes in line with the recorded data from those who either cannot perceive any changes and/or perceive the changes in the wrong direction. The next section describes the data sources. The third section discusses various responses on perceptions of changing temperature and rainfall patterns in the study area, and triangulates the perceptions with recorded data. The fourth section conducts test for spatial autocorrelation of those responses using Global Moran‟s I test. The empirical model to analyze the factors facilitating perceptions and the result of the model analysis is presented and discussed in the fifth part of the chapter. The last section concludes the chapter, and draws relevant policy recommendations.

5.2 Sources of data

This study is based on the primary data collected from group discussions in the first phase of field visit, and by household survey conducted in both the phases. The first phase of household survey was conducted in February-March 2010 and the second phase in May-June 2011. While assessing the perceptions of the households regarding the changes in climatic variables and the occurrence of extreme climatic events, time frame of past ten years was considered since longer time frame would be difficult for the respondents to remember and be subjected to recall bias (Gbetibouo, 2009). Also, the year 2001 was taken as the reference year because in July 2001, a large landslide in Kankada VDC claimed more than 60 human lives and caused huge property damage. The Chepangs in all the districts are aware of this epoch making incident, thus it becomes easier for taking this incident as a reference.

For comparing the community perceptions with the actual climate data, historical weather data comprising of mean monthly maximum temperature, minimum temperature, and rainfall were obtained for the year 1975-2008 from the Department of Hydrology and Meteorology (DHM) in Kathmandu, Nepal. Unfortunately, there are no weather stations located within any of the study VDCs. Thus, other weather stations located within the four districts at a similar altitudinal range as the study VDCs were selected for the analytical purpose. It comprises of four weather stations from Makwanpur district (Chisapanigadhi, Hetauda, Markhugaun, Makwanpurgadhi), three from Dhading district (Arughat, Dhading, Dhunibesi), and two from Gorkha district (Jagat-setibans, Gorkha). The locations of these weather stations within the respective districts are shown in Figure 5.1.

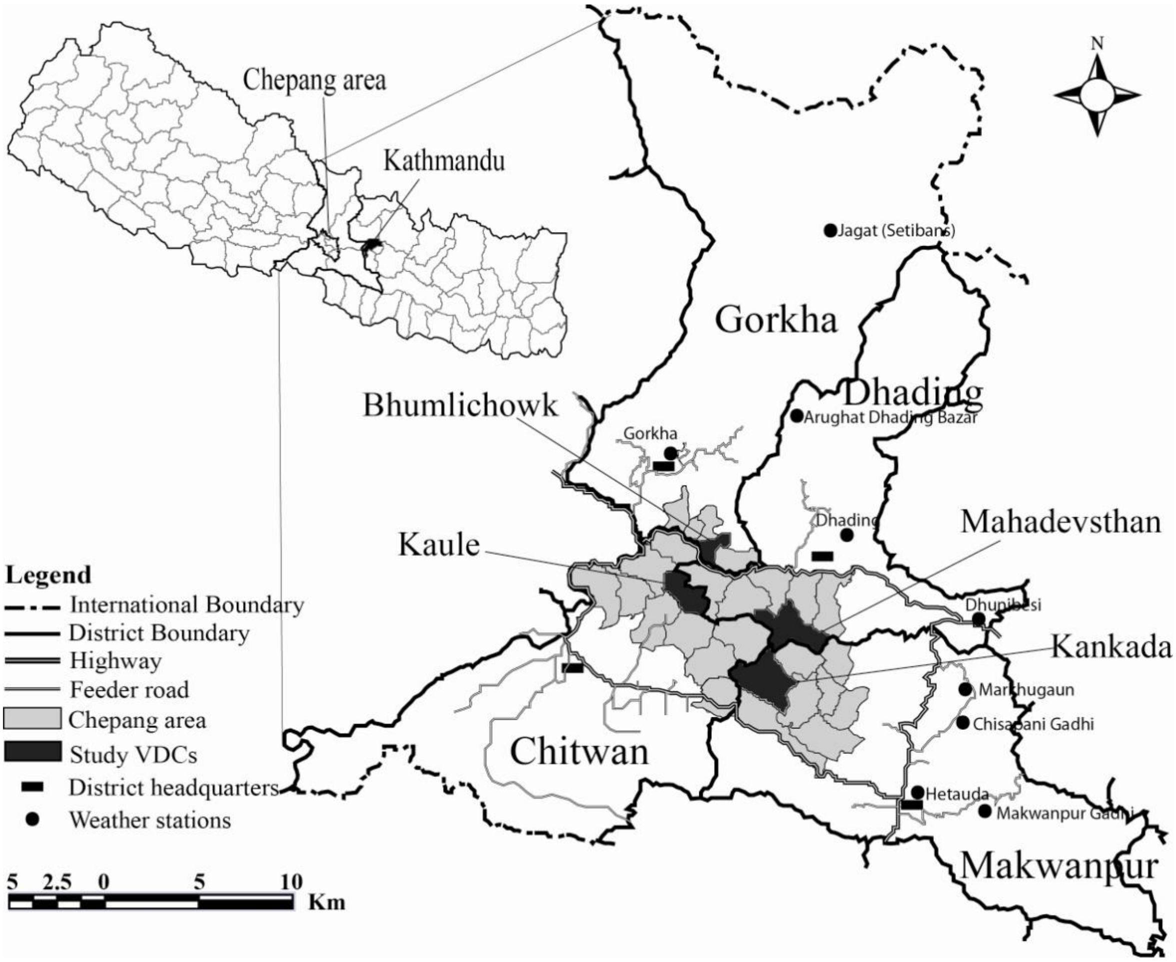


Figure 5.1 Map of study districts showing Chepang area, study VDCs, and weather stations considered for this chapter

The altitude, latitude and longitude of these weather stations are given in Table 5.1. Rainfall data is available for all these stations, whereas temperature data is available only for one station in each district (Hetauda, Dhunibesi, and Gorkha). As for Chitwan district, all the weather stations are located below 300 masl, which is far below the altitudinal range of the study VDC (810-1,920 masl). Therefore, none of the weather stations are considered from Chitwan district. This poses limitations for triangulating the perceptions of respondents from Chitwan district due to lack of recorded climate data for the given elevation range within the district.

Table 5.1 Weather stations selected for the purpose of analysis in this chapter

District	Weather Stations	Altitude (masl)[a]	Latitude[a]	Longitude[a]	Available data
Chitwan	None available within the similar altitudinal range as the study VDC				
Makwanpur	Chisapaani Gadhi	1,707	27.55	85.13	Precipitation (1970 – 2008)
	Hetauda	474	27.42	85.05	Precipitation (1966 – 2008) Temperature (1966 – 2008)
	Markhugaun	1,530	27.62	85.15	Precipitation (1972 – 2008)
	Makwanpur Gadhi	1,030	27.42	85.17	Precipitation (1975 – 2008)
Dhading	Arughat Dhading Bazar	518	28.05	84.82	Precipitation (1971 – 2008)
	Dhading	1,420	27.87	84.93	Precipitation (1970 – 2008)
	Dhunibeshi	1,085	27.72	85.18	Precipitation (1971 – 2008) Temperature (1975 – 2008)
Gorkha	Jagat (Setibans)	1,334	28.37	84.90	Precipitation (1971 – 2008)
	Gorkha	1,097	28.00	84.62	Precipitation (1971 – 2008) Temperature (1971 – 2008)

Source: [a] Raw data from DHM

5.3 Triangulation of perceptions with recorded data

The respondents were first asked if they have ever heard anything about climate change. Only 11.8% of the respondents replied that they have heard about it (Table 5.2). The source of information was cited as radio by 6.9%, staffs of NGOs by 2.5% and teachers at school by 1.5% of the respondents. Then they were further asked if they can say what climate change means. Only 4.5% of the respondents could reply that the phenomenon is related to changes in weather patterns, temperature, rainfall, wind, floods, landslides, and the environment. Similar situation is reported by Byg and Salick (2009) in Tibet where the respondents have never heard the term climate change.

Table 5.2 Response to whether the respondents have heard about climate change

Response category	Number of response				
	Aggregate (n = 221)	Kaule (n = 58)	Kankada (n = 56)	Mahadevsthan (n = 54)	Bhumlichowk (n = 53)
Yes	26 (11.8)	4 (6.9)	9 (16.1)	7 (13.0)	6 (11.3)
No	195 (88.2)	54 (93.1)	47 (83.9)	47 (87.0)	47 (88.7)

Source: Field survey 2011
Note: Figures in parenthesis indicate percentage

Most of the Chepangs may not literally understand what climate change means; but many of them can perceive how weather pattern has been varying over the years. They have experienced, for instance, that the rainfall patterns are changing, winter and post-winter rains are decreasing, monsoon is arriving late but causing lots of damage when it arrives, summer is getting hotter, hailstorms are increasing in frequency, and so on. This section presents an overall view of how the study community perceives the ongoing changes in climate. Trends of temperature and rainfall are presented as graphs side by side to community perceptions to see if the perceptions really match with the actual trends. Trend analysis has been done for two different time periods, the long-term trend for 1975-2008 and short-term trend for the time period of 2001-2008. The latter period was chosen since our household survey was more focused on the perceptions based on last ten years (2001-2010). Rural households tend to form their perception based on more recent events (Maddison, 2007), thus community perception is believed to be more representative of the climatic patterns after 2001. As stated in methodology section, there are no weather stations at the suitable elevation within Chitwan district; this puts limitations in the triangulation of the perception of respondents from Chitwan district. The comparison of perceptions with that of recorded data is possible only for the remaining three districts.

5.3.1 Changes in temperature: Perceptions and actual trends

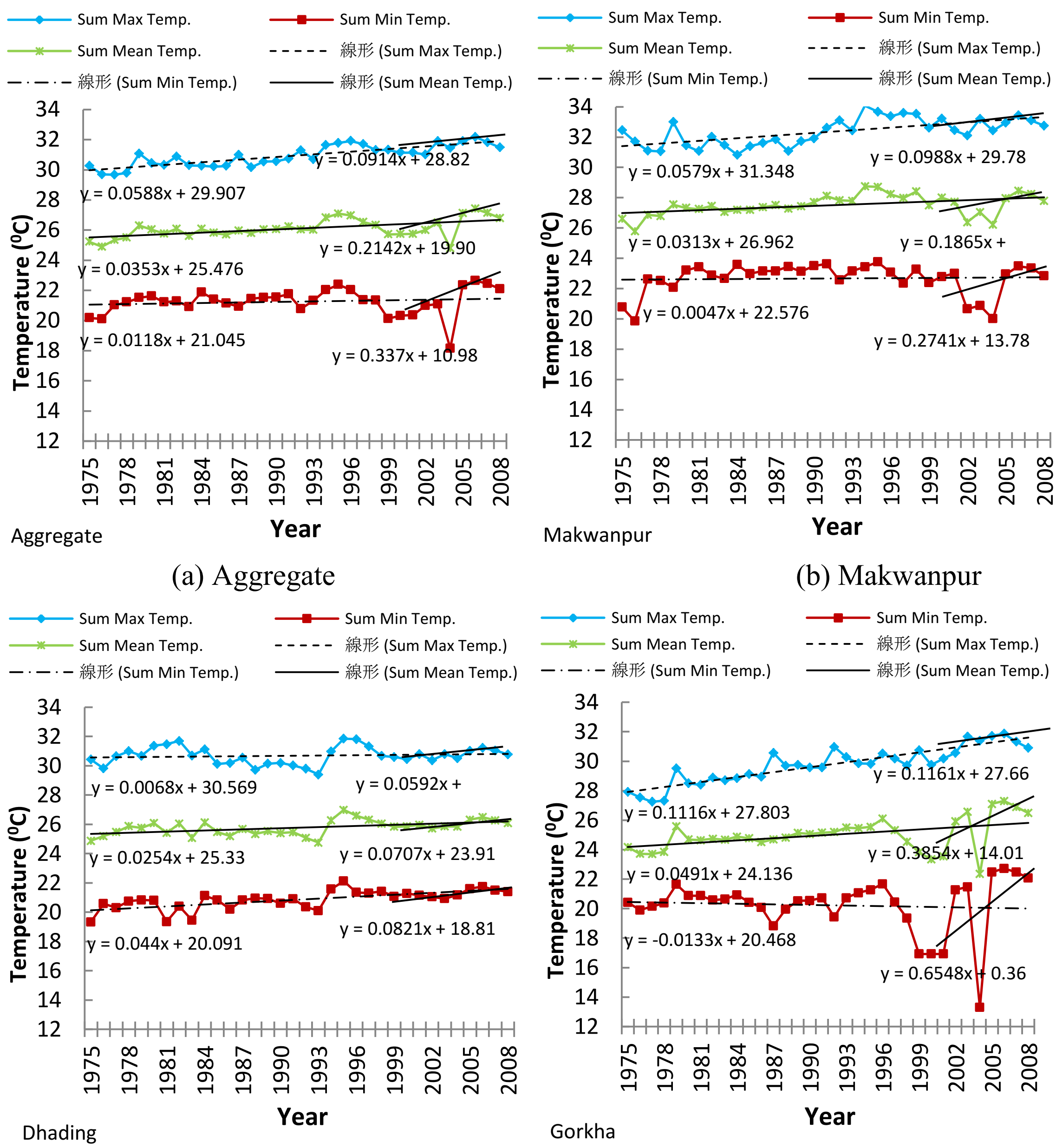
Regarding the changes in temperature, majority of the respondents have noticed the rising summer temperature (47.5%), while nearly 9.5% of the respondents perceive that summer has become cooler. For the winter temperature, nearly 21.8% perceive that winter is becoming colder while nearly equal percentage of the respondents (22.6%) perceive that winter is getting warmer. The perceptions are similar to those reported by other studies done in the hills of Nepal where majority of the respondents perceive increasing overall temperatures (Bhusal, 2009; Tiwari et al., 2010); however these studies do not differentiate seasonal temperatures. Another qualitative study by Dahal (2005) in the high Himalayas reports that the community perceived winters to be warmer and less frosty. In our study, there is a significant proportion of the respondents (38.5%) who do not perceive any changes in temperature. The reason why many respondents cannot perceive long-term changes in temperature might be because of what Vedwan and Rhoades (2001) describe as the lack of „visual salience". According to them, visual salience of rainfall facilitates better perception, whereas changes in temperature are comparatively perceived lesser. The detail of the categories of response to temperature changes has been tabulated in Table 5.3.

Table 5.3 Perceptions of changes in temperature

Perceptions	Number of response				
	Aggregate (n = 221)	**Chitwan (n = 58)**	**Makwanpur (n = 56)**	**Dhading (n = 54)**	**Gorkha (n = 53)**
Hotter summer	30 (13.6)	5 (8.6)	9 (16.1)	8 (14.8)	8 (15.1)
Cooler summer	4 (1.8)	2 (3.4)	2 (3.6)	-	-
Colder winter	3 (1.4)	-	-	2 (3.7)	1 (1.9)
Warmer winter	3 (1.4)	-	2 (3.6)	-	1 (1.9)
Hotter summer and colder winter	38 (17.2)	-	7 (12.5)	15 (27.8)	14 (26.4)
Hotter summer and warmer winter	37 (16.7)	15 (25.9)	3 (5.4)	6 (11.1)	13 (24.5)
Cooler summer and colder winter	7 (3.2)	2 (3.4)	4 (7.1)	1 (1.9)	-
Cooler summer and warmer winter	10 (4.5)	3 (5.2)	4 (7.1)	1 (1.9)	2 (3.8)
Fluctuating between the years	1 (0.5)	1 (1.7)	-	-	-
No changes perceived	85 (38.5)	26 (44.8)	25 (44.6)	20 (37.0)	14 (26.4)
Don"t know	3 (1.4)	2 (3.4)	-	1 (1.9)	-

Source: Field survey, 2011
Note: Figures in parenthesis indicate percentage

Districtwise responses show that in Chitwan and Makwanpur, there is quite a big proportion (44.8% and 44.6% respectively) of respondents who do not perceive any changes in temperature; the proportion is 37.0% and 26.4% for Dhading and Gorkha, respectively. Of the remaining who perceives changes, majority perceive rising summer temperature (34.5%, 34.0%, 53.7%, and 66.0% in Chitwan, Makwanpur, Dhading, and Gorkha, respectively). Regarding the winter temperature, the response is not as uniform and clear as the summer temperature. In Chitwan, majority (31.1%) perceive winter is getting warmer; in Makwanpur nearly 19.6% perceive colder winter while 16.1% perceive warmer winter; in Dhading majority (33.4%) perceive colder winter; and in Gorkha the two figures are again closer with 29.7% perceiving warmer winter and 28.3% perceiving colder winter.

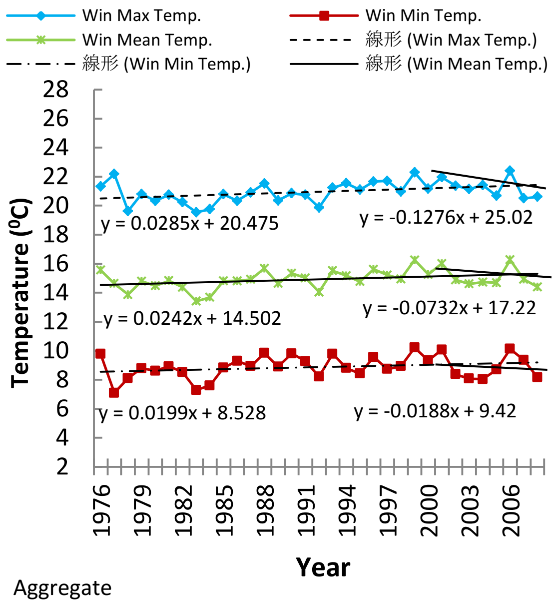


(a) Aggregate (b) Makwanpur

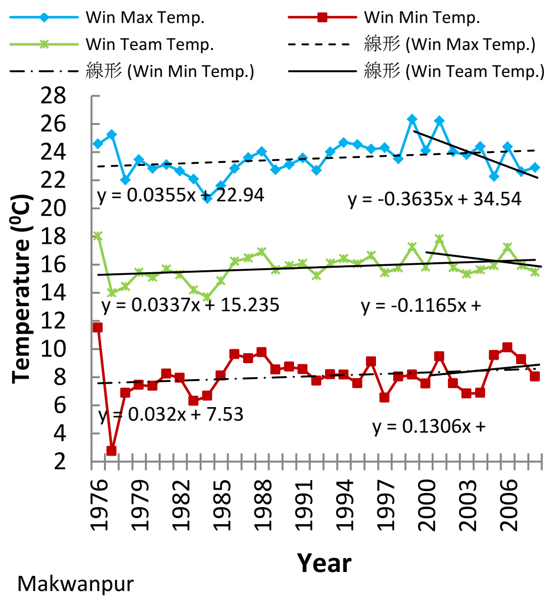
(c) Dhading (d) Gorkha

Figure 5.2 Average summer temperature trend (May-Aug) for the selected stations
Source: Raw data from DHM

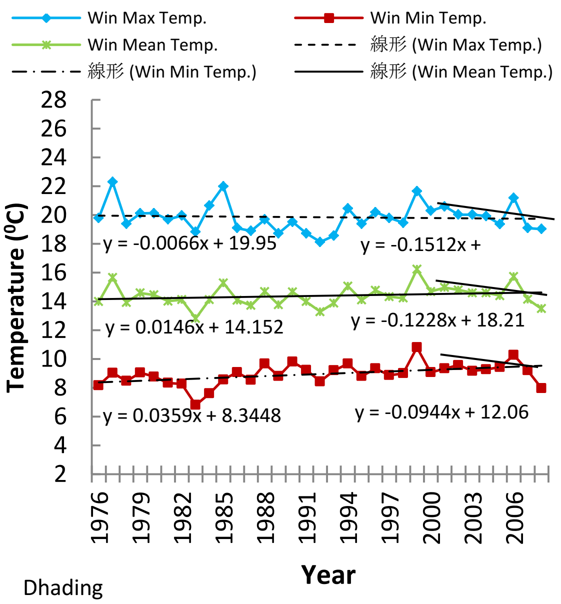
The recorded summer temperature trend is shown in Figure 5.2. The long-term summer temperature (May-August) shows rising trend for all the districts except for the minimum summer temperature in Gorkha. In the short-run also, the temperatures show an increasing trend in all the districts, and the rate of increase is faster than that in the long-run. The rate of increase in summer temperature is highest for Gorkha; unsurprisingly 66.0% of the households in Gorkha perceive the hotter summer. The perceptions regarding summer temperature is rightly perceived in other districts also, as majority of those who responded felt that summers are getting hotter in the study sites.



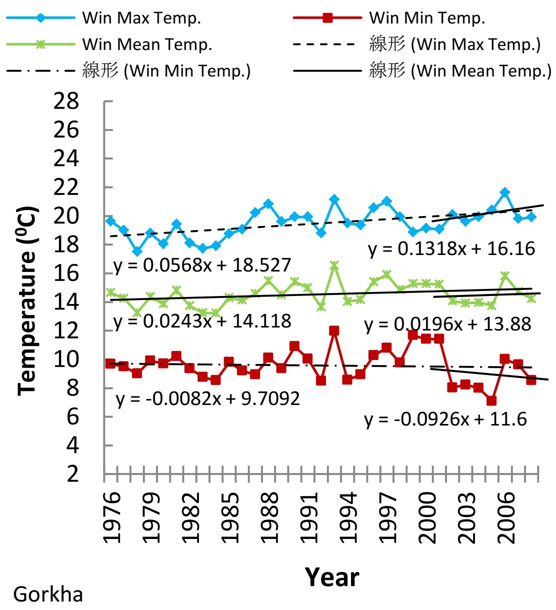
(a) Aggregate



(b) Makwanpur



(c) Dhading



(d) Gorkha

Figure 5.3 Average winter temperature trend (Dec-Feb) for the selected stations
Source: Raw data from DHM

In the long-run, trend analysis of winter temperature (December of earlier year, January and February) shows varying results with winter temperatures rising for Makwanpur district, maximum winter temperature falling for Dhading district and minimum winter temperature falling for Gorkha district (Figure 5.3). The long-term mean winter temperature shows a rising trend in all the districts. However, the trend analysis of short-term winter temperature shows quite surprising results. In Makwanpur district, the short run mean and maximum winter temperature shows a falling trend while the minimum winter temperature shows a rising trend. In Gorkha district, the short term mean and maximum winter temperature are rising while the minimum temperature is falling. Consequently, in these two districts, the perception regarding winter temperature is not clear among the respondents with almost equal percentage saying both warmer and colder winter: 16.1% and 19.6% respectively in Makwanpur and 30.2% and 28.3% respectively in Gorkha. In Dhading, most of the respondents (33.7%) rightly perceive colder winter, which is consistent with what the records show for the winter temperature in the short run. In Chitwan, most of the respondents perceive warmer winter (31.1%), but much can"t be said about the perceptions in Chitwan district due to lack of recorded data for comparison. The short-run mean winter temperature shows a falling trend in all cases except for Gorkha. However even in Gorkha, the minimum temperature is decreasing over the last ten years, which means winter nights are getting colder. Therefore, it can be concluded that the winter temperature shows a falling trend in the short-run in all the study sites.

5.3.2 Changes in rainfall: Perceptions and actual trends

5.3.2.1 Perceptions of changes in annual rainfall

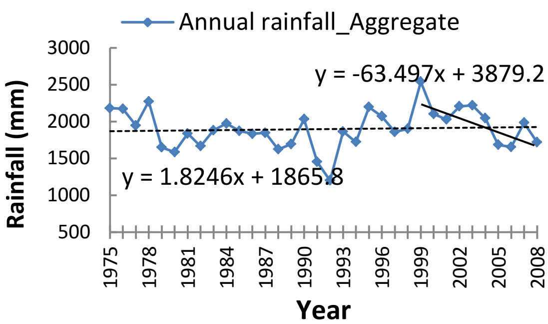
Perception of rainfall was asked to the respondents in terms of rainfall quantity as well as timings (Table 5.4). In terms of quantity majority of the respondents perceive decreasing rainfall and in terms of timings majority of the respondents perceive rainfall is arriving later in all the study sites. This perception is quite similar to what is mentioned in the studies conducted in the Himalayas (Chaudhary and Bawa, 2011; Byg and Salick, 2009; Vedwan, 2006), whereby the community perceived that snowfall and rainfall has shifted to a later timing. Most of the respondents (36.7%) feel that the total rainfall has decreased; the next majority of respondents (23.5%) feel that rainfall is unpredictable in terms of quantity (sometimes high, sometimes low); there are also quite many respondents (21.3%) who feel that rainfall is coming later than the usual time. Quite many respondents in Chitwan and Dhading perceive the unpredictable nature of rainfall. Other studies in Nepal also report that most respondents perceive rainfall to be very unpredictable regardless of whether the study was conducted in low-lying Tarai, Mid-Hill, High-Hills, or Mountains (Tiwari et al., 2010; Bhusal, 2009; Dahal, 2005). In our study, there are around 13.2% to 16.7% of respondents who do not perceive any changes in rainfall; yet this is far less compared to those who did not perceive any changes in temperature.

Table 5.4 Perceptions of changes in overall rainfall pattern

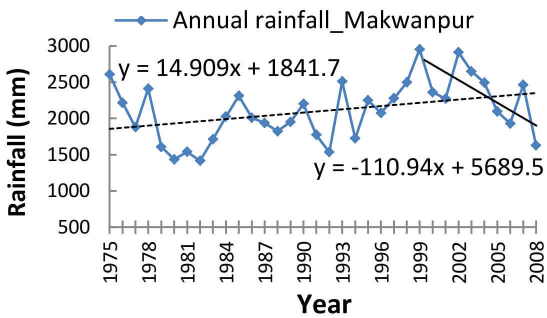
Perceptions	Number of response				
	Aggregate (n = 221)	**Chitwan (n = 58)**	**Makwanpur (n = 56)**	**Dhading (n = 54)**	**Gorkha (n = 53)**
Decreased total rainfall	81 (36.7)	12 (20.7)	19 (33.9)	17 (31.5)	33 (62.3)
Increased total rainfall	22 (9.9)	6 (10.3)	10 (17.8)	3 (5.6)	3 (5.7)
Late rainfall than usual	47 (21.3)	16 (27.6)	11 (19.6)	10 (18.5)	10 (18.9)
Early rainfall than usual	13 (5.9)	3 (5.2)	4 (7.1)	2 (3.7)	3 (5.7)
More damaging	23 (10.4)	8 (13.8)	10 (17.8)	12 (22.2)	3 (5.7)
Unpredictable	52 (23.5)	25 (43.1)	8 (14.3)	19 (35.2)	7 (13.2)
No changes perceived	34 (15.4)	9 (15.5)	9 (16.1)	9 (16.7)	7 (13.2)
Don‟t know	9 (4.1)	3 (5.2)	2 (3.6)	2 (3.7)	2 (3.8)

Source: Field survey, 2011
Note: Figures in parenthesis indicate percentage
Percentage may not add up to 100 due to multiple answers

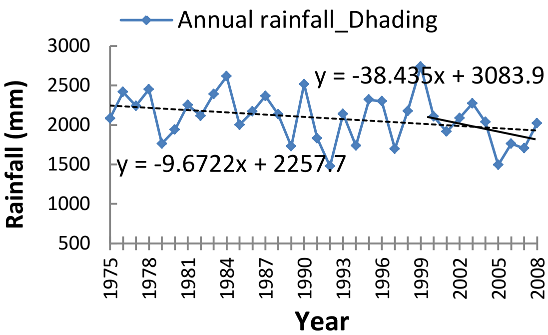
Triangulating the rainfall perceptions with actual trends was somewhat limited, since monthly averages can give the picture of total amount but do not give a picture of rainfall timings. Trend for total annual rainfall is presented in Figure 5.4. Rainfall patterns show that the inter-annual variations are very large for all the districts, thereby making the rainfall pattern quite unpredictable. The rainfall trend for overall Nepal also shows large inter-annual variations, making it difficult to draw a single conclusion regarding the rainfall patterns (Practical Action, 2009). Trend analysis for rainfall was also done for two time periods, the first being the period of 1975-2008, and another for the period 2001-2008. Similar to winter temperature, trend diagrams for annual rainfall also shows that the trends for the two different time periods can be totally different. For Makwanpur district, for example, for the period after 2001 the rainfall amount shows drastically decreasing trend while the trend in the longer run is seen to be slightly increasing. For the other two districts also, rainfall after 2001 is decreasing at a faster rate than the overall trend. The actual rainfall trend in the short run matches with the community perception, where majority say that quantity of rainfall is decreasing and is unpredictable. Among the four study sites, vast of majority of respondents from Gorkha (62.3%) could perceive decreasing rainfall in line with what the records show, while the proportion was least for Chitwan (20.7%). Alternatively, those perceiving unpredictable nature of rainfall (that is high is some years and low in others) is the highest in Chitwan (43.1%) and lowest in Gorkha (13.2%). Many respondents feel that rainfall pattern is unpredictable probably due to large interannual fluctuations in the rainfall quantity.



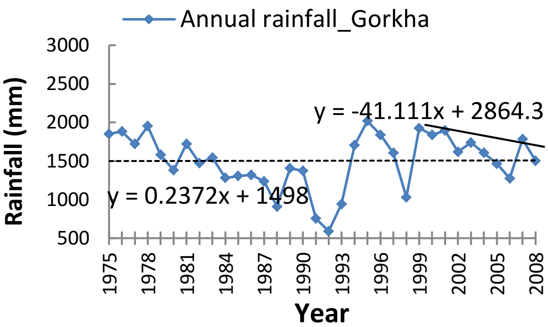
(a) Aggregate



(b) Makwanpur



(c) Dhading



(d) Gorkha

Figure 5.4 Total annual rainfall averaged for the selected stations
Source: Raw data from DHM

5.3.2.2 Perceptions of changes in seasonal rainfall

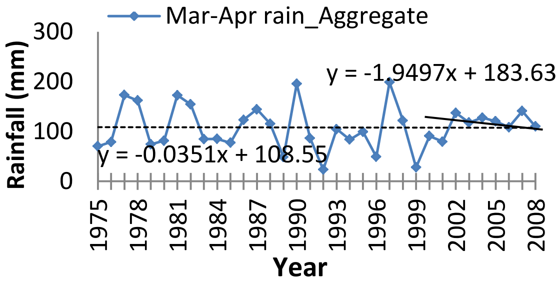
Seasonal breakdown of the rainfall was done for three different time periods having important implications for the agricultural activities. Since most of the agriculture practiced by the community is rain-fed, rainfall timings, duration and quantity has important implications for Chepang livelihoods. The first time period considered was the post-winter rainfall (March-April), which is the period for sowing maize. This period is very important for the Chepang community because maize is the most important staple food crops for this community. Too much rain or no rain, both is undesirable during this period. Too much rain interferes with the land preparation and timely sowing of maize and too little or no rain hampers the timely sowing and germination process. Majority of the respondents (51%) perceives that post-winter rainfall is coming later than usual and the amount of rainfall is decreasing. In the same line, many respondents (44%) perceive no changes in post-winter rainfall. The result is similar for all the districts with most of the respondents perceiving the post-winter rainfall to either arrive late with lesser amount of total rainfall or not perceiving any changes at all.

Table 5.5 Perceptions of post-winter rainfall (maize sowing season) (March-April)

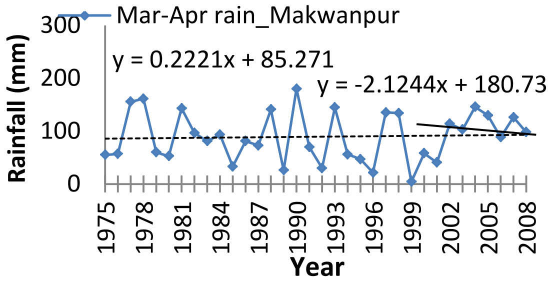
Perceptions	**Number of response**				
	Aggregate (n = 221)	**Kaule (n = 58)**	**Kankada (n = 56)**	**Mahadevsthan (n = 54)**	**Bhumlichowk (n = 53)**
Later and lesser than usual	111 (50.5)	34 (58.6)	28 (50.9)	23 (42.6)	26 (49.1)
Unpredictable (sometimes timely, sometimes late)	3 (1.4)	-	1 (1.8)	1 (1.9)	1 (1.9)
No changes perceived	96 (43.6)	19 (32.8)	26 (47.3)	28 (51.9)	23 (43.4)
Don‟t know	10 (4.5)	5 (8.6)	-	2 (3.7)	3 (5.7)

Source: Field survey, 2011
Note: Figures in parenthesis indicate percentage

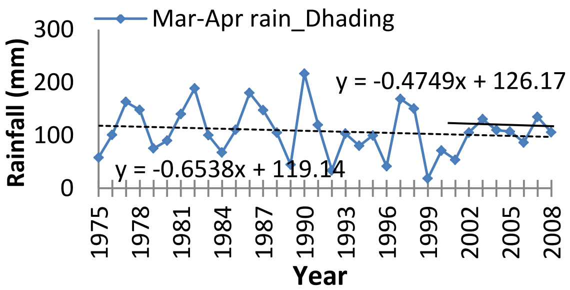
Trend analysis done in Figure 5.5 shows that, in the long run, the post-winter rainfall is decreasing only for Dhading district; while it is indeed decreasing over the period of 2001 – 2008 for all the districts. The rate of decrease is fastest in Gorkha district. The results show that, keeping aside those respondents who did not perceive any changes, the remaining did truly perceive the direction of change. That the amount of post-winter rainfall is decreasing is clearly seen from the trend analysis. It might also imply that the rains are arriving later than usual; however, it cannot be said with certainty unless day-to-day rainfall data is available for analysis.



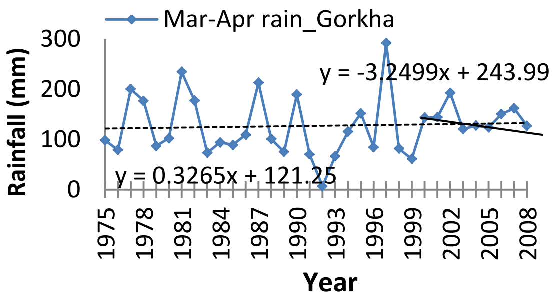
(a) Aggregate



(b) Makwanpur



(c) Dhading



(d) Gorkha

Figure 5.5 Total post-winter rainfall (March-April) averaged for the selected stations
Source: Raw data from DHM

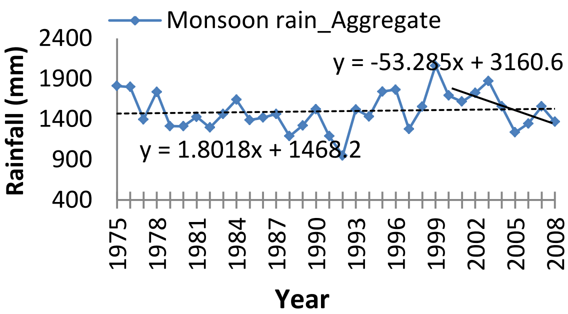
The annual precipitation pattern in Nepal is dominated by monsoon, with nearly 80% of the total precipitation occurring in monsoon season (June to September) (Practical Action, 2009). Monsoon rain is important for the Chepangs, as it coincides with the silking and tasseling stage of maize, the most critical physiological phase in terms of water demand. Similarly, monsoon rain also coincides with transplantation of millet and paddy. Table 5.6 summarizes community perceptions of monsoon rainfall. Again a significant proportion of the respondents (33%) do not notice any changes in monsoon. Of the remainder, nearly 29% says that the rainfall is unpredictable with monsoon arriving sooner in some years while arriving very late in the others. Around 15% feel that there has been a decrease in total amount of monsoon rainfall. In Kaule, 53% say monsoon rain is unpredictable, thus making it difficult to say when it rains or how much it rains; 29% do not perceive any changes, while nearly 9% feel there has been a decline in total monsoon rainfall. In Kankada, 39% perceived no changes, nearly 18% say its unpredictable, and 14% say monsoon rainfall has decreased. In Mahadevsthan, majority (32%) either feel no changes or say it is unpredictable; and 15% say monsoon arrives later than usual. In Bhumlichowk, nearly 34% perceive a decline in amount of monsoon rainfall, followed by 32% who do not perceive any changes, and 15% perceiving delay in the onset of monsoon.

Table 5.6 Perceptions of monsoon rainfall (June to September)

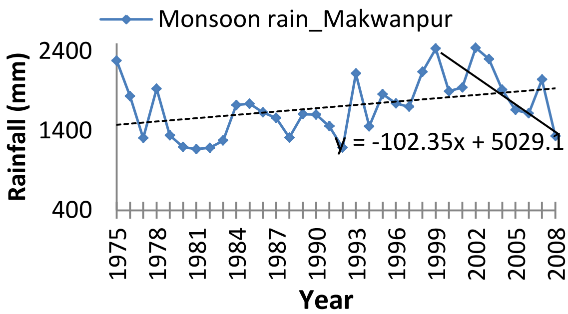
Perceptions	Number of response				
	Aggregate (n = 221)	**Kaule (n = 58)**	**Kankada (n = 56)**	**Mahadevsthan (n = 54)**	**Bhumlichowk (n = 53)**
Arrives later than before	21 (9.5)	2 (3.4)	3 (5.4)	8 (14.8)	8 (15.1)
Arrives earlier than before	14 (6.3)	-	6 (10.7)	5 (9.3)	3 (5.7)
Decrease in total rainfall	34 (15.4)	5 (8.6)	8 (14.3)	3 (5.6)	18 (33.9)
Increase in total rainfall	2 (0.9)	-	1 (1.8)	3 (5.6)	1 (1.9)
Damaging rainfall	20 (9.0)	1 (1.7)	6 (10.7)	5 (9.3)	5 (9.4)
Unpredictable (varying in different years)	63 (28.5)	31 (53.4)	10 (17.9)	17 (31.5)	6 (11.3)
Arrives late and finishes late	3 (1.4)	2 (3.4)	-	-	1 (1.9)
Arrives early and finishes early	4 (1.8)	1 (1.7)	-	1 (1.9)	2 (3.8)
Arrives late and finishes early	4 (1.8)	-	-	1 (1.9)	3 (5.7)
Either rains too much or doesn‟t rain at all	1 (0.5)	-	-	-	1 (1.9)
No changes perceived	73 (33.0)	17 (29.3)	22 (39.3)	17 (31.5)	17 (32.1)
Don‟t know	6 (2.7)	3 (5.2)	1 (1.8)	1 (1.9)	1 (1.9)

Source: Field survey, 2011
Note: Figures in parenthesis indicate percentage
Percentage may not add up to 100 due to multiple answers

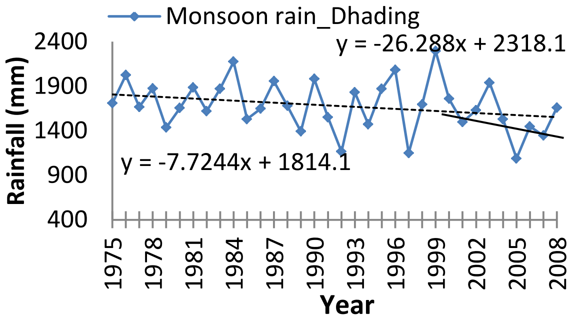
Trend analysis of monsoon rainfall is given in Figure 5.6. As perceived by most of the respondents, the amount of rainfall varies largely between the years. In the long run, the trend is increasing for Makwanpur, while it is decreasing for the other two districts. Trend analysis in the short run show decreasing trend for all the districts, the rate being the fastest for Makwanpur.



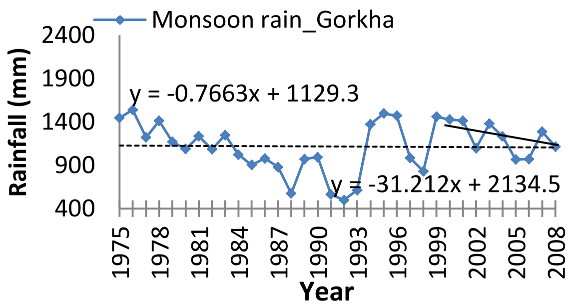
(a) Aggregate



(b) Makwanpur



(c) Dhading



(d) Gorkha

Figure 5.6 Total monsoon rainfall trend (June-Sept) averaged for the selected stations
Source: Raw data from DHM

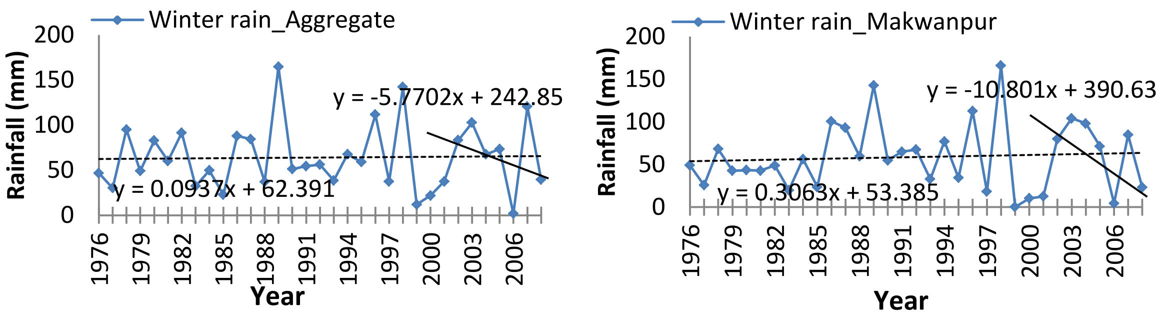
For perceptions regarding winter rainfall (December of earlier year, January and February), a clear majority of respondents feel that winter rains have decreased followed by quite many who do not perceive any changes. The result is consistent for all the districts and is shown in detail in Table 5.7.

Table 5.7 Perceptions of winter rainfall (December-February)

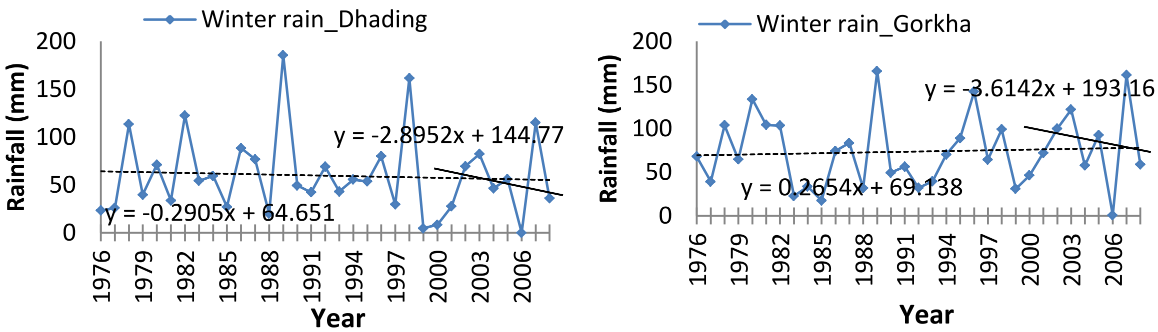
Perceptions	Number of response				
	Aggregate (n = 221)	**Kaule (n = 58)**	**Kankada (n = 56)**	**Mahadevsthan (n = 54)**	**Bhumlichowk (n = 53)**
Less winter rain	126 (57.3)	35 (61.4)	33 (58.9)	29 (53.7)	29 (54.7)
More winter rain	6 (2.7)	3 (5.3)	1 (1.8)	1 (1.9)	1 (1.9)
Unpredictable	6 (2.7)	1 (1.8)	1 (1.8)	-	4 (7.5)
Stopped raining in winter	2 (0.9)	-	1 (1.8)	1 (1.9)	-
No changes perceived	68 (30.9)	12 (21.1)	18 (32.1)	22 (40.7)	16 (30.2)
Don"t know	12 (5.5)	6 (10.5)	2 (3.6)	1 (1.9)	3 (5.7)

Source: Field survey, 2011
Note: Figures in parenthesis indicate percentage

Trend analysis shows that in the long run, amount of winter rainfall is decreasing only for Dhading district, while it is increasing for the other two districts (Figure 5.7). On the other hand winter rainfall for the period after 2001 is decreasing for all the districts, the highest rate of decrease being exhibited by Makwanpur district. This shows that the respondents could perceive the changes in winter rainfall quite well.



(a) Aggregate (b) Makwanpur



(c) Dhading (d) Gorkha

Figure 5.7 Total winter rainfall trend (Dec-Feb) averaged for the selected stations
Source: Raw data from DHM

It was found that over the 34 years duration (1975 – 2008), rainfall is decreasing in Dhading for all the seasons, which as reported by Practical Action (2009) is one of the areas exhibiting high decreasing trends of rainfall in Nepal. Similarly, rainfall trend is increasing for all the seasons in the long term for Makwanpur district, which again is consistent with the findings reported by Practical Action (2009). However, analysis of the shorter term trend shows that rainfall has been in the decreasing trend after 2001 in all the study districts, and for all the seasons. The rate of decrease is the fastest in Makwanpur district for all the seasons except post-winter rains.

5.4 Spatial clustering of perceptions of temperature and rainfall

The previous discussions show the different categories of changes in temperature-rainfall and the proportion of the respondents that perceive those changes. In each category, there is a majority of respondents who perceive that the temperature and rainfall pattern is changing in a certain way. Not to forget, there are quite many respondents who do not perceive that temperature and rainfall is showing any changes. Maddison (2007) and Gbetibouo (2009) suggest that in climate change studies, there might be some prominence bias in the questionnaire or the way questions are administered to the respondents that lead the respondents to answer in the way that the researchers want to hear. Also, it might be possible that the weather stations that we have considered in this chapter to triangulate the perceptions do not truly represent the study area. It is possible to validate the responses obtained by checking if those who perceive a particular type of change are clustered together. Utilizing the latitude-longitude-altitude data of the sample households, Global Moran"s I test for spatial autocorrelation with inverse distance weights matrix is employed in ArcGIS10 to see if a particular type of response is spatially correlated or if the responses were just random occurrence. Global Moran"s I tool measures spatial autocorrelation utilizing both the feature locations and feature values simultaneously. Given a set of features and an associated attribute, this tool evaluates if the pattern observed is clustered, dispersed, or random. A positive Moran"s I Index indicates that the attribute is clustered while a negative value shows that the attribute is spatially dispersed. The null hypothesis for Global Moran"s I statistic states that the attribute being analyzed is randomly distributed in the study area or the spatial pattern being observed is due to a random chance. A significant p-value indicates that the observed spatial pattern is not due to a random chance but rather the attributes in the data set is more spatially clustered or dispersed than would be expected if the underlying spatial processes were random.

The results for Global Moran"s I tests for spatial autocorrelation are presented in Table 5.8. The perceptions regarding summer temperature show that respondents agree that summer is getting hotter, whereas the perceptions about winter temperature show significant clustering for both colder as well as warmer winter. Those perceiving no changes in temperature do not show a significant clustering, thereby suggesting that the response about changing temperature is not due to prominence bias. The perceptions of overall rainfall pattern also show that those perceiving no changes in rainfall patterns are dispersed and insignificant. The results suggest that the respondents agree significantly that the overall rainfall is decreasing and the timing is becoming unpredictable.

Table 5.8 Global Moran‟s I test for spatial autocorrelation of perceptions of temperature and rainfall

Perceptions	Moran's I Index	P-value
Temperature		
Hotter summer	0.080	0.000***
Cooler summer	0.017	0.186
Colder winter	0.023	0.098*
Warmer winter	0.034	0.019**
No change in temperature	0.021	0.123
Overall rainfall		
Decreased total rainfall	0.088	0.000***
Increased total rainfall	0.012	0.321
Late rainfall than usual	-0.009	0.742
Early rainfall than usual	-0.010	0.728
Unpredictable overall rain	0.069	0.000***
Damaging overall rain	0.002	0.675
No change in overall rain	-0.009	0.796
Post-winter rainfall		
Late and less post-winter rain	0.014	0.261
No change in post-winter rain	0.024	0.080*
Monsoon		
Late monsoon	0.020	0.129
Early monsoon	0.024	0.073*
Less monsoon	0.065	0.000***
More monsoon	-0.013	0.435
Damaging monsoon	0.038	0.008***
Unpredictable monsoon	0.106	0.000***
No change in monsoon	-0.010	0.725
Winter rainfall		
Less winter rain	-0.003	0.920
More winter rain	0.009	0.387
Unpredictable winter rain	0.012	0.279
No change in winter rain	0.004	0.605

Note: ***, **, * indicate significant at 1%, 5%, and 10% level of significance respectively

The responses on seasonal rainfall are also tested for spatial autocorrelation. The results for post-winter rainfall shows that respondents perceiving both late/less post-winter rain and no changes are clustered together; however, the pattern is significant for those not perceiving any changes in post-winter rain. On the other hand, perceptions on monsoon shows that response of early monsoon, less rainfall in monsoon, damaging rainfall in monsoon, and unpredictable timing of monsoon each shows a significantly clustering pattern. On the other hand, those perceiving no change in monsoon are dispersed and insignificant, thus again validating that the responses about changing monsoon patterns are not biased. Finally, none of the responses about winter rainfall shows significant results. This might be because, as suggested by Vedwan (2006), farmers do not pay much attention to the climate patterns during the periods when they do not practice agricultural activities. In case of Chepangs, winter is an off-season for agriculture, thus they do not follow the patterns of winter rainfall that closely.

5.5 Analysis of the factors that facilitate perceptions using binomial probit model

5.5.1 Specification of the binomial probit model

Studies on climate change perceptions have adopted various models to analyze the factors determining perceptions: ordinal and nominal logistic regressions (Byg and Salick, 2009), Heckman sample selection probit model (Deressa et al., 2011) and binomial probit model (Gbetibouo, 2009; Maddison, 2007). This paper analyses which type of respondents perceive temperature and rainfall changes in line with the recorded data by running a simple binomial probit model. STATA is used to run the probit analysis.

Probit model estimates the probability of response, estimated by maximum likelihood estimation. Let i = 1,…,n be the independent observations, and x_i represent a vector of explanatory variables. Let y_i denote the binary response taking values {0, 1} on the i^{th} household. The binary response y_i is an indicator of the event that some unobserved latent variable z_i, which is a linear function of the explanatory variables, falls within a certain interval.

$$z_i = x_i\beta + u_i, i = 1, \dots, n \quad (1)$$

where β is the vector of regression coefficients and u_i is the error term. Probit model assumes that the error term has the standard normal distribution, $u_i \sim N(0,1)$. The latent variable z_i is related to the binary dependent variable y_i by the following rule

$$y_i = \begin{cases} 1 \; if \; z_i > 0 \\ 0 \; if \; z_i \leq 0 \end{cases} \tag{2}$$

The likelihood that y_i takes the value of 1 is given by

$$P(y_i = 1|x_i) = \Phi(x_i\beta) \tag{3}$$

where Φ(.) is the standard normal cumulative distribution function, which is expressed as an integral:

$$\Phi(z) \equiv \int_{-\infty}^{z} \emptyset(v)dv \tag{4}$$

where $ø(v)$ is the standard normal probability density function

$$\emptyset(v) = (2\pi)^{-1/2}\exp(\frac{-v^2}{2}) \tag{5}$$

The choice of standard normal cumulative distribution function, Φ(.) ensures that equation (3) is strictly between zero and one for all values of β and x_i.

The coefficient of probit model (β) is difficult to interpret because it is a measure of the change in unobserved latent variable z_i associated with the change in explanatory variables (x_i). Because of this difficulty, using marginal effect is preferred, which is the effect of x_i on the probability of response $P(y_i = 1|x_i)$ and is given by

$$ME = \frac{\partial P(y_i=1)}{\partial x_i} = \frac{\partial \Phi(x_i\beta)}{\partial x_i} = \Phi'(x_i\beta)\beta_j \tag{6}$$

Because Φ(.) is a cumulative distribution function of a continuous random variable, $\Phi'(.)$ is a probability density function. In probit model, the marginal effect always has the same sign as the coefficients (β) (Wooldridge, 2006, p.585). Marginal effect measures the change in the probability of response for an infinitesimal change in each independent continuous variable and reports the discrete change in case of dummy variables.

5.5.2 Description of variables used in the binomial probit model

The ability of the respondents to perceive temperature and annual rainfall in line with the recorded data is analyzed using binomial probit model. The variables of the model are presented in Table 5.9. The models are run separately for the changes in temperature and annual rainfall. As discussed earlier, recorded data shows increasing summer temperature, decreasing winter temperature, and decreasing annual rainfall over the last ten years. Around 32% of the respondents perceive temperature (sum of those perceiving hotter summer, colder winter and both) and 37% perceive annual rainfall in the same direction as shown by the records.

Table 5.9 Description of variables for the probit models to analyze perceptions

Response Variables	Unit	Mean[a]	
Perceive hotter summer and/or colder winter	Dummy; 1 = Yes, 0 = Otherwise	0.32 (0.47)	
Perceive decreasing rainfall	Dummy; 1 = Yes, 0 = Otherwise	0.37 (0.48)	
Independent Variables	**Unit**	**Mean[a]**	**Hypothesized relation**
Age of respondent	Years	38.43 (15.92)	+
Gender of respondent	Dummy; 1 = Male; 0 = Female	0.56 (0.50)	+
Education of respondent	Years of schooling	1.60 (2.5)	+
Own radio	Dummy; 1 = Yes, 0 = No	0.66 (0.48)	+
Membership in groups	Dummy; 1 = Yes, 0 = No	0.65 (0.48)	+
Participate in trainings	Dummy; 1 = Yes, 0 = No	0.37 (0.48)	+
Share of farming income (agriculture and livestock)	Percentage of total	52.51 (26.35)	+
Cultivate cash crops	Dummy; 1 = Yes, 0 = No	0.57 (0.47)	+
Share of non-farm remunerative income (salaried job, and non-farm skilled job)	Percentage of total	9.83 (20.17)	-
Share of income from wage labor	Percentage of total	26.30 (25.85)	-

Source: [a] Field survey, 2011
Note: Figures in parenthesis indicate standard deviation

Ten independent variables have been chosen based on previous literatures and specific characteristics of the study community. The average age of the respondents is 38.43 years. Literatures show that with age, the ability to perceive changes improves (Deressa et al., 2011), basically due to knowledge gained from increasing experiences

(Gbetibouo, 2009; Maddison, 2007). In the context of rural communities in developing countries, male respondents can perceive changes better, mainly due to their regular contact with outsiders and better access to information sources such as radios. However, some studies show that gender does not necessarily differentiate the ability to perceive climate change (Maddison, 2007). Education may influence perceptions either positively (Deressa et al., 2011; Maddison, 2007) or negatively (Gbetibouo, 2009). The average years of schooling among the respondents is very low (only 1.6 years), thereby reflecting the low literacy rate among the Chepang community. Accesses to information, extension services, and social networks have been shown to influence perception ability positively by all the literatures. In the study area, provision of village level extension services by the government agencies is totally absent. However, there are many non-governmental organizations (NGOs[5]) working in the field of agriculture, livestock, forestry, health, drinking water, and renewable energy. Such organizations work with the community by forming small groups of households and provide relevant trainings (like construction of poly-tunnels for off-season vegetable production, and plastic-ponds for water collection) to the group members. Thus membership in such groups and participation in trainings provided by these development agencies are the major sources of information, as well as extension services for this community. Although more than 65% of the respondents have membership in such community groups, only 37% have participated in the trainings provided by the development agencies. Furthermore ownership of radio has also been taken as a proxy for access to relevant information.

[5] The major NGOs who have worked or are currently working in the study areas are Support Activities for Poor Producers of Nepal (SAPPROS), Forum for Rural Welfare and Agricultural Reform for Development (FORWARD), Local Initiatives for Biodiversity Research and Development (LI-BIRD), Focus Nepal, Shanti Nepal, Center for Community Development Nepal (CCDN), Center for Community Development and Research (CCODER), Manahari Development Institute (MDI), and Practical Action Nepal. These organizations provide rural community development services mostly in the sector of agriculture, livestock, natural resource management and conservation, drinking water, community health, savings and credits, small-scale irrigation, and renewable energy (micro-hydro, solar lighting systems, and improved cooking systems).

Previous studies also suggest that the nature of livelihood activities that the household depends on and the degree of dependence on a particular livelihood source determine the level of interaction of the household members with the natural environment, thereby determining the ability to perceive any changes occurring in the climatic trends. Deressa et al. (2011) shows that higher farm income positively affects the perception of climate change while non-farm income has negative effects. On the other hand, study by Maddison (2007) shows that dependence on non-farm income does not necessarily hinder the ability to perceive some changes in climate. However, these studies do not differentiate between high-paid non-farm jobs and less-paid non-farm labor. Table 5.9 shows that farming (comprising of both agriculture and livestock) is the major livelihood sources for the Chepang households as 52.51% of the total income is derived from farming. The nature of farming has also been taken as a determinant of perception of climate change. While Maddison (2007) shows that subsistence farmer are more capable of perceiving the changes, Gbetibouo (2009) shows the opposite. In this study, 57% of the interviewed households cultivate at least one kind of cash crop (like tomato, cucumber, beans, blackgram, horsegram) to be sold in the market. Non-farm income has further been divided into remunerative income sources and wage labor. Remunerative non-farm income sources (salaried jobs and skilled non-farm jobs) that are not dependent on natural resources only form 9.83% of the total income. These sources are termed as remunerative sources because annual income from these sources is higher compared to other sources. Wage labor, which is also a non-farm source, contributes 26.3% to total income.

5.5.3 Results of the binomial probit model for the determinants of perceptions

The results of the probit model are presented in Table 5.10. Both the models are statistically significant at 1% level of significance. The percentage correctly predicted for the temperature model is 67.87% and that for the rainfall model is 60.63%. The estimates are presented in terms of marginal effects. The positive sign of the estimates denote that the factor enables perceptions in the right direction, while negative sign denotes that the particular factor does not facilitate perceptions. The coefficient estimates of the models are given in Appendix 5.

For the temperature model, interestingly, only four variables viz., gender, ownership of radio, membership in groups and participation in trainings have positive coefficients. As described in the earlier section, the last three variables denote the access of the households to information and extension services. These three variables also have positive effect in the rainfall perceptions. Ownership of radio is significant in the rainfall model, and membership in groups is significant in both the models. This result confirms the earlier literatures (Deressa et al., 2011; Maddison, 2007) about the importance of information and extension services in assisting the rural communities to perceive the ongoing changes in climate variables, which further facilitates them to formulate strategies to adjust to these changes. Possession of radio will facilitate the household"s access to information related to weather forecasts and agriculture. Currently, the weather forecasts in Nepal are made through radios and televisions for everyday weather, however there are no programs that give seasonal weather forecasts or combine these forecasts with agricultural advice. Program on agricultural information (like diseases and pest control, seeds, varieties, livestock breed) is broadcasted weekly, however these information are rarely discussed in connection with weather or climate. At the time of survey, radio was owned by 66% of the households while none of the households owned a television. Village-level extension services by the government agencies are absent in the study area. The government agriculture service centers are often situated far away from these remote settlements and the extension agents rarely visit these villages due to geographical difficulties. However, there are some NGOs implementing development projects especially in agriculture, livestock, forestry, health, infrastructure, and renewable energy. These NGOs form groups at the community level and provide the extension services and relevant capacity development trainings to those groups. Memberships in one or more of these groups are shown to significantly enable the respondent to perceive changes in both temperature and rainfall.

In general it is expected that higher dependence on farming will facilitate better perceptions of climatic variables as farming is directly dependent upon climate. However, in the temperature model, coefficients for farm income and cash crops are both negative, implying that merely higher dependence on farming is not sufficient to notice the changes in temperature. As stated before, temperature lacks visual salience as a result of which perceiving temperature is more difficult than perceiving rainfall (Vedwan and Rhoades, 2001). Perceptions of changes in temperature can be facilitated only by proper dissemination of climate related information and extension services at the community level.

Table 5.10 Estimates from the probit model to analyze perceptions

Independent variables	Perceive hotter summer and/or colder winter		Perceive decreasing rainfall	
	Marginal effect	**P-value**	**Marginal effect**	**P-value**
Respondent‟s age	-0.0035	0.118	0.0002	0.929
Respondent‟s gender	0.0042	0.952	0.0530	0.464
Respondent‟s education	-0.0227	0.100*	-0.0048	0.738
Own radio	0.1051	0.120	0.1458	0.035**
Memberships in groups	0.1627	0.013**	0.1178	0.095*
Participation in trainings	0.0512	0.468	0.0544	0.452
Farm income	-0.0040	0.094*	0.0003	0.892
Cultivate cash crops	-0.0909	0.172	0.1297	0.050**
Non-farm remunerative income	-0.0034	0.183	-0.0002	0.944
Income from wage labor	-0.0052	0.034**	-0.0001	0.974
LR Chi^2(10)	17.0100		15.91	
Prob > Chi^2	0.0742*		0.1023*	
Log likelihood	-130.2454		-137.2601	
Pseudo R^2	0.0613		0.0548	
% correctly predicted	67.87		60.63	

Note: **, * indicate significant at 5% and 10% level of significance respectively

On the other hand, in the rainfall model, the coefficients for both farm income and cash crops are positive. Since agriculture in the study hills are primarily rainfed, time and quantity of rainfall is very important for such households. This shows that those households who are dominantly dependent on agriculture and livestock for their livelihoods follow the precipitation trends more closely. Those households cultivating at least one type of cash crop to sell in the market are found to have significantly higher probability to perceive the changes in rainfall. That means those households cultivating cash crops perceive decreasing rainfall significantly better that those who only practice subsistence agriculture. This result is in contradiction with the findings of Maddison (2007), where it is reported that subsistence farmers are better able to perceive changes in both temperature as well as rainfall. In our study, there can be two explanations for why households cultivating cash crops are better able to perceive the changes in these climate variables. Firstly, cash crops like vegetables are by nature more susceptible to decreasing rainfall compared to traditional crops like millet, thus farmers cultivating vegetables will be following the rainfall patterns with greater care. Secondly, those farmers who cultivate cash crops are those who have received related trainings from the NGOs, thus they are better informed about these phenomena. Results in Table 5.10 show that if the households depend more on non-farm sources like salaried jobs (teaching), skilled jobs (carpenter, cook, carpet weaving), and wage labor (carrying loads, working in limestone mines, constructing roads), such households follow both temperature and rainfall trends less closely. This result is relevant because these non-farm income sources are not dependent on natural resources, and thus are less affected by climatic variables. Similar results have been reported by Deressa et al. (2011) where by farm income has significant positive effects on climate change perception, and non-farm income has negative effects though not significant.

Age and gender of the respondents are found to be non-significant in our study. This is in contrast to the previous studies like Deressa et al. (2011) reporting age of the household head as a significant factor. However, others like Byg and Salick (2009) opine that age is not a significant factor in perception. Respondents‟ age has negative sign for temperature, again implying that simply experience is not sufficient to perceive changes in temperature. On the other hand, rainfall is visually salient, so that ability to perceive rainfall changes increases with age. The positive sign on gender reveals that males have higher probability to perceive the changes in climate because males have more frequent contacts with development workers and have better access to information sources. Males are also more flexible in terms of their times to listen to radio while females are more involved in household chores and thus rarely find time to listen to radio broadcasts. Similar trends have been reported in farming communities in rural South Africa (Below et al., 2010). The direction of influence of education is also quite startling, as it contradicts the more usual concept that with education, ability to perceive will increase (Gbetibouo, 2009). However, in our study the direction of influence is negative for both temperature as well as precipitation and is significant for temperature. The implications here are two-fold: firstly, with higher education, the probability of pursuing non-farm jobs increases, thereby paying lesser attention to climate; secondly the curriculum in the schools do not yet cover the issues of climate change and its impacts on rural livelihoods, thereby failing to raise the awareness among the students regarding the subject.

5.6 Conclusion and policy implications

The trend analysis of temperature and precipitation trend for both long-term and short-term provides some important insights. Firstly, the direction of trends can differ for the two time-periods, as shown by the trends for winter temperature and annual rainfall. Secondly, as seen in the case of rainfall, community perceptions are more in line with short-term trends, rather than with the long-term trends. It is the latest trend that has effects on the people‟s livelihoods directly and the decisions are taken to adapt accordingly. Policy makers should be critical to analyze both the long term as well as the short term trends, before implementing any development decisions.

Around one-third of the respondents in this study perceive the changes in line with the data recorded in the weather stations. A matter of concern is that there is a significant proportion of population who has not been able to perceive any of those changes, thereby calling for a need for awareness raising and information dissemination in these rural areas, where the livelihoods are predominantly dependent upon farming. Unless the community realizes that there have been changes going on in the weather patterns, they cannot be motivated to take appropriate measures to adapt their farming systems according to these changes. Results of probit analysis well demonstrates the importance of information dissemination and community level extension services, which are very effective to inform the people about such changes and to convince them to take necessary adaptation actions. The NGOs and local governments working at the grassroots level can play an important role for disseminating the relevant information and conducting awareness raising campaigns. For this, the staffs themselves need to be knowledgeable about the changes, the impacts, and possible adaptation strategies. There is a need to first train the development workers working at the community level, so that they can effectively convey the messages to the community. Besides, our education system needs to update the curriculum so as to include climate change, its impacts, and possible mitigation-adaptation measures in order to raise awareness among the students.

Another facet where the government can improve is to conduct seasonal weather forecasts and assist the rural households to design their crop calendar in accordance to these forecasts. Only broadcasting such information through radio is not sufficient as not all the households possess radios; and even if possessed women may not have time to listen to those broadcasts. These types of information will be more effective if broadcasted by extension agents through direct interaction with the community. Agricultural extension services are very poor in this community especially from the side of the government. Village level extension service systems need to be improved and such programs should emphasize participation of both males and females.

Finally, there is a need to expand the existing meteorological facilities especially in the hills and mountains. Without recorded data, monitoring the changes is not possible, thus establishment of small hydrological stations at the local level is recommendable. As already recommended by Dahal (2005), training the staffs and students at local schools or members of local community-based organizations to obtain readings from rain-gauge and thermometers would not only make it possible to generate datasets on local climate, but it would also be easier to raise awareness among the local communities about the changing climate, and the appropriate measures that can be taken to tackle its adverse impacts.

Chapter 6. Community vulnerability to climate change

6.1 Introduction

Natural climate variability has always been a challenge to human livelihoods. Human-induced climate change has lent a complex new dimension to this challenge. Evidences show that the natural climatic variability, compounded with climate change will adversely affect millions of livelihoods around the world (IPCC, 2007c). The rural communities in the developing countries are expected to be affected more due to their extensive dependence on climate sensitive livelihood options, and limited adaptive capacity to adapt to the changes (UNFCCC, 2009). Nepal, with its fragile geography, predominantly natural resource based livelihoods, and low level of adaptive capacity due to higher incidence of poverty, is placed among the most vulnerable country to climate change (Oxfam, 2009). Nepal is already a country vulnerable to natural disasters particularly floods and landslides. With an increased intensity in monsoon risks, the risk of flash flooding, erosion, and landslides will be increased. The adverse impacts of climate change and extreme events will definitely exacerbate the vulnerability, existing poverty and inequalities in least developed countries like Nepal. Within the country, poor and marginalized communities tend to be those least able to cope with climate-related disasters.

Climate change is a global phenomenon; however its manifestations and impacts vary locally, so do the adaptation capacities, preferences, and strategies. Effective planning for climate change adaptation programming requires an assessment of local vulnerabilities so as to bridge the gap between community needs and priorities at the local level, and policy processes at the higher level. Micro-level studies should form the inputs for formulating relevant policies at the macro level (Burton et al., 2006). Researches done at the national level fail to capture the location specificity of smaller areas. This calls for the need of detailed explorations at the finer spatial level. Even at the local level, the most marginalized section of the community must be the focus as they are the ones who are the most vulnerable. In this direction, this research focuses on the Chepang community, one of the highly marginalized indigenous nationalities in the rural Mid-Hills of Nepal. This chapter will conduct an in-depth analysis of the local level vulnerabilities by integrating quantitative analysis with qualitative information obtained from primary field survey. The next section deals with the conceptualization of vulnerability based on literatures followed by a theoretical framework for analyzing adaptive capacity and a brief review of various methodologies followed by researchers to measure social vulnerability. Methodology is discussed in the second part. Results and discussion of data analysis are dealt in the third section and the last part concludes the chapter.

6.1.1 Theoretical framework for analyzing vulnerability

Following the definition of vulnerability given by IPCC (2001), vulnerability in this study is taken to be a function of exposure, sensitivity, and adaptive capacity. Exposure is the nature and degree to which a system is exposed to significant climatic variations. Sensitivity is the degree to which a system is affected, either adversely or beneficially by climate-related stimuli. Adaptive capacity is the ability of a system to adjust to climate change including climate variability and extremes, to moderate the potential damage from it, to take advantage of its opportunities, or to cope with its consequences. Because vulnerability is always hazard specific, integrating exposure and sensitivity with the socio-economic aspects or adaptive capacity is important to give the context of the hazard under consideration. This integrated approach helps to focus the discussion of the adaptive capacity in response to the exposure and sensitivity posed by that particular hazard in question.

Following Jakobsen (2011) and Nelson et al. (2010b), this paper uses the sustainable rural livelihoods framework given by Ellis (2000) and DFID (1999) to analyze the adaptive capacity of the study community. The sustainable livelihoods approaches which views livelihood outcomes as a function of the ownership or access to livelihood assets is principally based on Nobel Laureate Amartya Sen‟s entitlements approach, where by households with sufficient range of entitlements, capabilities or assets have more choices of adopting strategies suitable to cope during the periods of adversities or minimize the associated risks (Jakobsen, 2011; Ludi and Slate, 2008). The lack of or limited access to livelihood assets increases the defenselessness or incapacity to avoid risks as well as increases the shocks and stresses to which an individual or household is exposed to (Shahbaz, 2008). On the other hand, households with diversified asset portfolio are more capable to reduce risks and to cope with or adapt to increased level of risks. Such households will have more options to substitute among alternative livelihood activities during the times of stress, thereby having more adaptive capacity. For instance, households with access to irrigation (physical assets) will face less risks of crop damage during droughts compared to those households depending entirely on rainfed agriculture. Similarly, households with higher savings (financial assets) or memberships in saving and credit institutions (social assets) have greater capability to minimize livelihood risks posed by crop failure during bad weather. Households having some non-farm sources in addition to farming will improve the adaptive capacity of the households against the climatic stresses through distribution of risks across various livelihoods sources.

6.2 Methodology

6.2.1 Sources of data

Chepangs live in areas most at risk to floods and landslides, are more reliant on local natural resources and would therefore suffer the most from drying up of local water resources or changes in vegetation cover. Even small changes in rainfall patterns can have devastating consequences on their crops. They are vulnerable to extreme weather events;

have poor access to information and lack resources to cope with and recover from weather-related disasters. Their vulnerability is further compounded by geographical isolation poorly served by roads and other infrastructure, often isolated by landslides and floods. Studies related to the vulnerabilities of climate change and extremes should focus on such poor and marginalized communities because they are the most vulnerable and least able to cope with the adverse impacts. Studies based on the livelihood of these vulnerable communities will help to draw the attention of the government and development agencies to this issue. This chapter is an attempt towards this direction.

This chapter is based on the primary data collected by household survey in both phases. The first phase of household survey was conducted in February-March 2010. This chapter uses data related to demographics, livelihood assets (landholdings, livestock holdings, savings, loans, education, trainings, membership to CBOs, infrastructure, and physical assets), food production, livelihood activities, income sources, and expenditures from the first phase of the household survey. Besides the household survey, group discussions were also carried out in the first phase of field visits to obtain a timeline of climate related disasters like flood/landslides, droughts, and hails in the locality; information on general perceptions of climate change, locally observed indicators, and the impacts on livelihoods were also assessed during the discussions. Based on the information from these group discussions, interview schedule was designed and follow-up field visit was again made in May-June 2011. In the follow-up survey of 2011, questions were focused on the individual perceptions of climate change, adaptation strategies adopted, and the impacts of extreme climate events (flood/landslides, drought, hail) on crop production and livelihood assets. Also, latitude, longitude, and altitude were recorded for all the households. This chapter utilizes the information on livelihood impacts and households‟ geographical position collected during the second phase of field visits.

This chapter also makes use of raw minimum and maximum temperature and rainfall data obtained from DHM in Kathmandu, Nepal for the time period of 32 years, from 1977-2008. Temperature data was obtained from 49 stations and precipitation data from 218 stations distributed all over the country. The temperature and precipitation at the household level was interpolated for each year from the weather stations using the latitude-longitude-altitude information of each household by ordinary kriging method in ArcGIS 10.

6.2.2 Choosing the vulnerability indicators

Vulnerability to climate change is multidimensional and is determined by a complex inter-relationship of multiple factors. Many variables representing components of vulnerability are not directly quantifiable. Nevertheless, devising an index to measure vulnerability is helpful to compare similar systems and provide insights into the underlying processes and determinants of vulnerability that is of relevance to policy makers. The first step in constructing the index comprises of the selection of indicators, then weights are assigned to these indicators, and finally these indicators are aggregated to form an index. Indicators and indices are useful in representing a complex reality into simpler terms. However, the methodology adopted in the choice of indicators is very crucial, since choice of wrong indicators may lead to a construction of an invalid index. Choice of indicators to represent the index for vulnerability is constrained by the fact that vulnerability itself has no tangible element. There are two approaches in the selection of indicators, data-driven and theory-driven (Vincent, 2004). The selection of suitable indicators can best be done based on some theories that provide insight into the nature and causes of vulnerability. However, even theory-based deductive approaches are constrained by data-limitations due to which subjectivity enters in the process of indicator selection. The best option is to verify the representativeness of the theory-based indicators with insights gained from focus group discussion conducted at the local level. This approach was adopted while selecting the indicators used in this chapter.

6.2.2.1 Exposure

For this study, historical changes in climate variables and occurrence of extreme climatic events are taken as indicators of exposure (Table 6.1). Rate of change in average annual maximum temperature, average annual minimum temperature and average annual precipitation for the time period of 1977–2008 represent the historical climate changes. The temperature and precipitation for individual household was interpolated for each year from the station level data (49 temperature stations and 218 precipitation stations) using the latitude, longitude, and altitude information of the stations and the households by ordinary kriging method in ArcGIS10. The coefficient of the trends of climate variables is calculated separately for each household. Floods/landslides, droughts and hailstorms are the most commonly occurring natural disasters in the study area. Number of occurrence of these extreme events for the last ten years was obtained for each household from the household survey (Appendix 6). It was hypothesized that higher the rate of change of the climate variables and higher the frequency of natural disasters, higher will be the exposure of the households to climate change and extremes.

Table 6.1 Indicators for exposure

Component indicators	Description of the indicators	Unit	Hypothesized relation
Historical change in climate variables	Rate of change in average annual minimum temperature (1977 – 2008)	Coefficient of trend	+
	Rate of change in average annual maximum temperature (1977 – 2008)	Coefficient of trend	+
	Rate of change in average annual precipitation (1977 – 2008)	Coefficient of trend	+
Extreme climate events	Frequency of climate related natural disasters (floods, landslides, droughts and hailstorms) over the last 10 years	Number	+

6.2.2.2 Sensitivity

Sensitivity is given by the degree to which a system is modified or affected by an internal or external disturbance or set of disturbances (Gallopin G. C., 2003). Livelihood impacts of climate related disasters were taken as the sensitivity indicator following Daze et al. (2009) and Marshall et al. (2009). These literatures take the cumulative impacts of past climate hazards on the livelihoods as a proxy for future sensitivity with the assumption that current sensitivity represents the future sensitivity of the households or in other word, households facing higher impacts are the ones who are also more sensitive in the future. Deaths of family members and loss of properties (viz. land, livestock, and crop) due to climate related disasters over the last ten years represent the sensitivity for the purpose of this study. It is hypothesized that higher impacts of past climatic hazards will increase the sensitivity of the households to such events.

Table 6.2 Indicators for sensitivity

Component indicators	Description of the indicators	Unit	Hypthesized relation
Fatalities	Death of family members due to climate related disasters (floods, landslides) over the last 10 years	Number of family members	+
Damage to properties	Total land damaged by flood/landslides over the last 10 years	Area in local units (*Kattha*[6])	+
	Total livestock death due to flood/landslides/drought/hail over the last 10 years	Livestock Standard Unit (LSU[7])	+
	Total crop damage due to flood/ landslides/ drought/ hail over the last 10 years	Value in Nepali Rupees (NRs)	+
Income structure	Share of natural resource based income (agriculture, livestock, forest, honey, and handicraft) to total income	%	+
	Share of non-natural based remunerative income (salaried job, remittance, skilled non-farm job) to total income	%	-

The income structure will also determine the household sensitivity. Higher share of natural resource based income (composed of agriculture, livestock, forest, honey and handicrafts) will increase the sensitivity of the household as these sources are more dependent on climate; while higher share of non-natural resource based remunerative income sources (composed of salaried jobs, non-farm skilled jobs, and remittances from abroad) will reduce the sensitivity. The detailed breakdown of the share of various income sources are given in Appendix 4.

[6] 1 Kattha = 0.033 ha

[7] LSU is aggregates of different types of livestock kept at a household in standard unit calculated using the following equivalents; 1 adult buffalo = 1 LSU, 1 immature buffalo = 0.5 LSU, 1 Cow = 0.8 LSU, 1 calf = 0.4 LSU, 1 pig = 0.3 LSU, 1 sheep or goat = 0.2 LSU and 1 poultry = 0.1 LSU (Baral, 2005; CBS, 2003).

6.2.2.3 Adaptive capacity

As described in the theoretical framework, adaptive capacity of a household is taken to be an emergent property of the five types of livelihood assets viz. physical, human, natural, financial, and social. These indicators are not necessarily specific to climate shocks only but are also relevant in addressing other shocks like food shortages. Although only few of the selected indicators like house types and irrigation facilities have a direct role in minimization of risks from climate shocks, all of these indicators do assist households to combat climate shocks through risk pooling, risk distribution or as buffer during extreme climatic events. The relevance of each indicator in building household adaptive capacity in the face of climate related risks is discussed hereafter.

Table 6.3 Indicators for adaptive capacity

Component indicators	Description of the indicators	Unit	Hypothesized relation
Physical Assets	Type of house (1 = thatch roof, thatch/wooden wall; 2 = thatch roof, stone+mud wall; 3 = stone/tin/tile roof, stone/wood/brick+mud wall)	Ordinal value	+
	Have devices to access information (mobile, radio) (0 = No, 1 = Yes)	Ordinal value	+
	Walking distance to nearest motor road	Hours	-
	Irrigated land	% of total	+
Human Assets	Highest qualification in the family	Number of schooling years	+
	Dependency Ratio	-	-
	Trainings or vocational course attended by family members	Number	+
Natural Assets	Share of more productive land (*khet* + *bari*) possessed	% of total	+
	Share of less productive land (*khoriya*) possessed	% of total	-
	Have bullock (0 = No, 1 = Yes)	Ordinal	+
Financial Assets	Gross household annual income	NRs	+
	Livelihood Diversification Index	-	+
	Total household savings	NRs	+
	Ownership of goat, poultry, and pig	LSU	+
Social Assets	Memberships in CBOs	Number	+
	Access to credit (1 = needed, but no access; 2 = credit used only for subsistence purposes; 3 = credit used for productive investment +/- subsistence; 4 = no need)	Ordinal Value	+

Indicators for the physical assets are type of house, ownership of devices to access information (mobile phone and radio), walking distance to the nearest road, and irrigated land. Out of these, only house quality and irrigation are directly related to climate risks.

Possession of better quality house will improve the capacity to withstand the risks from extreme climate events. Type of house was indicated from a value of 1-3, 3 indicating the most durable type of house (see Table 6.3). Ownership of mobile phone and radio will increase the adaptive capacity through access to weather related information. Better access to information enables a household in planning proactive adaptation measures against climate risks. Walking distance to the nearest motor road, which in this case is also equivalent to the nearest marketplace, is assumed to be inversely related to adaptive capacity as household located far away from the markets will be in a disadvantageous position for lacking the opportunity of income generation from alternative sources like non-farm labor, which help in securing livelihoods during the periods of food shortage or crop failure. Farther distance from the roads also symbolizes poor access to inputs as the service centers are located at the road-heads. In addition, greater distance from the motor roads also means limited access to information as the marketplace acts as informal gathering centers where information exchange takes place, and also the formal institutions providing extension services are located there. Irrigation is directly related to climate shocks as it minimizes risks posed by droughts. Higher percentage of irrigated land means lesser dependence on natural rain for agricultural purposes, which is becoming more unpredictable with climate change.

Human asset is represented by the highest qualification in the family; trainings or vocational courses attended by the family members; and dependency ratio. These indicators are not directly related to climate shocks; however they are still relevant because development of human capabilities through vocational trainings or formal education enable households to increase their income by undertaking skilled non-farm activities, which are less climate-sensitive compared to farming and gathering, thereby helping the households to avert climate risks. Furthermore, it also diversifies household livelihood sources which help to buffer the risks posed by climate on farm income. Households with higher dependency ratio will have more burdens on the earning members thereby reducing the adaptive capacity. The implication of dependency ratio is common to any types of shocks including those related to climate.

The quality of land possessed by the households is taken as an indicator of natural assets. Chepangs possess three categories of land. Paddyland (*khet*) is the most productive category of land, usually having an irrigation source. *Bari* is terraced upland, which may or may not be irrigated, and is less productive than *khet*, but more productive than the third category, *khoriya*, which is unterraced sloppy land-plot. Natural assets, by their own nature, are more vulnerable to climate shocks than other types of assets. While terraced land types (*khet* and *bari*) are less prone to erosion, *khoriya* face greater risks of landslides and loss of top-soil due to run-off during rains. Households possessing higher share of *khet* and *bari* compared to *khoriya* will suffer less from climate disasters. Higher share of more productive land (*khet* and *bari*) also means higher food self-sufficiency, thus higher adaptive capacity. Higher share of *khoriya* indicates the opposite. Besides land, possession of bullock, which is the only means of ploughing fields in the hills, is another indicator of household natural assets.

Gross household annual income, livelihood diversification index, household savings, and ownership of small livestock (goat, poultry, and pig) are taken as the indicators of financial assets. These indicators of financial assets are not specific to climate shocks only. Gross annual income of the household is the sum total of the cash and non-cash income from 11 different sources discussed in Chapter 4. Higher income means greater availability of resources at disposal to maximize positive livelihood outcomes. Besides the amount of annual income, the sources from which the income is derived also need to be considered. If all of the income is derived from farming alone, then such income will be adversely affected during the years of bad weather. On the other hand, if the income is derived from more than one source, then risk will be distributed among the sources. In order to capture this aspect of income, Livelihood Diversification Index (LDI) is calculated; higher diversification indicating better ability of the household to switch among the activities when needed. Herfindahl index of diversification is used (Kimenju and Tschirley, 2009), which is calculated as

$$D_k = 1 - \sum_{i=1}^{N} (S_{i,k})^2$$

where, D_k is the diversification index, i is the specific livelihood activity, N is the total number of activities being considered, k is the particular household, and $S_{i,k}$ is the share of i^{th} activity to the total household income for k^{th} household (see Appendix 4). In addition to the income at disposal, households which are able to make some savings out of their income will be able to make productive investments like family education or use the savings as buffer during the times of need. For Chepangs, small livestock are also important sources of cash income; they keep these livestock as buffer to sell during the times of stress or to pay back the loan that they take from moneylenders.

Finally, social asset is represented by the number of membership in formal community based organizations (CBOs) and access to credit. Membership in CBOs will improve the households" social networks and access to information through their constant contact with the outsiders during the meetings in CBOs. Also, management of resources like water collection tanks and forests is done jointly by the members of these CBOs. Such activities help in pooling risks across the households in a community. Access to credit is also taken as social assets because for the Chepangs, taking loans from social contacts is one of the most important strategies to cope with seasonal food shortages, which they repay by selling agricultural produce, livestock, or forest products. Thus, access to credits in this community is equivalent to the social safety nets against all types of shocks. Also, some semi-formal saving and credit organizations in the community have recently started providing interest-free loans for productive investment like vegetable farming, and rearing cattle. Thus, access to productive loans denotes the access of the households to existing credit providing organizations in the locality. Better the access to credit, higher will be the adaptive capacity of the households.

6.2.3 Calculation of the vulnerability index

Having chosen the suitable indicators, now these need to be normalized so as to bring the values of the indicators within the comparable range (Nelson et al., 2010a; Gbetibouo and Ringler, 2009; Vincent, 2004). Normalization is done by subtracting the mean from the observed value and dividing by the standard deviation for each indicator.

$$Normalized\ value = \frac{Observed\ Value - Mean}{Standard\ Deviation}$$

Next, weights should be assigned to these indicators. Some researches follow equal weighting (Nelson et al., 2005; Vincent, 2004), however it may be too arbitrary and lead to overweighting of some less important indicators, while underweighting the important ones. Weighting can also be based on expert judgement (Vincent, 2007; Adger and Vincent, 2005; Vincent, 2004), however this approach is often criticized for being too subjective, and is often constrained by the availability of subject matter specialists or lack of consensus among the experts themselves (Gbetibouo and Ringler, 2009). Assigning weight by Principal Component Analysis (PCA) following Filmer and Pritchett (2001) is thus preferred compared to the former two methods (Nelson et al., 2010b; Gbetibouo and Ringler, 2009; Cutter et al., 2003). PCA was run for the selected indicators of exposure, sensitivity, and adaptive capacity separately in STATA for assigning the weights. The loadings from the first component of PCA are used as the weights for the indicators. The weights assigned for each indicator varies between -1 and +1, sign of the indicators denoting the direction of relationship with other indicators used to construct the respective index. The magnitude of the weights describes the contribution of each indicator to the value of the index. PCA was run separately for the indicators of exposure, sensitivity and adaptive capacity. Stepwise PCA was run for the indicators of adaptive capacity. The first-step PCA was run for the indicators of each asset group separately to observe the relative importance of indicators within each asset category. From the weights obtained from first-step PCA, individual index values for each asset type was calculated. Second-step PCA was run using the index values for each of the five asset types to analyze which asset group contributes the most to the total adaptive capacity. Overall adaptive capacity index was calculated using the weights (loadings) obtained from the second step PCA run for the five asset categories.

The normalized variables are then multiplied with the assigned weights to construct the indices (for exposure, sensitivity, and adaptive capacity separately) using the following formulae:

$$I_j = \sum_{i=1}^{k} b_i \, [\frac{a_{ji} - x_i}{s_i}]$$

where, „*I*“ is the respective index value, „*b*“ is the loadings from first component of PCA (PCA1) taken as weights for respective indicators, „*a*“ is the indicator value, „*x*“ is the mean indicator value, and „*s*“ is the standard deviation of the indicators. Finally, vulnerability index for each household is calculated as: $V = E + S - AC$, where, *V* is the vulnerability index, *E* the exposure index, *S* is the sensitivity index and *AC* is the adaptive capacity index for respective household, *i*. The overall vulnerability index facilitates inter-household comparison and inter-VDC comparison as well. Higher value of the vulnerability index indicates higher vulnerability. However negative value of the index does not imply that the household is not vulnerable at all. This index does not give the absolute measurement of vulnerability; rather the index values give a comparative ranking of the sampled households and/or study VDCs. Tests of analysis of variance (ANOVA) was conducted to compare the means among the four study sites and four vulnerability quartiles.

6.3 Results and discussion

The weights obtained from PCA analysis for the indicators of exposure is given in Tables 6.4, along with the average values of the indicators across the four study sites. The weights for the indicators of exposure are all positive as hypothesized except for maximum temperature trend. This shows that while minimum temperature trend, rainfall trend and number of natural disasters contribute positively to the exposure index, maximum temperature contributes in the opposite direction. As revealed by the absolute value of the weights, temperature and rainfall trends contribute more to the exposure index compared to the incidence of natural disasters. Both minimum and maximum temperature coefficients show a slow increasing trend for all the study VDCs. Precipitation also shows an increasing trend; the rate for Kaule and Bhulichowk VDC being significantly higher compared to the other two VDCs. The number of natural disasters over the last ten years is the highest for Mahadevsthan, followed by Bhumlichowk, Kaule, and Kankada.

Table 6.4 Weights and VDC wise mean values for indicators of exposure

Indicators	Weight	Aggregate (n=221)	Kaule (n=58)	Kankada (n=56)	Mahadevsthan (n=54)	Bhumlichowk (n=53)	P-value
Minimum Temperature	0.58	0.04 (0.00)	0.05 (0.00)	0.05 (0.00)	0.04 (0.00)	0.05 (0.00)	0.00^{***}
Maximum Temperature	-0.59	0.03 (0.00)	0.03 (0.00)	0.04 (0.00)	0.04 (0.00)	0.03 (0.00)	0.00^{***}
Rainfall	0.56	5.87 (1.04)	7.00 (0.23)	4.46 (0.01)	5.45 (0.41)	6.59 (0.20)	0.00^{***}
Natural disasters	0.09	2.65 (1.18)	2.66 (1.43)	2.05 (0.92)	3.00 (1.05)	2.92 (1.00)	0.00^{***}

Source: Interpolated raw data from DHM; Field Survey, 2011
Note: Figures in parenthesis indicate standard deviation
*** indicate significant at 1% level of significance

The indicators of sensitivity are contributing to sensitivity index in the direction as hypothesized (Table 6.5). Among the weights for sensitivity indicators, livelihood impacts due to natural disasters are seen to influence more to the overall sensitivity index compared to the income structure. Share of remunerative income assist to decrease the overall household sensitivity (shown by negative weight), while higher share of natural resource based income makes the household more sensitive to climate change and extremes. Although the number of natural disasters was least reported in Kankada (Table 6.4), the damage caused by the natural disasters is the highest in Kankada for all the indicators (Table 6.5). This can be related to the incidences of very intensive and destructive rainfall over the last decade, thereby causing more landslides in the area. Second highest crop damage was reported in Mahadevsthan followed by Bhumlichowk because of higher occurrences of drought over the last 10 years in these two VDCs (Appendix 6). Higher share of natural resource based income compared to non-natural resource based income for all the study VDCs show that Chepang livelihoods is predominantly based on natural-resource based activities most notably agriculture, livestock, and forestry (Appendix 4).

Table 6.5 Weights and VDC wise mean values for indicators of sensitivity

Indicators	Weight	Aggregate (n=221)	Kaule (n=58)	Kankada (n=56)	Mahadevsthan (n=54)	Bhumlichowk (n=53)	P-value
Fatalities	0.52	0.09 (0.91)	0.00 (0)	0.36 (1.79)	0.00 (0)	0.00 (0)	0.09^{*}
Land affected	0.42	5.45 (12.55)	1.23 (3.33)	17.64 (19.79)	1.79 (4.68)	0.90 (1.73)	0.00^{***}
Livestock affected	0.51	0.28 (1.34)	0.13 (0.5)	0.87 (2.48)	0.08 (0.54)	0.02 (0.16)	0.00^{***}
Crop affected	0.53	17,958.5 (32,521.7)	6,628.8 (7,549.5)	35,329.6 (51,563.6)	17,202.3 (31,026.1)	12,773.1 (11,081.1)	0.00^{***}
Share of natural resource based income	0.09	60.24 (26.71)	51.98 (25.35)	61.10 (28.30)	61.29 (28.59)	67.32 (22.50)	0.02^{**}
Share of remunerative income	-0.06	11.21 (21.20)	9.56 (18.50)	14.60 (23.91)	10.67 (23.16)	9.99 (18.93)	0.57

Source: Field Survey, 2011

Note: Figures in parenthesis indicate standard deviation

***, **, * indicate significant at 1%, 5%, and 10% level of significance respectively

In general, the mean value of assets reveals that Bhumlichowk has the highest asset possession while Kaule has the least possession among the study VDCs (Table 6.6). First step PCA was run separately for the five groups of indicators for each asset type, based on which separate index score for each asset-class was calculated. These index scores for each asset-class are the inputs for second step PCA, based on which aggregate adaptive capacity index score was computed. First step PCA shows the relative importance of indicators within each asset type. Second step PCA shows relative importance of the asset types to determine total adaptive capacity. The index in this study makes use of both composite and aggregate types. A single aggregate score of adaptive capacity index is computed while maintaining the transparency in the composite make-up of that score (Figure 6.1).

Table 6.6 VDC wise mean values for indicators of adaptive capacity

Indicators	Aggregate (n=221)	Kaule (n=58)	Kankada (n=56)	Mahadevsthan (n=54)	Bhumlichowk (n=53)	P-value
House type	2.24 (0.48)	2.16 (0.45)	2.23 (0.47)	2.20 (0.49)	2.38 (0.49)	0.09*
Have device to access information (mobile, radio)	0.69 (0.46)	0.47 (0.50)	0.73 (0.45)	0.78 (0.42)	0.81 (0.39)	0.00***
Walking distance to nearest road	2.12 (2.62)	3.09 (0.82)	3.15 (0.69)	1.39 (4.76)	0.72 (0.33)	0.00***
Irrigated land	13.06 (21.9)	7.72 (19.8)	2.94 (13.34)	22.45 (24.85)	20.03 (22.32)	0.00***
Highest qualification	4.62 (2.90)	4.36 (2.76)	4.88 (2.94)	3.74 (3.08)	5.51 (2.58)	0.01**
Dependency Ratio	1.21 (0.76)	0.93 (0.65)	1.42 (0.84)	1.11 (0.68)	1.40 (0.75)	0.00***
Trainings / vocational course	0.52 (0.78)	0.41 (0.62)	0.48 (0.74)	0.56 (0.88)	0.62 (0.86)	0.52
Share of productive land type	74.49 (25.46)	77.11 (20.97)	61.64 (33.34)	84.43 (23.24)	75.07 (15.66)	0.00***
Share of less productive land type	25.02 (25.03)	22.88 (20.98)	36.58 (32.65)	15.46 (23.27)	24.88 (15.64)	0.00***
Have bullock	0.66 (0.47)	0.64 (0.48)	0.71 (0.46)	0.59 (0.50)	0.70 (0.46)	0.51
Gross household annual income	87,973.3 (59,252.8)	61,193.0 (35,826.2)	89,695.1 (51,915.4)	76,820.7 (52,118.5)	126,823.5 (73,191.1)	0.00***
Livelihood Diversification Index	0.53 (0.14)	0.54 (0.17)	0.54 (0.14)	0.54 (0.13)	0.52 (0.13)	0.82
Savings	2,136.9 (9,469.9)	1,119.9 (4,554.1)	1,822.3 (10,660.1)	1,481.7 (4,678.5)	4,249.6 (14,419.4)	0.30
Ownership of goat, poultry, and pig	1.93 (1.35)	1.61 (1.07)	2.22 (1.47)	1.87 (1.22)	2.03 (1.56)	0.09*
Membership in CBOs	1.11 (1.15)	0.88 (1.11)	1.05 (1.24)	1.41 (1.30)	1.11 (0.87)	0.10*
Access to credit	2.65 (0.95)	2.31 (0.86)	2.77 (1.06)	2.74 (0.85)	2.79 (0.95)	0.01**

Source: Field Survey, 2010/2011
Note: Figures in parenthesis indicate standard deviation
***, **, * indicate significant at 1%, 5%, and 10% level of significance respectively

For physical assets, house type and the information devices have the highest influence followed by distance to road and percentage of irrigation. Walking distance to the nearest road negatively impacts the adaptive capacity as hypothesized. For the human assets highest qualification and training received higher weights; dependency ratio decreases the adaptive capacity as shown by the negative sign of the weight. Under natural assets, quality of land owned has higher impact in determining the adaptive capacity, while higher share of *khoriya* land decreases the adaptive capacity as hypothesized. Among the financial assets, household annual income receives the highest weightage followed by small livestock, saving, and diversification index. For the social assets, both the indicators have equal weights.

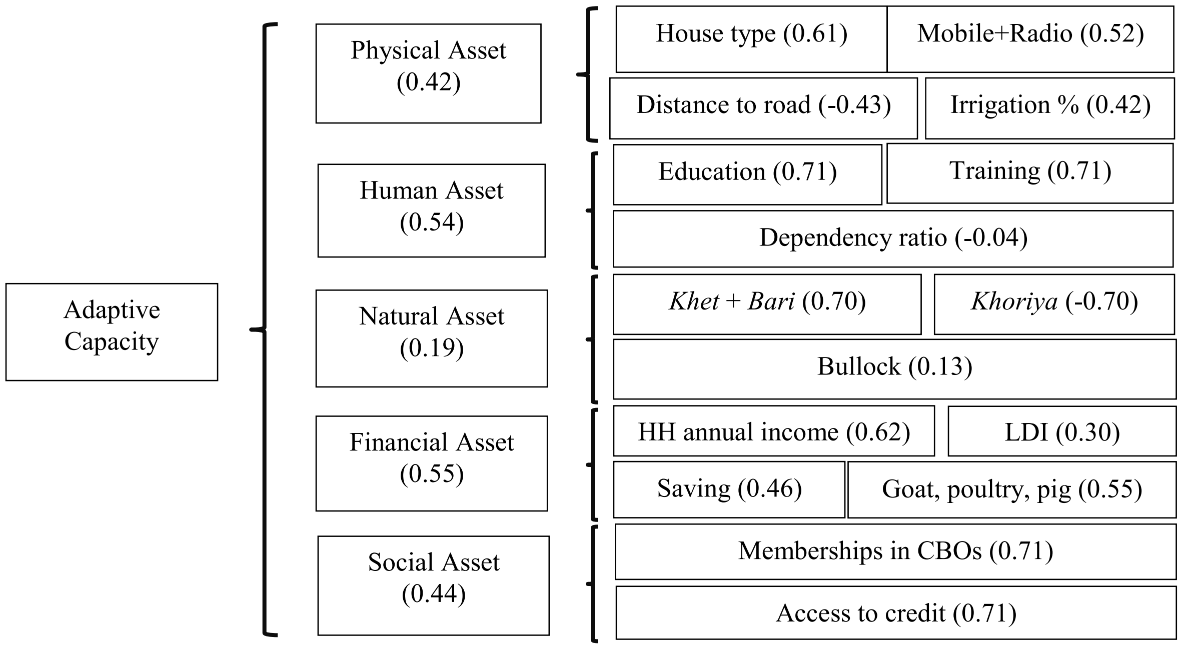


Figure 6.1 Structure of aggregate adaptive capacity index, composite sub-indices, and component indicators

Note: Figures in parenthesis are the loadings obtained from first principal component taken as weights for the respective indicators (b_i)

Second-step PCA shows that financial assets and human assets are the two most important determinants of overall adaptive capacity followed by social and physical assets. Financial asset is important as it is the most convenient form of asset that can be converted into other forms of asset when needed. Development of human assets in terms of education and skill development trainings is a must in order to be able to properly utilize the existing physical and financial assets. Furthermore, local institutions and social networks are equally crucial as demonstrated by the importance of social assets. Physical assets, especially infrastructures like roads, are important to improve the access to social assets (e.g. institutions) and financial assets (e.g. employment opportunities) as well as to improve human assets (e.g. educational infrastructures). Natural assets receives the least weightage, which is quite relevant given the fact that natural resources are more impacted upon by climate change and related disasters compared to the other asset types. Thus improving the adaptive capacity against climate extremities requires diversification to livelihoods that is less dependent on natural resources.

As shown by the weights obtained from PCA analysis for asset categories, the first and foremost policy focus in the Chepang community should be to increase their access to financial assets and improve human assets. This does not imply that the remaining asset categories are not important. Social networks and physical assets are equally important as well. Financial assets enable households to make investment in education and the savings can be used as capital for investments like buying good quality land or buying necessary inputs for cash crop cultivation. However, financial asset is very limited in the remote rural areas that are far from the market due to fewer opportunities that generate cash income. Development supports that create employment opportunities for cash income generation in the area is recommendable. Highest qualification among the Chepang community is less than 5 years on average (Table 6.6), which is very low thus having several negative consequences in their livelihoods. Illiteracy, for example, hinders them from attaining the skills required to make more productive use of the available natural and physical resources. Policies should be geared towards improving the literacy rate of the community, and also towards providing trainings and vocational education for capacity building and skills development, so that they can diversify their livelihoods to more remunerative sources.

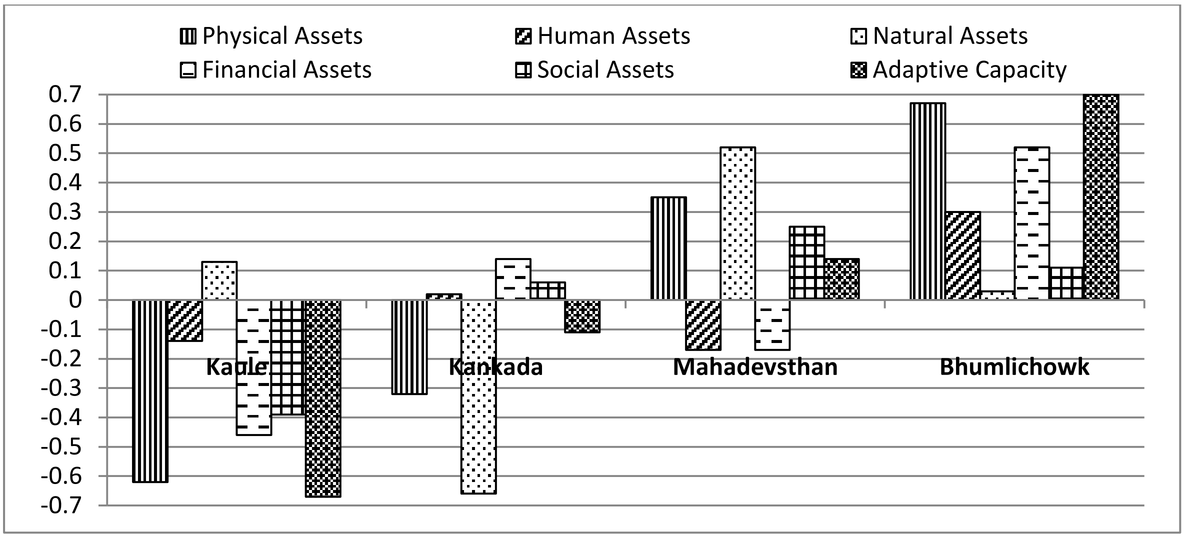


Figure 6.2 Index scores for adaptive capacity and its components in the four study VDCs

Figure 6.2 shows the index values for adaptive capacity and its components across the four study sites (values given in Appendix 7). Bhumlichowk fares the best in three of the asset categories (physical, human and financial) and second-best in social assets, thereby scoring the highest in overall adaptive capacity. The mean values of individual indicators in Table 6.6 shows that Bhumlichowk ranks the first in terms of possession of physical assets (house type, information devices), is nearest to the road, has comparatively higher percentage of irrigated land, highest education and training, highest annual income, highest saving and best access to credit. Kaule stands the last in terms of all the asset categories (except natural assets) and thus has the least adaptive capacity. Mahadevsthan ranks the second and Kankada third in terms of adaptive capacity index.

According to the value of the vulnerability index (Figure 6.3 and Appendix 8), Kaule is the most vulnerable VDC while Mahadevsthan is the least vulnerable. Bhumlichowk and Kankada rank the second and third in terms of vulnerability index. Kaule has the highest exposure coupled with lowest adaptive capacity as a result of which, it is the most vulnerable VDC. Bhumlichowk, despite having the highest adaptive capacity ranks the second most vulnerable VDC owing to its high exposure index; however it has to be noted that this VDC has been able to reduce its vulnerability considerably owing to higher adaptive capacity. Despite having comparatively lower adaptive capacity than Bhumlichowk, Kankada and Mahadevsthan VDC fares better in terms of overall vulnerability as these VDCs face lesser exposure.

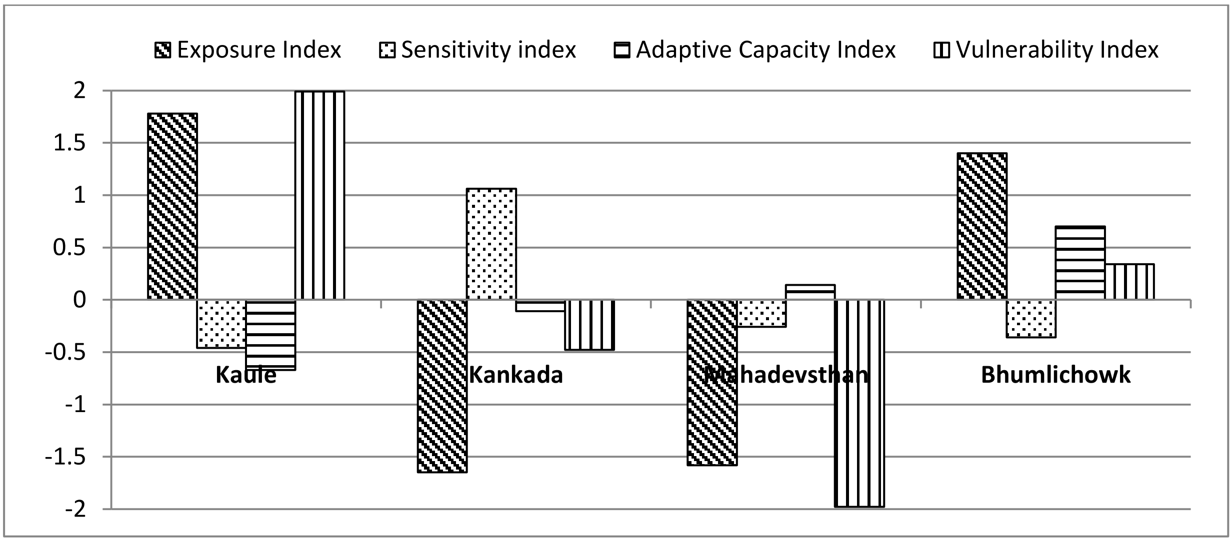


Figure 6.3 Index scores for vulnerability and its components for the study VDCs

Comparing between the two least vulnerable VDCs, both are similar in terms of exposure, however higher sensitivity and lower adaptive capacity in Kankada results in higher vulnerability there compared to Mahadevsthan. However, Kankada and Mahadevsthan VDCs have quite low adaptive capacity, which means that the livelihood impacts of sudden extreme climatic events will be quite high in these VDCs. This fact is demonstrated in Table 6.5, where the livelihood impacts of extreme climatic events is the highest in Kankada VDC (thereby having the highest sensitivity index). This is because the number of landslides reported in the highest for Kankada VDC (Appendix 6). It faced a big landslide in 2001, which claimed several more than 60 human lives and enormous property damage. Similarly, the second highest livelihood impacts of extreme events in terms of damage to land, crop and livestock is in Mahadevsthan VDC (Table 6.5). In case of Mahadevsthan, the VDC has been suffering the most from a series of droughts in the recent years (see also Appendix 6). On the other hand, comparing Bhumlichowk and Mahadevsthan, despite having higher number of reported landslides and similar number of reported droughts in Bhumlichowk (Appendix 6), it has lesser reported damages because of its higher adaptive capacity. This implies that it is very important to build the adaptive capacity of the community to enable them to face the risk of sudden natural disasters. Besides, relief measures to support the community during emergencies must be put in place for all the VDCs having both higher exposure as well as lesser adaptive capacity.

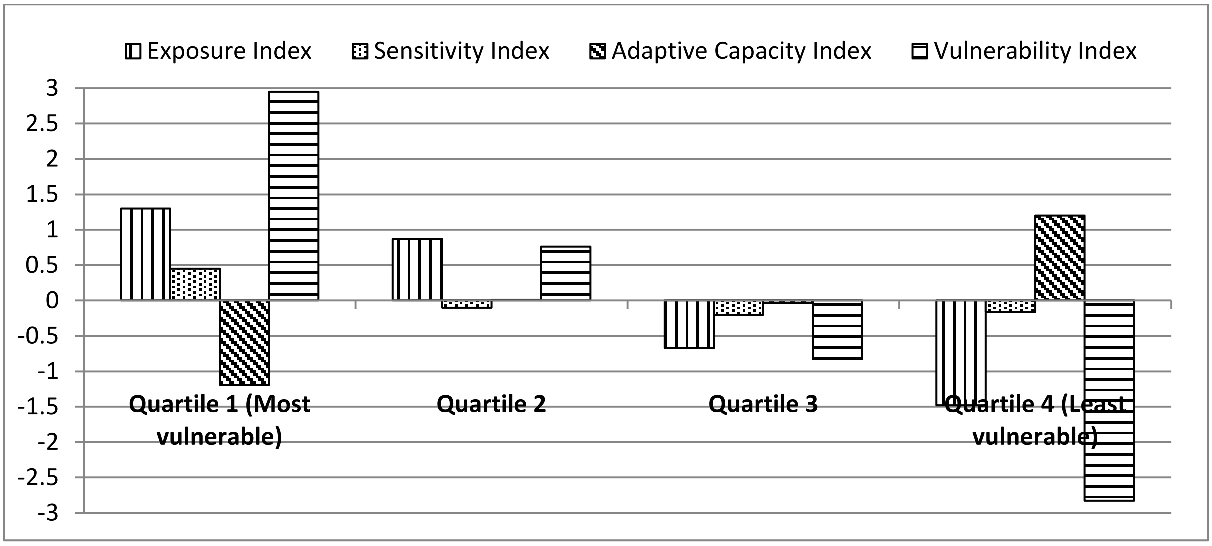


Figure 6.4 Index scores for vulnerability and it‟s components by vulnerability quartiles

Next for inter-household analysis, the sample households from all four VDCs were categorized into four vulnerability quartiles, the first quartile representing the most vulnerable and fourth quartile representing the least vulnerable households. The index values for the quartiles are presented in Figure 6.4 (also see Appendix 9). Index for exposure is the highest for the first quartile and the least for the last quartile as expected. Index values for sensitivity is also the highest for the first quartile and lesser for the last quartile. Similarly, adaptive capacity follows the expected order, with the value being lowest for the first quartile and the highest for the last quartile. Sensitivity is also highest for the first quartile and second least for the last quartile. This shows that irrespective of the locations, households with lower adaptive capacity are faced with higher exposure and higher sensitivity to climate change and extreme events. Poorer households are thus vulnerable anywhere irrespective of their locations.

6.4 Conclusion and policy implications

The results imply that exposure of a locality to long term changes in climate variables and occurrences of natural disasters is the most important component to determine the overall vulnerability of the locality. However, biophysical elements determining the exposure like temperature, rainfall and natural disasters are beyond the immediate influence of the policy makers. Out of the three components of vulnerability, adaptive capacity is the component having direct policy implications. Improving the adaptive capacity also has indirect implications on improving the sensitivity of the community. For example, improving the irrigation facilities (physical assets) in the locality decreases the sensitivity of crops to droughts. Similarly, creating opportunities for non-farm income reduces the extensive dependence of the community on natural resource based livelihoods, thereby reducing their sensitivity towards climate change and extremes. Inter-VDC comparison of vulnerability shows that despite having higher adaptive capacity, such capacity may not be fully realized in the face of higher exposure (e.g. Bhumlichowk). On the other hand, even in VDCs with comparatively lower exposures, sudden onset of extreme events can result in significant property loss if the community does not possess sufficient adaptive capacity. Thus, policy measures should be in place for the arrangement of activities like provision of post-disaster relief measures, maintaining buffers (like food stores), establishment of early warning systems, and evacuation centers in localities having both higher exposure and lower adaptive capacity. Inter-quartile analysis of the components of vulnerability shows that the most vulnerable households are the ones with the lowest adaptive capacity and they are the ones facing highest exposure as well as sensitivity irrespective of the locality. Thus, improving the adaptive capacity of these vulnerable households also reduces their sensitivity and finally decreases their overall vulnerability.

Among the various components of adaptive capacity, the foremost policy emphasis should be placed to create opportunities for non-farm livelihoods options, which will not only improve the cash income of the community, but also reduce their dependence on natural resources. Higher financial assets at hand mean more choices for productive investments. However, this has to be backed-up by educating the community and providing relevant trainings and vocational education so as to develop the human capacity able to utilize the existing opportunities and assets. As agriculture still forms the mainstay of the community, development of basic infrastructure like irrigation facilities is a must. Similarly, construction of all-weather roads linking the settlements to the nearest market centers will help to create markets for their farm outputs, and also improve their access to inputs, information, and off-farm employment opportunities. Finally, memberships in CBOs working in various sectors of rural livelihoods will improve the access of the community to information, inputs, services, and credits thereby reducing their vulnerability.

Chapter 7. Livelihood impacts of climate change and extreme events

7.1 Introduction

The climate change impact studies have quite well explained the trends of physical factors like temperature, rainfall, and the frequency of extreme events; and the primary consequences of such changes in glaciers, polar ice sheets, permafrost, and sea levels. These are the physical manifestations of climate change. At the local level, there are varied manifestations of climate change impacts, which are most often not addressed by the scientific models that are conducted at the global, regional or national level. Firstly, as also identified by IPCC, climate models are yet to gain accuracy at the micro-spatial scale (IPCC, 2007a). Secondly, the impacts of climate change at the local level are often manipulated not only by the physical factors, but also by economic, institutional, and social factors that are outside the scope of biophysical models (Adger and Kelly, 1999; Adger, 1999). The local people"s observations are based on their day-to-day interactions with the local climate (Vedwan, 2006); therefore local observations can provide substantial inputs for scientific researches on the topics that may have been overlooked (Byg and Salick, 2009). Integrated participatory assessment of local impacts by community and researchers jointly can also provide locally relevant policy recommendations (Patino and Gauthier, 2009). This chapter assesses the locally observed impacts of changing trends of temperature, precipitation, and the occurrence of extreme climatic events on the livelihood activities and outcomes of the Chepangs.

7.2 Data source and analysis

This chapter uses the information obtained from group discussion and key informants" interview in the first phase of the field visits, and household survey in the second phase of the field visit. The impacts of changing temperature patterns, rainfall patterns, and occurrence of extreme climatic events were assessed through key informant"s interviews, group discussions, and household survey. After asking the respondents if they perceived any changes in temperature and rainfall, those perceiving some changes were asked about the impacts those changes brought in their livelihoods. Similar to Chapter 5, the impacts assessment was also based on the perceptions of the respondents for the last ten years. The analysis in this Chapter is basically descriptive in nature.

7.3 Impacts of climate change and extreme event on people's lives

The questions on impact study were basically directed towards three particular aspects of climate change, viz. changing temperature patterns, rainfall patterns and occurrence of extreme climatic events.

7.3.1 Impacts of temperature changes

Table 7.1 Impacts of changes in temperature

Impacts of	Types of impacts
Higher temperature on crops	Drying of crops (43), More flower drop in fruits (1), Yellowing of maize (1)
Higher temperature on livestock	Death of small livestock due to heatstroke (3), More diseases in livestock (13), Lesser livestock productivity (6), Less fodder availability (7)
Higher temperature on human	Illness in human (diarrhea, vomiting, dysentery, indigestion, loss of appetite, headache) (25), Difficult to work (labor) (14), Decay of food (1)
Lower temperature on crops	Dews decay millet (1)
Lower temperature on livestock	Death of small livestock due to cold (3)
Lower temperature on human	Illness in human (cough, cold) (3)

Source: Field Survey, 2010/2011
Note: Figures in parenthesis indicate the number of responses received

The impacts of changes in temperature are summarized in Table 7.1. Corresponding to the majority of respondents perceiving rising summer temperature, most of the impacts felt are also due to higher temperature. The most cited impact of rising summer temperature is drying of crops. Respondents reported that due to rising temperatures coupled with untimely rainfall, maize crops are the hardest hit as maize is cultivated rainfed in the area. Other impacts of increasing temperatures are human illnesses like diarrhea, vomiting, indigestion, dysentery, loss of appetite and headache due to higher temperature, while one of the respondents also report food decay due to higher temperatures. Many respondents also report difficulties to work during summer, and higher incidences of diseases like bloating in the livestock. Responses of lesser fodder availability, lesser livestock productivity, and death of small livestock (especially poultry) due to heatstroke are also obtained. The impacts felt due to lower temperature is quite few because the proportion of respondents perceiving decreasing temperature is also lesser. One of the impacts of lower temperature reported is decaying of millet due to higher dew formation at the time of harvest. This corresponds to decreasing winter temperature (December to Februrary). The *Mangsirey* variety of millet is harvested during the first half of December. Other impacts of lower temperature reported are death of small livestock and illnesses in human due to cold. All the impacts reported due to changing temperature are negative.

7.3.2 Impacts of rainfall changes

Table 7.2 Impacts of changes in rainfall

Impacts of	Types of impacts
Lesser rainfall on crops	Less production due to less/no rain (53), Drying of crops/fruit trees (26)
Lesser rainfall on livestock	Lesser fodder availability (9), Diseases in livestock (9), Lesser livestock productivity (3)
Lesser rainfall on human	More illness in human (4)
Shifts in rainfall patterns on crops	Cannot sow/transplant on time (22), Less crop production due to untimely sowing (1), Hampers land preparation for sowing (3)
Unpredictable rainfall on crops	Alternate dry and wet periods hamper crops (6)
Higher rainfall on crops	Lodging (2), Lesser crop production due to water logging (2), More diseases in fruits/crops (3), Higher crop production (11)
Higher rainfall on livestock	More fodder available (2)
High rainfall on properties	Properties/crops washed away by heavy rains/landslides (8)

Source: Field Survey, 2010/2011
Note: Figures in parenthesis indicate the number of responses received

The impacts of changes in rainfall quantity and patterns are summarized in Table 7.2. As majority of the respondents perceive decreasing rainfall quantity, many respondents feel that the crop production is declining due to lesser rain or no rain especially during the tasseling and silking stage of maize. In reference to Chapter 5, around 50.5% of the respondents report that the post-winter rainfall (March-April) is arriving later than usual and the amount is decreasing. The recorded data also shows declining amount of post-winter rainfall. Chepangs wait for post-winter rain to prepare land and sow maize. Maize is the staple food crop for the Chepangs, and is thus the most important crop. The impact of shifting post-winter rain has resulted in the shift in sowing time of maize by 1-1.5 months from early March to mid-April. Overall, 29% of the respondents say that monsoon rainfall is getting unpredictable; nearly 12% say monsoon rain is arriving later than usual; and 15% say the total monsoon rain is decreasing (which is again in accordance to what the records show). Monsoon rain is also important for maize as the period coincides with silking and tasseling stage of maize, the most critical growth phase in terms of water requirements. The unfavorable changes (decreasing amount and later onset) in post-winter and monsoon rainfall are reported to hamper maize crops, the staple food for Chepangs. Besides maize, millet crop is also hampered due to the changing nature of rainfall. Indigenous variety of maize is harvested from August to early September depending on the sowing date. Millet is transplanted after the harvest of maize crop in early August. However, when maize is sown late, transplanting of millet is also hampered due to late harvest of maize. The respondents report that they had to transplant millet within the standing maize crop because maize could not be harvested due to shift in showing time owing to the later onset of post-winter rain. Some households even report that they could not sow millet in some of the recent years due to considerable shift in the sowing time for maize.

Many also report drying of crops and fruit trees due to lack of rain. Similarly, lesser fodder availability due to drought is also reported subsequently resulting in lesser livestock productivity and diseases in livestock. Human illnesses like fever and headache are also reported. The impact of late rainfall shows impact on the shift sowing and transplanting time of crops, one respondent felt crop production is decreasing due to untimely sowing, while a few said that land preparation for sowing maize is hampered due to late post-winter rains. The unpredictable nature of rains is also affecting the productivity of crops. More recently, onset of monsoon has shifted from June to mid-July causing mid-season drought in maize during this period. The drought during June to early July is hampering the maize crop while too much rain in August is hampering the tomato harvest. There are mixed responses obtained from those perceiving higher rainfall. Some respondents say the crop production is higher and fodder is more available due to higher rainfall, while few of them say that too much rain causes lodging of crops, problems of water logging, and higher incidences of crop diseases. Similarly, eight respondents report washing away of standing crops, and land by erratic rainfall during monsoon.

Some impacts like lesser crop production, drying of crops due to lesser rainfall and shift in the sowing time due to shift in rainfall patterns are more consistently mentioned by many of the respondents while others are mentioned by only few. In general, the seasonal rainfall changes reported by the respondents are in line with the recorded data, thus the impacts reported are also plausible. Most of the impacts of changing rainfall patterns are negative except for increase in crop production and fodder availability due to increasing rainfall; however positive responses are considerably fewer.

7.3.3 Impacts of extreme climate events

The most commonly reported climatic hazards in the study area are floods/landslides, drought and hailstorms; and these are main shocks having direct implications on their agriculture and thus their livelihoods. Landslides are common in the geographically fragile Mahabharata hills where most of the Chepang settlements are located. The foot of the Mahabharata range is the region which receives greatest number of high intensity rains, that is to say number of occurrences of highest amount of rainfall within 24 hours (Practical Action, 2009). Furthermore, these hills are geographically very fragile, and thus prone to floods and landslides. Respondents opine that droughts have become more frequent over the last five years; especially short-duration droughts during the maize-growing season coupled with uncertain timing of rainfall that have hampered maize cultivation. Hailstorms have been occurring frequently over the last few years during April-May that coincides with germination of maize and early fruiting stage of pears and oranges. Many farmers report re-sowing of maize after the losses from hailstorms. Pears and oranges are the major cash crops for Chepangs, especially in Kaule VDC. Due to hailstorms, they have been unable to sell the produce for the last 3-5 years.

Table 7.3 Extreme climatic events reported for the last ten years

VDC	Parameters	Flood/landslide	Drought	Hailstorm
Aggregate	No. of reporting households	132 (59.7)	174 (78.7)	159 (71.9)
	Range of occurrences	1 – 4	1 – 3	1 – 3
	Mean number of occurrence	0.79	1.01	0.85
Kaule	No. of reporting households	20 (34.5)	45 (77.6)	52 (89.7)
	Range of occurrences	1 – 4	1 – 3	1 – 3
	Mean number of occurrence	0.52	0.93	1.21
Kankada	No. of reporting households	56 (100.0)	24 (42.9)	11 (19.6)
	Range of occurrences	1 – 2	1 – 3	1
	Mean number of occurrence	1.34	0.52	0.20
Mahadevsthan	No. of reporting households	26 (48.1)	52 (96.3)	51 (94.4)
	Range of occurrences	1 – 3	1 – 2	1 – 3
	Mean number of occurrence	0.59	1.35	1.06
Bhumlichowk	No. of reporting households	30 (56.6)	53 (100)	45 (84.9)
	Range of occurrences	1 – 3	1 – 2	1 - 2
	Mean number of occurrence	0.70	1.28	0.94

Source: Field survey, 2011
Note: Figures in parenthesis indicate percentage

Table 7.3 shows the number of occurrences of the climatic disasters that happened over the last ten years, as reported by the households. Flood/landslide is reported by all the households in Kankada with the highest mean number of occurrences; after Kankada flood/landslides is the second highest in Bhumlichowk in terms of both the number of households reporting such incidents and also the mean number of occurrences; the number of households reporting flood/landslide and the frequency is the lowest in Kaule (34.5%). Drought is reported by all the households in Bhumlichowk, by 96.3% of the households in Mahadevsthan, and the least by households in Kankada (42.9%); the mean number of occurrences being highest in Mahadevsthan (1.35), second highest in Bhumlichowk (1.28), and the lowest in Kankada (0.52). Households reporting hailstorm is the highest in Mahadevsthan (94.4%), followed by Kaule (89.7%) and Bhumlichowk (84.9%); only 19.6% of the households report hailstorms in Kankada. The number of occurrences of hailstorm is the highest for Kaule (1.21), followed closely by Mahadevsthan (1.06) and Bhumlichowk (0.94); the lowest being for Kankada (0.20). VDC wise, in Kaule the most commonly reported event is hailstorm and drought reported by nearly 90% and 78% of the households respectively; flood/landslides are reported by comparatively fewer households (35%). In Kankada, floods/landslides are reported by all the households and the frequency of occurrence is also the highest; however, drought and hailstorm is comparatively less reported in Kankada than in other VDCs. In Mahadevsthan, both drought and hailstorm is reported by most of the households, the frequency being highest for droughts. In Bhumlichowk, all the households reported drought and the frequency of occurrence is also higher; those reporting flood/landslides are relatively lesser (57%). Thus among the four VDCs, hailstorm is the major climatic hazard in Kaule, flood/landslide is the major hazard in Kankada, and drought (closely followed by hailstorm) is the major hazard in Mahadevsthan and Bhumlichowk. The occurrence of drought and hailstorm was reported mostly within the last four years, showing that these climate extremes are getting more frequent recently.

The livelihood impacts of these extreme climatic events over the last ten years, as shown in Table 7.4, have been already discussed in Chapter 6. The impacts were quantified in terms of fatalities of family members, land washed away by flood/landslides in hectares, death of livestock due to these events measured in LSU and loss of standing crops due to these events were measured in terms of monetary values. Fatalities were reported only in Kankada VDC, which is caused by the big flood/landslide that occurred in the VDC in

2001. Consequently, impacts on land, livestock, and standing crop are also the highest in Kankada VDC. Besides flood/landslides, the occurrences of droughts and hailstorms in Kankada VDC are considerably lower compared to the other VDCs, yet the livelihood impacts are the highest here implying that floods/landslides are the most devastating climatic hazards among those reported in the study area.

Table 7.4 Livelihood impacts of flood/landslide, drought, and hailstorms over the last ten years (average per household)

Impacts	Aggregate (n=221)	Kaule (n=58)	Kankada (n=56)	Mahadevsthan (n=54)	Bhumlichowk (n=53)	P-value
Fatalities (Number)	0.09 (0.91)	0.00 (0.00)	0.36 (1.79)	0.00 (0.00)	0.00 (0.00)	0.09^{*}
Land washed away (hectare)	5.45 (12.55)	1.23 (3.33)	17.64 (19.79)	1.79 (4.68)	0.90 (1.73)	0.00^{***}
Livestock affected (LSU)	0.28 (1.34)	0.13 (0.5)	0.87 (2.48)	0.08 (0.54)	0.02 (0.16)	0.00^{***}
Crop affected (NRs.)	17,958.5 (32,521.7)	6,628.8 (7,549.5)	35,329.6 (51,563.6)	17,202.3 (31,026.1)	12,773.1 (11,081.1)	0.00^{***}

Source: Field Survey, 2011
Note: ***, * denote significant at 1% and 10% level of significance respectively

7.4 Conclusion and policy recommendations

While the major highlights of climate change impact studies are large scale physical impacts like sea level rise, occurrence of large scale floods, and glacier melts; the smaller less dramatic impacts like mid-season droughts, landslides, hails, shifting rainfall patterns, and declining rainfall quantity are more significant to the marginalized rural communities like Chepangs. For Chepangs whose livelihoods is always on the brink of food scarcity, a two-months drought during the maize growing season is enough to push the family into destitution. Therefore, this chapter can provide insights for scientific studies and mitigation policies to focus on the impacts of increasing occurrences of mid-season droughts, hailstorms, increasing number of torrential rains causing landslides, shifting rainfall patterns and declining quantity of rainfall on the livelihoods of highly marginalized communities living in geographically vulnerable areas and depending predominantly on subsistence rainfed farming for livelihoods. Policy implications are that while the emergency relief measures in place can help short-term coping for the households after an extreme event, early warning systems coupled with emergency shelters in place can help the households seek refuge during such incidents. Declining rainfall amount and increasing frequency of droughts call for a need to drought resistant crop varieties, especially maize and millet, the two most important staple crops for the Chepangs. Finally, all season irrigation infrastructures would reduce the dependency on rainfall for farming, thereby also reducing the impacts of uncertain timing and declining quantity of rainfall on crop production.

Chapter 8. Adaptation strategies and factors influencing the adaptation choices

8.1 Introduction

As the challenges and opportunities of climate change become clear, adaptation issues have been placed high on the international agenda, with emphasis being placed on the natural resource dependent rural and marginalized communities in developing countries (Jones and Boyd, 2011; UNFCCC, 2009). As pointed out by Smit and Wandel (2006), much of the earlier studies related to climate change adaptation were based on hypothetical adaptation practices presumed by the researchers used to model the degree to which climate change impacts would vary with and without those practices or to make a comparative analysis among a suite of possible adaptations using tools like cost-benefit analysis and cost effectiveness. Until then, few studies were done to document the actual adaptation practices that are ongoing or suitable in a particular locality and to analyze the drivers of adaptive capacity or the process by which the capacity is translated into actual adaptation actions (Adger et al., 2003; Adger and Kelly, 1999; Adger, 1999; Wall and Smit, 2005). The most important characteristic of this body of literature is that the assessment is done on the basis of direct interaction with the communities, thus termed as a bottom-up approach, as opposed to the earlier top-down approaches where adaptation practices or indicators of adaptive capacity are presumed by the researchers themselves.

Adaptation refers to the process, action or outcome in a system that helps to better cope with, manage or adjust to some changing condition, stress, or opportunity (Smit and Wandel, 2006). Adaptation to climate change is defined by Intergovernmental Panel on Climate Change (IPCC) as adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts (McCarthy et al., 2001). Human beings have always adapted to different stresses that may be economic, political, social, cultural, technological, and biophysical. Adaptation actions undertaken to address one type of stress may reduce or aggravate the risk to climatic stresses, and vice versa. The choice of high yielding hybrid varieties is a good example. These varieties are capable to address the problems of low productivity and food insecurity if managed properly; however these varieties are less resistant to drought, thus more vulnerable to untimely rains in rain-fed systems. The adaptation responses to two or more of these stresses may overlap, making it difficult to single out the adaptation practices formulated in response to climatic stresses only (Below et al., 2010). For example, a farming household may decide to shift from agriculture to livestock with a motive of profit maximization or in response to increasing drought spells hampering crops, or both. In addition, adaptation is often a dynamic process. A coping strategy like a switch in the crops or varieties grown by farmers in response to a short-term drought spell may over time be translated into permanent adaptation strategy suitable to long-term climate change. Adaptation actions suitable at the community level do not necessarily involve only local actors at the micro-scale; but may involve multiple scales and multiple actors. For instance, decisions to implement crop insurance schemes by the national level policy makers can be a suitable adaptation option for the subsistence farmers at the micro level. Rural communities have been adapting to climate related risks since time immemorial; however climate change may drive the frequency of such extreme events beyond their adaptive capacity and pose new challenges. For example, in a dry year a community may thrive on previous year‟s storage, wild foods, sale of livestock, and income from wage labor. However, if drought becomes recurrent for the second year, the community might cross the threshold of vulnerability due to the depletion of storage, lack of livestock to sell, and lesser regeneration of wild foods. With the unanimous agreement that climate change is an ongoing phenomenon, it is imperative that researches on community level adaptive capacity and adaptation practices be directed from the perspective of climate change and related extreme events. Bottom-up approach has been emphasized to explore the ongoing and potential adaptation practices that can be promoted or implemented at the community level in response to the changing climate (Gbetibouo, 2009; Smit and Wandel, 2006).

In this chapter, the adoption rate of different adaptation practices is compared in terms of the percentage of households adopting each practice across the study sites. Inherent adaptive capacity is the minimum necessary condition for adaptations to take place, and adaptation practices are taken as the manifestations of adaptive capacity (Smit and Wandel, 2006). Some authors also opine that the capacity may not always be translated into action (Jakobsen, 2011; Vincent, 2007) or adaptive capacity is not always equivalent to capacity to respond (Gallopin, 2006). However these literatures do not make a quantitative comparison of adaptive capacity and adaptation practices. This chapter compares the adaptive capacity and adoption rate of adaptation practices across the study sites and analyzes if the adoption rate really corresponds to the adaptive capacity. Such analysis is a step towards understanding the relationship between adaptive capacity and the process by which adaptation takes place; and has the possibility to guide future researches focusing on the analysis of underlying drivers of adaptation practices. This chapter also analyses the determinants of household adaptation choices. Understanding the determinants of household decision to adopt a particular adaptation option among the various available choices can provide insights on the factors that enable or constrain the adaptation actions. Policy implications can be drawn from these insights so as to facilitate suitable adaptations at the community level.

The next section of the chapter presents the theoretical framework for the classification of adaptation practices based on previous literatures. The third section deals with the data sources and analysis. Description of the adaptation practices and comparison of the adoption rate with the adaptive capacity of the respective study VDC is done in the fourth section. The fifth section of the chapter focuses on the analysis of the determinants of the various adaptation choices made by the households. The last part concludes the chapter.

8.2 Theoretical framework for classifying adaptation practices

As already noted in the literature review in Chapter 2, past studies highlights four important features of adaptation to climate change. Firstly, adaptation practices are not always necessarily entirely new in the community, traditional coping strategies with or without modifications can still serve to adapt to climate change. Secondly, climate change adaptation practices may not be implemented only in response to climate related risks, but will serve to address multiple risks. Thirdly, even planned adaptation activities are not always implemented as a response to climate change alone, but integrated with other development sectors like soil-conservation, infrastructure construction, land-use planning, etc. Fourthly, climate change adaptation activities might sometimes conflict with development priorities.

Agrawal (2010) proposes an analytical approach to classify adaptation practices based on distribution of risks across space, time, assets, households, and markets. Based on these approaches of risk pooling, the adaptation strategies can be classified into five analytical categories of risk management techniques: „mobility, storage, diversification, communal pooling and market exchange". Mobility refers to the distribution of risks across space; storage helps to distribute risks across time; diversification is a strategy to distribute risks across assets; communal pooling is distributing risks across households within a community; and finally market exchange substitute for previous four categories through product exchange in the market. This paper adopts this five-fold classification of adaptation strategies as the analytical framework for analyzing the ongoing adaptation practices in the study community.

Mobility is a way of life for many rural households that are not food self-sufficient and one or more members in the family have to adopt temporary labor-migration. Mobility as such is contested whether it is an adaptation mechanism or occurs when adaptation in a locality fails; there are diverse views on involuntary migration as an adaptation means given the social, cultural and economic pressures that is exerted on both migrating as well as receiving communities (Raleigh and Jordan, 2010). Nevertheless, for rural societies whose livelihood already involves mobility within definite time periods, constraints to mobility would be an indicator of failed adaptations. Storage is a means to reduce risks across time. There are various indigenous methods of storage of food to be used for dry periods in all the rural communities. With increasing uncertainties in the rainfall patterns, storage of water is also a relevant adaptation strategy. Storage helps to create buffer for the lean periods. Diversification is the most common adaptation method in the list of UNFCCC coping strategies database. Diversification may occur within assets, livelihood activities, and production technologies. Diversification helps to diversify risks across assets and capabilities by enabling the household to substitute among various sources when one source of livelihood fails in the event of stress. Communal pooling is characterized by joint action by the households within a community with a motive of increasing the coping range compared to what the households would cope with individually. Joint management of natural resources and labor pooling are very common examples. Communal pooling often requires mediation by a viable institution in the community. Market exchange helps to distribute risks through product exchange, provided that the households have fair access to the market. Rural households might need institutional support, at least initially, to help them with networking and bargaining for fair price of their products. A single adaptation practice can be a combination of two or more classes; for example diversification is usually combined with market exchange.

This classification system is different from previous literatures. IPCC assesses the current adaptation practices based on several criteria: spatial scale (local, regional, national); sector (water, transportation, etc.); type of action (physical, technological, etc.); actor (government, private sectors, communities, individuals); climatic zone (mountain, arctic, etc.); development level (least developed or developed country); time-scale (current coping vs. long term adaptation); and timing (anticipatory or proactive, reactive) (Adger, et al., 2007). FAO (2007) further classifies adaptation practices into planned and autonomous (or spontaneous) depending on whether the practices are guided by external support or implemented by the communities on their own. These classifications are sometimes unclear. As Agrawal (2010) points out, with repeatedly occurring climate hazards, the distinction between short-term coping and long-term adaptation no longer holds. Similarly, climate extremes like droughts occurring frequently due to climate change may make it difficult to say whether the adaptation responses are proactive or reactive. Adger and Vincent (2005) opine that the distinction between planned and spontaneous adaptation is not entirely correct due to the fact that possibility of every individual or community action is controlled by the existing policies formulated by the government. These classifications do not shed light on the types of risks posed on the livelihoods by climate change and related extreme events. The analytical approach adopted in this paper, on the other hand, is more applicable to livelihoods studies as the classification is based on how the climate-risks affect the household assets and community capabilities across space and time.

8.3 Data sources and analysis

This chapter utilizes the information from both phases of field survey. The description of adaptation practices is based on the group discussions conducted in the first phase and household survey done in the second phase of field visits. Qualitative description of ongoing adaptation practices is done using the theoretical framework previously described. The adoption rate (i.e. the percentage of households adopting the particular practice) is used for comparison among the four study sites. These adoption rates are further compared with adaptive capacity (already discussed in detail in Chapter 6) to analyse if the adoption of particular practice by a household is determined by the inherent adaptive capacity. The determinants of the households‟ adaptation choices are analysed using a multivariate probit model. The empirical model and the variables are discussed later in the chapter.

8.4 Adaptation practices in the community

This chapter describes the actual adjustments or practices at the community level that is of relevance in reducing the vulnerabilities or enhancing the resilience of the community to the observed and expected changes in climate and associated extreme events. These adaptation practices have been discussed in line with the classification already described under theoretical framework. Altogether 10 different adaptation practices were identified (Table 8.1). These practices can be categorized into six broad categories depending upon the nature of risk distribution. The adoption rate of each practice is compared across the four study sites. Further, these adoption rates are discussed in line with the asset holdings and adaptive capacity presented in Chapter 6.

8.4.1 Diversification

Diversification helps to pool risks across assets possessed by a household. Diversification includes changes in the choices of crops or varieties, improvement in production technologies and increasing the range of livelihood activities. Similar to the documentation in the UNFCCC coping strategies database, majority of the adaptation practices in this study also fall within the diversification category. Similar findings have been reported by the studies related to rural adaptation practices by small-scale farmers around the world (Below et al., 2010; Gbetibouo, 2009; Howden et al., 2007; Wall and Smit, 2005).

Table 8.1 Existing adaptation practices across the four study sites

Adaptation practices	Number of households adopting the practice					P-value
	Aggregate (n=221)	Kaule (n=58)	Kankada (n=56)	Mahadevsthan (n=54)	Bhumlichowk (n=53)	
1. Diversification						
Varietal selection	42 (19.0)	3 (5.2)	16 (28.6)	11 (20.4)	12 (22.6)	0.01***
• *Short-duration maize*	41 (18.6)	3 (5.2)	16 (28.6)	10 (18.5)	12 (22.6)	0.01***
• *Mixing different maize varieties*	17 (7.7)	1 (1.7)	6 (10.7)	3 (5.6)	7 (13.2)	0.1*
Collecting wild edibles	165 (74.7)	39 (67.2)	47 (83.9)	43 (79.6)	36 (67.9)	0.1*
Adjusting sowing time	118 (53.4)	36 (62.1)	28 (50.0)	25 (46.3)	29 (54.7)	0.37
• *Late sowing*	117 (52.9)	35 (60.3)	28 (50.0)	25 (46.3)	29 (54.7)	0.48
• *Re-sowing*	3 (1.4)	2 (3.4)	0 (0.0)	0 (0.0)	1 (1.9)	0.32
• *Different dates in different plots*	7 (3.2)	0 (0.0)	0 (0.0)	0 (0.0)	7 (13.2)	0.00***
Soil conservation	218 (98.6)	57 (98.3)	54 (96.4)	54 (100.0)	53 (100.0)	0.31
• *Terracing*	168 (76.0)	44 (75.9)	34 (60.7)	46 (85.2)	44 (83.0)	0.01***
• *Wall*	172 (77.8)	47 (81.0)	37 (66.1)	43 (79.6)	45 (84.9)	0.09**
• *Drainage canals*	112 (50.7)	32 (55.2)	13 (23.2)	34 (63.0)	33 (62.3)	0.00***
• *Legume*	196 (88.7)	48 (82.8)	50 (89.3)	47 (87.0)	51 (96.2)	0.15
• *Agro-forestry*	176 (79.6)	44 (75.9)	39 (69.6)	42 (77.8)	51 (96.2)	0.00***
• *Planting hedge-row*	25 (11.3)	4 (6.9)	6 (10.7)	0 (0.0)	15 (28.3)	0.00***
• *Cover crop*	19 (8.6)	5 (8.6)	10 (17.9)	0 (0.0)	4 (7.5)	0.01***
• *Mulching*	51 (23.1)	9 (15.5)	12 (21.4)	10 (18.5)	20 (37.7)	0.02**
• *Minimum tillage*	7 (3.2)	3 (5.2)	2 (3.6)	0 (0.0)	2 (3.8)	0.45
2. Communal pooling						
Use social networks	214 (96.8)	57 (98.3)	53 (94.6)	52 (96.3)	52 (98.1)	0.65
• *Borrowing food*	179 (81.0)	51 (87.9)	44 (78.6)	42 (77.8)	42 (79.2)	0.47
• *Buy food on credit*	207 (93.7)	55 (94.8)	52 (92.9)	48 (88.9)	52 (98.1)	0.25
• *Cash loans*	189 (85.5)	52 (89.7)	46 (82.1)	46 (85.2)	45 (84.9)	0.72
3. Mobility + Diversification (Temporary migration)						
Wage labor	181 (81.9)	51 (87.9)	47 (83.9)	43 (79.6)	40 (75.5)	0.35
Other non-farm jobs	36 (16.3)	5 (8.6)	13 (23.2)	5 (9.3)	13 (24.5)	0.02**
4. Storage + Communal pooling						
Water collection pond	43 (19.5)	8 (13.8)	9 (16.1)	5 (9.3)	21 (39.6)	0.00***
5. Diversification + Market exchange						
Cash crop	126 (57.0)	27 (46.6)	39 (69.6)	11 (20.4)	49 (92.5)	0.00***
6. Storage + Diversification + Market exchange						
Livestock	154 (69.7)	39 (67.2)	44 (78.6)	36 (66.7)	35 (66.0)	0.42

Source: Field survey, 2011
Note: Figures in parenthesis indicate percentage
***, **, * indicate significant at 1%, 5%, and 10% level of significance respectively

8.4.1.1 Adjustments in varieties

There are two types of varietal adjustments made by the Chepang households: adoption of short-duration maize varieties and varietal mixing. Among the four study sites, most of the households adopting early varieties of maize are from Kankada (28.6%)

followed by Bhumlichowk (22.6%); the least is from Kaule (5.2%). This variety is suitable in response to the late onset of post-winter rain that Chepangs wait to sow maize. Post-winter rain has been reported to shift by 1-1.5 months from early March to April. However, most of the households are still sowing the indigenous varieties because the short-duration variety cannot sustain drought especially during the tasseling stage. Since agriculture is basically rainfed, most households do not want to bear the risk of possible droughts. This might contradict the development goals of achieving higher yield; however studies have shown that households are often ready to sacrifice some level of their well-being rather than undertaking the risks. For example, Afar pastoralists in Ethiopia would be ready to live with some level of poverty in exchange for similar reductions in vulnerability (Agrawal, 2010).

As a risk management strategy, fewer households mix high yielding and indigenous varieties of maize seeds, either in the same plot or sow different varieties in different plots. In case of ample rain, hybrids will give higher yield; if in case rain fails to arrive timely, the indigenous varieties would still be surviving. For this strategy of mixing maize varieties, the rate of adoption is higher in Bhumlichowk (13.2%) and Kankada (10.7%) while the least is again from Kaule with only 1.7%.

The variation in adoption rates among the study VDCs is statistically significant for both the strategies under varietal adjustment. The adaptive capacity index score in Figure 6.2 (Chapter 6) shows that Bhumlichowk and Kaule stand at the first and last position respectively. As a general rule, it is expected that households with higher adaptive capacity has higher possibility of adopting most of the adaptation practices. The adoption rate of varietal selection corresponds with this expectation in that Kaule has minimum households adopting the practices while Bhumlichowk has either the highest or second highest adoption rates. Furthermore, adoption of hybrid varieties of maize is better explained by financial assets of the household as hybrid maize varieties need extra investment in terms of purchase of seeds and the fertilizer inputs required. Tallying the adoption rate with financial assets in Figure 6.2 shows that Bhumlichowk and Kankada VDCs having comparatively higher financial assets are also the VDCs with higher adoption rates for the varietal selections discussed above. Similarly, Mahadevsthan VDC ranking third in financial assets also ranks third in the adoption rates under varietal selection and Kaule VDC with least financial assets also ranks the last in the adoption rates.

8.4.1.2 Increased dependence on wild foods

The annual subsistence cycle of Chepangs is completed by the complementarity between farming and gathering, whereby they depend dominantly on wild foods during the dry months when the grain storage is depleted and new harvest is not yet available. Dependence on wild foods is not entirely a new phenomenon for this community; and the degree of dependence increases during the years when crops are damaged due to droughts, untimely rainfall, and landslides caused by torrential rains. Almost three-fourths of the households reported they increase their collection of wild foods in such years and the dependence is quite high across all the four study sites, the highest being in Kankada (83.9%) and the lowest in Kaule (67.2%).

This corresponds to the comparison of index score for natural assets in Figure 6.2. Kankada fares the lowest in natural assets (represented by landholding and bullocks), therefore higher dependence on forest edibles is very relevant. Similarly, Kaule has second highest natural assets index score, thus it"s lesser dependence on wild food. Surprising here is Mahadevsthan, where despite the highest value of natural assets index score, the percentage of households depending on forest for wild food is second highest among the four sites. The difference among the study sites is statistically significant.

8.4.1.3 Shifting the sowing dates

Shifting rainfall patterns have led to changes in sowing dates, most notably for maize. As discussed before, post-winter rains have been arriving lately, as a result of which maize sowing has also been delayed from early March to April. This adjustment, originally adopted as a short-term coping strategy might be possibly converted into a long-term practice, given the long-term changes in rainfall pattern. Some farmers adjust their sowing dates such that the tasseling stage of maize does not coincide with the possible short term dry-spells during June to early July. Nearly 53% of the households on average reported that they shift the sowing dates to match the rainfall pattern. Relatively fewer farmers reported re-sowing of maize after the previously sown maize failed to germinate due to lack of timely rain, or was damaged due to hailstorms that have been occurring for the past three years during April. For the above two practices of late sowing and re-sowing, the difference in adoption rate among the study sites is not statistically significant. The practices of late sowing or re-sowing are common practices as farmers under rainfed conditions quite naturally have to wait for the rains before they can sow their crops. Thus these practices are not necessarily determined by the level of adaptive capacity, and the adoption rates do not vary significantly across the four study sites.

Some innovative farmers also sow maize in different plots at an interval of one to two weeks for minimization of risks related to short-term droughts. This is a recent practice in response to the intense drought in April-May for the past two years that have severely damaged the maize crops. However this practice is adopted only in Bhumlichowk VDC, the VDC with best adaptive capacity. Since Bhumlichowk is the VDC with highest human assets development in terms of qualification as well as vocational trainings (Table 6.6), it can be expected that farmers in Bhumlichowk are significantly more innovative compared to the other VDCs.

8.4.1.4 Soil conservation practices

The Mid-Hills where the Chepangs live fall under the Mahabharata range, which have faced the highest incidents of torrential rains over the last 30 years in Nepal (Practical Action, 2009). These hills are thus very vulnerable to landslides. Soil conservation practices like terracing, building stone walls and dikes, digging drainage sluices during monsoon are quite common practices in hill agriculture and holds relevance in the face of climate change due to which events of short-duration high-intensity rainfall is increasing in Nepal (Baidya and Karmacharya, 2007). While terracing and making stone walls is practiced by most of the households in all the four VDCs, drainage is practiced by very few households in Kankada, where respondents have reported highest number of destructive landslides over the past ten years. Practices like legumes integration with cereals for improving the soil fertility, and agro-forestry are very common practices that are practiced by rural communities. Besides improving the soil fertility through addition of biomass, these practices also help to reduce soil erosion by holding the soil in place and preventing the loss of top-soil by wind and running water. The remaining four practices: planting hedge-row in unterraced slopes, cover crops to protect top soil, mulching and minimum tilling for soil water retention are practiced by fewer households. These simple yet potential soil conservation practices can be promoted among the Chepang households through effective extension services. Some non-governmental organizations working in Bhumlichowk are promoting hedge-row construction in unterraced *khoriyas*. Hedge-row construction at definite intervals across the slopes helps to catch biomass and soil carried along by run-off during monsoon, and the slope is gradually converted into terraces over the long-run.

Out of the nine practices identified for soil conservation, Bhumlichowk, the VDC with highest adaptive capacity, has the highest adoption rate for five practices and the second highest for three practices. The remaining three VDCs have either the lowest or the second lowest adoption for five to six categories out of nine. The average number of soil conservation activities per household is also highest for Bhumlichowk (5 out of 9), followed by Mahadevsthan (4.11), Kaule (4.07) and Kankada (3.63) (not shown in the table). This is in accordance to the general expectations that VDC with highest adaptive capacity also has highest adoption rates.

8.4.2 Communal pooling: Utilizing the social networks

Most of the households (>78% in all four VDCs) depend upon social networks for borrowing food, buying foods on credit, and cash loans as coping strategies after a climate disaster. These practices, again, are not new in the Chepang community and are not only practiced in response to climate events. Borrowing grains from neighborhood and repaying either in grains or through agricultural labor contribution is a common practice among the Chepangs. But usually after a climate disaster like droughts, all the households in the neighborhood face food shortage together. During such times, Chepangs buy grains on credit from the shops at the nearest road-head market. As described under social assets, Chepangs depend upon informal sources of credit for fulfilling their cash needs. Many Chepang households have established a network with the road-head shopkeepers and money lenders for the purpose of credits and loans. The Chepangs repay by selling goat, poultry, commercial forest products, fruits, agri-products, honey, etc. Most literatures discredit this relationship between the Chepangs and shopkeepers/moneylenders due to the lower prices offered by the shop-keepers for the products sold by the Chepangs and the high interest rates imposed on loans by the moneylenders. However, it should be remembered that such kinds of informal lending is indispensable for the Chepangs for whom sources of cash income is very few and seasonal, and there are no formal lending institutions at their disposal. As already discussed in Chapter 4, even if formal lending institutions exist, Chepangs lack necessary documents like citizenship certificates and land-registration certificates, thereby restricting them from obtaining loans. Unless there are some measures implemented by the government or private institutions for lending money to the Chepangs, the existing informal networks continue to function as the social safety nets for the community. The adoption rate for the practices under communal pooling is not significantly different among the four study sites. The strategy of depending on social networks during the times of need is quite common in this community, and is an integrated component of their livelihoods. As a result, these practices are equally adopted in all the VDCs irrespective of the level of asset holdings.

8.4.3 Combination of mobility and diversification: Temporary labor migration

Temporary migration of male members during the dry season to nearby cities in search of non-farm jobs helps to pool risks across space and also diversify the livelihood activities in the household. The purpose for labor migration can be broadly classified into two categories: less-remunerative wage labor and other remunerative non-farm jobs. Wage labor includes jobs like portering, carrying stones for road construction, digging limestone mines, etc. These jobs are paid on daily or hourly basis. The adoption rate of wage laboring is quite high (>75%) in all the four sites and the difference is not statistically significant. Chepang households depend on seasonal wage labor during the dry periods every year when agricultural activities are not practiced due to lack of irrigation, and the households reported that their dependency on wage labor increases after a natural disaster. Wage laboring is also an integrated component of the Chepang livelihoods. Since majority of households adopt wage laboring as a source of cash income without significant differences across the study sites, this practice is not necessarily dependent upon the asset holdings of that particular household.

Other remunerative jobs include salaried jobs (clerks and guards in offices, teaching, assistants in petrol pumps, etc.); skilled non-farm jobs (carpenter, drivers, carpet weaving, etc.); and laboring in foreign countries especially Malaysia and India. Since these income sources are not based on natural resources, income flow is less affected by climate. Also annual income from these sources is comparatively higher (Chapter 4). Thus, assistance by the development agencies to diversify the households to non-farm remunerative jobs will help them reduce the risks posed by extreme climatic events. As can be seen from Table 8.1, very few households have been able to diversify to remunerative sources, the highest being 24.5% of households in Bhumlichowk and lowest in Kaule (only 8.6%). Bhumlichowk scores highest in human assets (Figure 6.2) with highest average qualification and vocational trainings (Table 6.6). The adoption rate of remunerative non-farm jobs corresponds to the index scores of human assets and financial assets for all the VDCs. Kaule and Mahadevsthan, the two VDCs scoring lower in human and financial assets also has very few households (around 9%) adopting remunerative non-farm jobs; meanwhile Bhumlichowk and Kankada VDCs having relatively higher index scores for human and financial assets also have relatively higher adoption rates (24.5% and 23.2% respectively). Higher education and vocational training is necessary to pursue salaried jobs or skilled non-farm jobs. Also financial resource is needed for investing in education, vocational trainings, and related expenditures to go abroad.

8.4.4 Combination of storage and communal pooling: Construction of water collection tanks/ponds

Irrigation is still a big constraint to agriculture in the Chepang settlements. Only 13% of the total land is irrigated (Table 6.6), due to which recurrently occurring droughts are major threats to Chepang livelihoods. Few small-sized cemented tanks or plastic ponds have been recently constructed for collecting water from natural sources in the Chepang area with support from government and non-governmental organizations. This practice helps in the distribution of risks over time by storing flowing water that was previously unused, and also across households as the use of water from these tanks is regulated by a group of households in the community. Water from these tanks is used for irrigation purposes; a single tank can serve 5 – 10 houses. During the dry seasons, water from these tanks is circulated among the households on a turn basis. The adoption is the highest, again for Bhumlichowk VDC (nearly 40%), the VDC having highest adaptive capacity, followed by Kankada (16.1%), Kaule (13.8%), and Mahadevsthan (9.3%). The difference across the study VDC is statistically significant. Once again Mahadevsthan VDC has the lowest adoption rate despite having higher adaptive capacity index score compared to Kaule and Kankada VDCs. Construction of water collection tanks or ponds in all the cases is supported financially and technically by some institutions, especially the non-governmental organizations (NGOs) working with the community. Thus, social assets in terms of households‟ memberships in community based groups formed by such institutions can explain the differences in the adoption rate of this adaptation practice. Though the mean number of memberships in CBOs is the highest in Mahadevsthan VDC, the household having access to water collection tanks is the least in this VDC. NGOs working in this VDC may not put emphasis on building collection tanks because Mahadevsthan VDC already has quite good source of irrigation as shown by the highest percentage of irrigated land among the four VDCs (Table 6.6). Otherwise, the adoption rate of rest of the three VDCs is in accordance with the household‟s possession of social assets in terms of mean number of memberships in CBOs (Table 6.6). Leaving Mahadevsthan VDC aside, both the adoption rate as well as membership in CBOs is higher in Bhumlichowk, followed by Kankada and Kaule.

8.4.5 Combination of diversification and market exchange: Growing cash crops

Diversification from subsistence agriculture to cash crops helps to increase the adaptive capacity of the households by increasing cash income. However cash crops like vegetables are more vulnerable to droughts, therefore this adaptation practice can only be realized when households have access to irrigation and market. The percentage of irrigated land is comparatively higher for Mahadevsthan (22%) and Bhumlichowk (20%) while it is very low for Kankada (3%) and Kaule (8%) (Table 6.6). In terms of households having access to some forms of irrigation, the rate is higher again for Mahadevsthan (59%) and Bhumlichowk (62%) while it is only 7% for Kankada and 22% for Kaule (not tabulated). In terms of walking distance to the motor road, Bhumlichowk is the nearest with average 0.72 hours, followed by Mahadevsthan (1.4 hours), while the distance is above 3 hours for Kaule and Kankada. Unsurprisingly, most of the households in Bhumlichowk (92.5%) grow cash crops (mainly tomato and few other vegetables) due to the availability of irrigation facilities and proximity to the road compared to other VDCs. Households in Bhumlichowk have stopped cultivating millet to allocate lands for vegetables because return from vegetables is much higher. However, in the absence of irrigation facilities, millet is a better option as it is more drought tolerant compared to vegetables. Surprisingly, after Bhumlichowk, Kankada has the second highest percentage of households (69.6%) diverting to cash crops, despite its distance away from the road and lack of irrigation facilities. However, different from Bhumlichowk, the cash crops grown in Kankada are blackgram and horsegram. These legumes are drought tolerant crops, thus do not require irrigation. Dried grains of these legumes are sold as pulses, thus perishability is not a problem and distance from the road matters less. Once again, Mahadevsthan VDC shows surprisingly the lowest adoption rate of cash crops despite a relatively higher percentage of irrigated land and proximity to the motor road.

8.4.6 Combination of storage, diversification, and market exchange: Raising livestock as buffer

As already discussed under adaptive capacity, small livestock, especially goats are a major source of financial income for the Chepang households. Goat is the most suitable livestock for the Chepangs because goats can easily walk across the difficult terrains. They are left to graze openly during the day and are brought back home in the evening. Nearly 70% of the sample households reported that due to recurrent droughts they have increased their focus on livestock and rear goats as a buffer to cope with natural disasters including droughts and landslides. The trend is very similar across the four study VDCs and the adoption rate does not differ significantly. The practice of growing small livestock as a source of cash income is also an integrated livelihood strategy for the Chepangs and is practiced by the households even without any particular reference to climate shocks. This practice is followed by majority of the households without any significant differences in the adoption rates across the study sites. Thus, adoption of this practice is not determined by the level of household adaptive capacity or possession of any particular assets by the households.

Out of 22 different adaptation practices listed in Table 8.1, Bhumlichowk has the highest or second highest adoption rate for 18 practices and has the lowest adoption rate for only two of the practices. Bhumlichowk VDC has the highest adaptive capacity index score and also has a balanced possession of all the asset categories (Figure 6.2). It appears quite relevant for this VDC to have the highest adoption rates. In the same line, it will be expected that Mahadevsthan VDC, which ranks second in the adaptive capacity index score, must have the next highest adoption rates after Bhumlichowk. However, much to the contradiction, Mahadevsthan fares the lowest in terms of adoption rate, even lower than Kaule, the VDC with least adaptive capacity index score. Mahadevsthan has the highest or second highest adoption rate for only 5 out of 22 practices, while Kankada has 12 and Kaule 10. Similarly Mahadevsthan has the least adoption rate for 10 adaptation practices, while the figures are 7 each for Kankada and Kaule. This result has two important implications. Firstly, balanced possession of all asset categories is necessary to recognize the full adaptation potential. As already explained, Bhumlichowk VDC has the balanced possession of all types of assets, thus has the highest adoption rate. On the other hand, in case of Mahadevsthan VDC, despite having higher physical and natural assets, the adoption rate is not as expected mainly due to the imbalance in human and financial assets. No single asset is sufficient to adapt or cope with risks; rather balanced possession of all five types of assets is important. A minimum development of human capabilities and financial resources for capital investment are necessary to utilize the existing resources to the fullest. Secondly, assessment of adaptive capacity in terms of asset possession might not give the complete picture because it is not clear why Mahadevsthan VDC has surprisingly lowest adoption rates, even lower than Kaule VDC, despite the fact that Kaule has the lowest possession of all asset categories except natural assets. The institutions and policies also form an important backdrop against which households formulate the asset utilization strategies to maximize livelihood outcomes. The analysis in this paper is limited in the sense institutions and policies are not taken into considerations. Future researches that analyze the factors determining the implementation of adaptation actions including the institutions, policies and asset holding is recommendable to arrive at a better explanation of the process by which adaptive capacity is translated into adaptation practices.

8.5 Determinants of households' choices of adaptation practices

As discussed in the literature review in Chapter 2, there are many recent studies conducted on the determinants of household adaptation choices in Africa. This chapter draws relevant implications from these studies and builds location-specific indicators to conduct similar analysis for the Chepang community in the Mid-Hills of Nepal. There are a few studies conducted in Nepal that assess the factors influencing climate change adaptation among the rural communities (Jones and Boyd, 2011; Onta and Resurreccion, 2011; Bouma et al., 2009). All of these studies are descriptive analyses focusing only on the social and institutional factors that enhance or constrain households from undertaking adaptation actions. The first two studies analyze the role of caste and gender in the rural parts of western Nepal; the last research is more focused on the impact of market and institutions on adaptation in the mid-hills of Central Nepal. This chapter builds upon and adds to the existing literatures by conducting a quantitative analysis of the determinants of household adaptation decisions over a range of socio-economic variables, and perception of climate change, in addition to the social and institutional factors emphasized by the earlier studies conducted in Nepal. The next sub-section of the chapter deals with the empirical model and variables used in this analysis followed by results and discussion. The last part concludes the chapter highlighting the policy implications derived from the analysis.

8.5.1 Empirical model to analyze determinants of adaptation: Multivariate Probit

Maddison (2007) and Deressa et al. (2011) analyze the binomial choice of household decision to adapt or not against a range of socio-economic and climate variables using Heckman sample selection probit model. However, these studies do not differentiate among the different types of adaptation practices that an adapting household undertakes. Different adaptation practices are affected differently by various factors and when all the adaptation actions are lumped into a single category, this difference is not accounted for. The simplest option to analyze the choices of different adaptation practices is to estimate independent discrete choice models or univariate models for each of the choices as functions of the same set of independent variables. However, as pointed out by Golob and

Regan (2002), such independent estimations will fail to take into account relationships between different adaptation choices. Two or more adaptation choices may be complementary or competing. For a simple illustration, constructing a water storage structure will be complementing the choice to grow vegetables or other cash crops as a means to reduce dependency on subsistence cereal crops. This aspect of decision-making among various available choices is not captured by univariate models. A better alternative to univariate model is the multinomial discrete choice model, which assumes independence across different outcomes and requires that the choice variables be mutually exclusive (Seo and Mendelsohn, 2006). Many studies do differentiate among the various adaptation practices undertaken by the households and analyze the determinants influencing the probability of adopting those practices by using the multinomial logit (MNL) model. Kurukulasuriya and Mendelsohn (2008; 2006) and Seo and Mendelsohn (2008a) focuses on the crop choices as an adaptation strategy in Africa and South America respectively; Seo et al. (2009) and have conducted similar analysis in livestock choices in Africa; Hassan and Nhemachena (2008) use MNL to model the choice of multiple cropping or monocropping along with livestock under irrigated or dryland conditions; Deressa et al. (2009b), and Gbetibouo (2009) analyze the influencing factors for a range of adaptation actions adopted in a particular community. The major limitation of a MNL model is the assumption of the practices to be mutually exclusive. This assumption is not true in reality, as a single household can simultaneously adopt more than one adaptation strategies. Rather, the choice set is composed of all possible combinations of *n* adaptation choices leading to 2^n-1 alternatives. Although estimation of a big number of choices would not be impossible, the interpretations of the influences of independent variables on each of the original adaptation choices would be very difficult. Seo and Mendelsohn (2008b) and Kurukulasuriya and Mendelsohn (2008) first identify the possible combinations of livestock and crop choices, and employ MNL to study the determinants of the choices of these combinations. However as already explained, using combinations of available options as the choice variables makes it difficult to interpret the influence of explanatory variables on each of the available options separately. Nhemachena and Hassan (2007) and Seo and Mendelsohn (2006) address this problem by running a multivariate probit (MVP) model where a household choosing more than one option is simultaneously modeled against a set of explanatory variables. MVP model estimates the influence of explanatory variables on the probability to adopt each of the available adaptation options simultaneously, while the error terms are allowed to be freely correlated (Golob and Regan, 2002). MVP models are more suitable in cases of correlated binary data where it is important to take into account the correlation structure among the variables (Tabet, 2007). An additional advantage of the MVP model over MNL model is that the MVP relaxes the assumptions of independence of the irrelevant alternatives (IIA) assumed by the logit model, which in many cases is considered to be an unrealistic assumption (Tabet, 2007). Furthermore, Young et al. (2009) demonstrate that when the outcomes are correlated, the MNL model produces substantially different predictions relative to true predictions; and even in ideal conditions under which outcomes are independent, MNL is still a poor approximation to the true underlying outcome probabilities relative to the MVP model. This paper uses the MVP model to analyze the determinants of adaptation choices among the Chepang households in the context of rural mid-hills in Nepal.

The MVP model assumes that given a set of explanatory variables the multivariate response is an indicator of the event that some unobserved latent variable (Z), assumed to arise from a multivariate normal (Gaussian) distribution, falls within a certain interval. Following Tabet (2007), the MVP model assumes that each subject has J distinct binary responses. Let $i = 1,\ldots,n$ be the independent observations (households in this study), $j =$

$1,\ldots,J$ be the available options of binary responses, and X_i be a matrix of covariates composed of any discrete or continuous variables. Let $Y_{ij} = (Y_{i1},\ldots,Y_{iJ})$ denote the J-dimensional vector of observed binary responses taking values {0,1} on the i^{th} household, and $Z_{ij} = (Z_{i1},\ldots,Z_{iJ})'$ denote a J-variate normal vector of latent variables such that

$$Z_{ij} = X_i\beta + \epsilon_i, i = 1, \ldots, n \tag{1}$$

where $\beta = \left(\overrightarrow{\beta_1}', \ldots, \overrightarrow{\beta_J}'\right)$ is a matrix of unknown regression coefficient, ϵ_i is a vector of residual error distributed as multivariate normal distribution with zero means and unitary variance; $\epsilon_i \sim N(0,\Sigma)$, where Σ is the variance-covariance matrix having value 1 on the leading diagonal. The off-diagonal elements in the correlation matrix, ρ_{kj} represents the unobserved correlation between the stochastic component of the k^{th} and j^{th} options; necessarily $\rho_{kj} = \rho_{jk}$ (Young et al., 2009; Cappellari and Jenkins, 2003). The relationship between Z_{ij} and Y_{ij} in the MVP model is given by

$$Y_{ij} = \begin{Bmatrix} 1 \; if \; Z_{ij} > 0; \\ 0 \; otherwise. \end{Bmatrix} i = 1, \ldots, n \; and \; j = 1, \ldots, J \tag{2}$$

The likelihood of the observed discrete data is then obtained by integrating over the latent variables Z:

$$P\left(Y_{ij} = 1 \middle| X_i, \beta, \Sigma\right) = \int A_{iJ}, \ldots, \int A_{i1} \, \Phi_T\left(Z_{ij} \middle| X_i, \beta, \Sigma\right) dZ_{ij} \tag{3}$$

where A_{ij} is the interval $(0,\infty)$ if $Y_{ij} = 1$ and the interval $(-\infty,0]$ otherwise, and $\Phi_T\left(Z_{ij} \middle| X_i, \beta, \rho_{ij}\right)$ is the probability density function of the standard normal distribution.

This study uses the simulated maximum likelihood (SML) using Geweke-Hajivassiliou-Keane (GHK) simulator in STATA developed by Cappellari and Jenkins (2003) to estimate the MVP model. According to Cappellari and Jenkins (2003), the SML estimator is consistent as the number of observation and number of draws tends to infinity. For sample sizes in the order of several thousands, the number of draws set to approximately the square root of the sample size would suffice. However, for smaller sample size, the number of draws should be sufficiently large. The number of draws (R) in this paper was set to 100 (compared to the default of R = 5) to ensure consistent estimates. To run the diagnostic tests for checking heteroscedasticity and multicollinearity among the selected variables, individual ordinary least squares (OLS) estimates were run for each individual choice variable against the same set of explanatory variables. Variation inflation factor (VIF) test was run to check multicollinearity among the variables. The VIF value for all the independent variables was much below 10, with mean VIF value of 1.21 suggesting no problems of multicollinearity. Breusch-Pagan / Cook-Weisberg test was done to test for linear forms of heteroscedasticity. The null hypothesis of homoscedasticity was strongly rejected in favor of heteroscedasticity in four out of five choices. White"s test of heteroscedasticity, which is an extension of Breusch-Pagan / Cook-Weisberg test for testing other forms of heteroscedasticity besides the linear form, was also conducted. White"s test, however, yielded insignificant p-values for all the choices, thereby strongly failing to reject the null hypothesis of homoscedasticity. In any case, to correct for the presence of heteroscedasticity of any kind, model estimation was conducted using robust standard errors, as done by Nhemachena and Hassan (2007) for MVP model and Hassan and Nhemachena (2008) for MNL model. The use of robust standard errors does not change the significance of the model and the coefficients, but it gives relatively more accurate p-values, and is an effective way of dealing with heteroscedasticity (Wooldridge, 2006, p. 274).

8.5.2 Variables for the MVP model to analyze determinants of adaptation

The choices of adaptation practices listed in Table 8.1 are the dependent variables for the MVP model estimated in this paper. Soil conservation and seeking assistance from the community are practiced by almost all the households (98.6% and 96.8%, respectively). The analysis of the impacts of particular determinants on the households" choices to adopt a particular practice is not meaningful when it is adopted by all the households. Therefore, these two practices were dropped from the analysis. The remaining eight practices were run as the dependent variables against a set of common explanatory variables. However, the model could not calculate numerical derivatives due to the failure to achieve convergence. Therefore cash crops, livestock and non-farm jobs was merged into a single variable as livelihood portfolio diversification; and wage laboring and collecting wild edibles was merged as traditional coping strategies to run the model. Our final model comprises of five categories of adaptation practices as the binary choice variables, viz. livelihood portfolio diversification, varietal selection, construction of water collection tank, adjusting sowing time, and traditional coping strategies (Table 8.2).

Table 8.2 Adaptation practices adopted by Chepang households in the study site

Adaptation practices	Percentage of households adopting the practice (n=221)
Livelihood portfolio diversification	61.1
Cash crops	57.0
Livestock	69.7
Non-farm jobs	16.3
Varietal selection	19.0
Construction of water collection tank	19.5
Adjusting sowing time	53.4
Traditional coping strategies	91.4
Wage laboring	81.9
Collecting wild edibles	74.7

Source: Field survey, 2011

The thirteen independent variables selected for this paper are listed in Table 8.3. The variables were selected based on literature review and location specific characteristics of the study areas. The first two variables are related to the perception of the respondents regarding changes in rainfall and temperature over the last decade. Ability to notice changes in climate have been found to influence adaptation choices positively (Nhemachena and Hassan, 2007). The meteorological records in the study area show decreasing annual rainfall, increasing mean summer temp, and decreasing mean winter temperature over the last decade (Chapter 5). The changes in climatic variables were considered for the last ten years because literatures suggest that communities base their decisions on more recent climatic events rather than the long term trends (Gbetibouo, 2009; Maddison, 2007). It is hypothesized households able to perceive rainfall and temperature are more likely to adopt livelihood diversification, varietal selection, construction of water collection tanks and adjusting sowing time; while they are less likely to continue depending on traditional coping strategies.

Table 8.3 Explanatory variables selected for the multivariate model of adaptation

Variables	**Unit**	**Mean[a]**	**SD[a]**	**Hypothesized relation**
Perceive decreasing rainfall	Dummy; 1 = Yes, 0 = Otherwise	0.36	0.48	+ve except TCS[b]
Perceive temperature change (hot summer and/or cold winter)	Dummy; 1 = Yes, 0 = Otherwise	0.32	0.47	
Age of the HHH	Years	49.21	16.27	
Education of the HHH	Years of schooling	1.23	2.31	
Number of economically active members (EAM) in the household (HH)	Number	3.27	1.62	+ve for all
Total landholding per capita	Area in local unit (*Kattha*)	2.36	1.85	+ve except TCS
Unregistered land per capita	*Kattha*	0.45	0.85	-ve for LPD[c] and tanks
Walking distance to nearest road	Hours	2.12	2.62	-ve except TCS
Access to credit	Dummy; 1 = Yes, 0 = Otherwise	0.94	0.24	+ve except TCS
Listen to related information in the radio	Dummy; 1 = Yes, 0 = Otherwise	0.47	0.50	
HH membership in organizations	Number	1.11	1.15	
Trainings received by HH members	Number	0.52	0.78	
Site	Dummy; 1 = Kaule, 0 = Otherwise	0.26	0.44	-ve except TCS

[a]**Source:** Field survey 2010/2011
[b]TCS: Traditional Coping Strategies; [c]LPD: Livelihood Portfolio Diversification

The next three variables represent the household characteristics. The impact of the age of the household head on adaptation decisions is not uniform across literatures with some studies reporting higher propensity to adapt with age (Deressa et al., 2009b; Seo and Mendelsohn, 2008a) and some reporting both positive and negative impacts across a range of adaptation options (Hassan and Nhemachena, 2008; Nhemachena and Hassan, 2007). As for the education of the household head, Deressa et al. (2011; 2009b) and Maddison (2007) report greater probability of adopting adaptation with higher education; on the other hand

Below et al. (2012) report that educated households head are less likely to adopt on-farm adaptation options, while Seo and Mendelsohn (2008a) and Gbetibouo (2009) reports mixed results depending on the nature of adaptation practices. For this study, it is hypothesized that households with higher age and education of the household head are less likely to depend on traditional coping strategies and more likely to adopt the remaining adaptation practices. Most literatures show positive relations between household size and the propensity to adopt various adaptation practices (Deressa et al., 2011; Hassan and Nhemachena, 2008; Kurukulasuriya and Mendelsohn, 2008; Nhemachena and Hassan, 2007). However some studies also report that households with larger family size are less likely to adapt (Below et al., 2012; Seo and Mendelsohn, 2008a) or the influence depends on the nature of adaptation practices (Deressa et al., 2009b; Gbetibouo, 2009). For this study, number of economically active members in the household is taken instead of simply taking the family size or number of family members and it is expected that adoption of all practices will increase with higher number of economically active population in the family.

The next two variables are related to landholding. The total landholding per capita has been taken as an indicator of farm size while the area of unregistered land per capita is taken as an indicator of tenure status. Hassan and Nhemachena (2008) found that larger farms are more likely to opt for monocropping or specialization in a single crop. Landholding or farm size is found influence positively in adoption of various adaptation practices (Below et al., 2012; Gbetibouo, 2009; Seo and Mendelsohn, 2008b; Maddison, 2007); Nhemachena and Hassan (2007) reports that larger farms are less likely to adopt non-farm options. Surprisingly Deressa et al. (2011) find that larger farms are less likely to undertake any adaptation practices. In this paper, it is hypothesized that larger farms are more likely to adopt all the adaptation practices except traditional coping strategies. Studies show that land tenure is important to determine whether farmers adopt certain adaptation practices, especially if they involve long-term investments. In the case of Chepangs, due to certain government policies, difficult administrative procedures, and ignorance on the part of Chepangs, many land plots that Chepangs cultivate are still unregistered (Aryal and Kerkhoff, 2008). In this study, 44.3% of the households were found to be cultivating unregistered land plots. Gbetibouo (2009) and Maddison (2007) find that farmers cultivating rented-in or borrowed land are less likely to adopt adaptation practices compared to farmers cultivating own lands. For this study, it is expected that households with higher area of unregistered land are less likely to invest in construction of water tanks. Households located farther away from markets have been found to adopt lesser adaptation practices (Below et al., 2012; Bouma et al., 2009; Hassan and Nhemachena, 2008). Maddison (2007) and Deressa et al. (2011) further differentiate between input and output market and report that households farther away from output market are less likely adapt while households farther away from input market are more likely to adapt. In this study, all the sample households are untouched by motor roads. The walking distance to the nearest motor road in this case is also equivalent to the nearest market, both input and output. Farther distance from the roads symbolizes poor access to inputs and information as the marketplace acts as informal gathering centers where information exchange takes place, and the extension institutions and service centers are located there. Thus it is expected that households located farther away from the road are less likely to adopt the adaptation practices of livelihood diversification, varietal selection, and construction of tanks, but more likely to continue depending on traditional coping strategies. It has been found that access to credit facilitates adaptation by enabling the household to invest in farm inputs, machineries and infrastructures (Below et al., 2012; Deressa et al., 2011; Deressa et al., 2009b; Gbetibouo, 2009; Hassan and Nhemachena, 2008). It is expected that household"s access to credit will reduce their dependence on traditional coping strategies and facilitate adoption of other adaptation options. The next three variables viz. listen to climate/agriculture related information in the radio, membership in community based organizations, and participation in trainings represent the household‟s access to information and extension services. Households‟ access to climate and agriculture related information either on the radio or through extension agents have been found to facilitate adaptation to climate change (Deressa et al., 2011; Deressa et al., 2009; Gbetibouo, 2009; Hassan and Nhemachena, 2008). In the study area, provision of village level extension services by the government agencies is totally absent. However, there are many non-governmental organizations (NGOs) working in the field of agriculture, livestock, forestry, health, drinking water, and renewable energy. Such organizations work with the community by forming small groups of households and provide relevant trainings (like construction of poly-tunnels for off-season vegetable production) to the group members. Thus membership in such groups and participation in trainings provided by these development agencies are the major sources of information, as well as extension services for this community. Below et al. (2012) found that memberships in social organizations facilitated household adaptation in Tanzania and Bouma et al. (2009) report that access to institutions positively influences adaptation in the Mid-Hills of Nepal. Thus it is hypothesized that radio-information, membership in NGOs and participation in trainings will enable the households to deviate from the traditional coping strategies to adopt the rest of the adaptation choices. Finally, to capture the site specificities, Chitwan variable has been considered as the dummy variable. Among the four study districts, Chitwan district is reported to have the least adaptive capacity in terms of indicators based on the possession of various livelihood assets (Chapter 6). Thus it is hypothesized that households in Chitwan are less likely to adapt to climate vagaries.

8.5.3 MVP model of households' adaptation choices: Results and discussion

The results of the MVP model presented in Table 8.4 show that the direction of influence for most of the explanatory variables is as expected with a few exceptions. The likelihood ratio statistics as denoted by the Wald χ^2 is highly significant ($p = 0.0000$) showing that the variables sufficiently explain the model. Also, the likelihood ratio test of the null hypothesis of the absence of correlation among the individual equations is strongly rejected ($p = 0.0005$), thus validating the rationale to estimate all the equations simultaneously using MVP instead of estimating individual probit equations. The percentage correctly predicted is the highest of 90.04% for the equation for traditional coping strategies while it is the minimum of 49.77% for equation for adjusting sowing time.

Livelihood portfolio diversification is significantly more likely to be adopted by those households who perceive decreasing rainfall and listen to relevant information on the radio; it is significantly less likely to be adopted by households farther away from road and households having access to credit. The direction of influence is rather surprising for households with access to credit. This is because Chepangs borrow credit to fulfill their subsistence needs rather than for investing it in productive investment. Except for few NGOs recently lending credit to facilitate vegetable farming or rearing livestock in the study area, there is a total absence of formal lending institutions. The direction of the influence of the perception of temperature change is also negative. It might be because the adaptation practices covered by this model are more valid for rainfall changes, and the practices undertaken in response to temperature changes are not covered by this research. It is also possible that compared to rainfall changes, the farmers do not perceive the temperature changes as directly threatening their livelihoods or agricultural production, and thus they are not prompted to take any adaptation measures against changing temperatures. The direction of influence for the age of the household head is also not as hypothesized revealing that aged households are reluctant to diversify away from subsistence agriculture and adopt new practices as also reported by southern African countries (Nhemachena and Hassan, 2007). Also, land tenancy does not limit households from diversifying to cash crops. The opposite direction of influences of membership and trainings show that simply being a member in organizations is not sufficient, rather they need to be trained for capacity development to undertake cash crop cultivation or skill oriented off-farm jobs.

Table 8.4 Parameter estimates of the multivariate probit model of adaptation

Explanatory variables	**Livelihood portfolio diversification**		**Varietal selection**		**Water collection tank**		**Adjusting sowing time**		**Traditional coping strategies**	
	Coeff.	**P-value**	**Coeff.**	**P-value**	**Coeff.**	**P-value**	**Coeff.**	**P-value**	**Coeff.**	**P-value**
Perceive rainfall	0.434	0.027**	0.134	0.558	0.385	0.078*	0.283	0.131	-0.249	0.275
Perceive temperature	-0.150	0.456	-0.456	0.039**	-0.169	0.475	-0.019	0.919	-0.212	0.427
Age	-0.004	0.527	-0.013	0.109*	-0.009	0.221	0.000	0.893	-0.011	0.272
Education	0.036	0.478	-0.072	0.181	0.039	0.422	0.004	0.925	-0.030	0.649
EAM	0.095	0.136	0.048	0.502	0.008	0.902	-0.015	0.798	0.098	0.347
Total land	0.004	0.932	0.107	0.077*	0.107	0.074*	-0.045	0.401	-0.117	0.057*
Unregistered land	0.153	0.211	0.032	0.811	-0.286	0.012**	0.074	0.504	-0.130	0.325
Distance to road	-0.052	0.092*	-0.009	0.791	-0.130	0.134	-0.031	0.293	0.098	0.411
Credit	-1.197	0.002***	-0.119	0.800	-0.412	0.312	0.233	0.517	-3.651	0.000***
Information in radio	0.482	0.010***	0.476	0.023**	0.127	0.544	-0.030	0.862	-0.323	0.198
Membership	-0.082	0.340	0.219	0.016**	0.117	0.190	-0.024	0.773	-0.067	0.567
Training	0.065	0.643	0.028	0.839	-0.048	0.758	0.058	0.641	-0.010	0.940
Site	-0.342	0.125	-0.997	0.002***	-0.043	0.880	0.471	0.030**	-0.094	0.809
Constant	1.131	0.028**	-0.749	0.197	-0.297	0.607	-0.208	0.669	5.969	0.000***
% correctly predicted	60.18		81.00		80.54		49.77		90.04	

Correlation coefficients	**Coefficient**	**P-value**
$\hat{\rho}_{21}$	0.359	0.003***
$\hat{\rho}_{31}$	0.151	0.221
$\hat{\rho}_{41}$	0.298	0.004***
$\hat{\rho}_{51}$	-0.002	0.990
$\hat{\rho}_{32}$	-0.019	0.905
$\hat{\rho}_{42}$	0.382	0.002***
$\hat{\rho}_{52}$	0.357	0.034**
$\hat{\rho}_{43}$	-0.303	0.008***
$\hat{\rho}_{53}$	-0.162	0.402
$\hat{\rho}_{54}$	0.069	0.648

Draws	100
Number of observations	221
Wald $\chi^2(65)$	980.16
P-value	0.0000***
Log pseudo likelihood	-511.48526
Likelihood ratio test H_0: $\hat{\rho}_{21} = \hat{\rho}_{31} = \hat{\rho}_{41} = \hat{\rho}_{51} = \hat{\rho}_{32} = \hat{\rho}_{42} = \hat{\rho}_{52} = \hat{\rho}_{43} = \hat{\rho}_{53} = \hat{\rho}_{54} = 0$, $\chi^2(10) = 31.475$, P-value = 0.0005***	

Note: ***, **, * denote significant at 1%, 5%, and 10% level of significance respectively

Households with larger landholding per capita are significantly more likely to make varietal selection. Similarly households with access to information and extension services via radio and memberships in groups are significantly more likely to practice varietal selection whereas households in Chitwan are significantly less likely to adopt this practice. Once again, the influence of perception of temperature change and age of the household head is not in the direction as hypothesized, the possible reasons have already been discussed earlier. Also unexpected is the negative influence of the education of the household head in varietal selection. Below et al. (2012) also reports that educated household heads are less likely to formulate adaptation strategies related to farming. Households with unregistered land are also adopting varietal selection as it does not involve any long term investments.

Construction of water collection tank is significantly facilitated by perception of decreasing rainfall and larger landholding. Households with higher area of unregistered land are significantly less likely to invest in water collection tanks as it is a long term investment. As with the earlier two adaptation choices, the influence of perception of temperature changes, age of the household head, and credit are not as hypothesized. Although the influence of training is also not as hypothesized, households with membership in organizations are more likely to construct water collection tanks as stated before, the water construction tanks are constructed with technical and partial financial support from these organizations.

Only the site variable is the significant in adjusting sowing-time; the households in Chitwan having higher propensity to adopt this practice. As before perception of rainfall facilitates the time adjustment while the perception of temperature change does not influence in the hypothesized direction. The direction of influence of the size of landholding shows that smaller farms are more likely to stick to this practice. The negative influence of radio information and membership reveals that information related to weather forecast is not circulated effectively in the radio or by the development agencies. Although the information of daily weather forecast is broadcasted daily in the radio, firstly such forecast is limited to the major cities only and secondly weather information is not discussed in connection with agricultural advice.

The adoption of traditional coping strategies is significantly influenced by the size of landholding with smaller farms relying more on such strategies. The relationship between access to credit and adoption of coping strategies is also negatively significant implying that households rely on credit only when they are constrained to adopt other alternative traditional coping measures.

The results in Table 8.4 provide some important location specific insights on the determinants of adaptation choices made by the households. While the rainfall perceptions facilitate adaptation practices, the temperature perceptions do not influence as expected. This is possibly because the reported adaptation choices are adopted in response to changing rainfall patterns and not to the changing temperatures. Previous literatures analyzing determinants of adaptation have not considered the perception factors in their analysis except for Nhemachena and Hassan (2007) who do not differentiate between perception of rainfall and temperature. Future analysis focusing on adaptation to changing temperatures is recommended. With higher age of the household head the propensity to adapt decreases except for adjusting the sowing time according to rainfall timings. This shows the reluctance of aged members to adopt new practices. Families with educated household head and higher number of economically active members are more likely to adopt most of the adaptation practices. Households with larger landholding are more likely to adapt as they can afford to make the necessary investments (Below et al., 2012; Gbetibouo, 2009; Maddison, 2007). However, households with higher area of unregistered land are reluctant to make investments in infrastructure that is intended to be utilized for a longer time period (Gbetibouo, 2009; Maddison, 2007). Households farther away from road rely more on traditional strategies and lesser on other adaptation practices. Similar findings are also reported by Below et al. (2012) in Tanzania and Bouma et al. (2009) in Nepal. As already discussed, this is because households in remote areas are constrained by the lack of information, lack of access to market to dispose their products, have less off-farm employment opportunities, and are less served by development agencies leading to lesser dissemination of information regarding the improved agricultural practices and no support for construction of water collection tanks. As shown in Table 8.3, 94% of the sample households report that they have access to some credit sources. However, the negative influence of credit highlights the fact that credits are used by the Chepangs only for subsistence purposes. This necessitates the need of provision of credits for productive investments in the area. Households listening to related information on the radio are significantly more likely to adopt livelihoods diversification and varietal selection, but less likely to adjust sowing time according to the rains. This means that the households are receiving agriculture related information like techniques of cash crop cultivation and the suitable varieties, but not receiving the information related to weather forecasts so as to adjust the sowing time accordingly. As stated before, weather forecasts are not available for the rural areas of Nepal. However, the extension agents working in the community can be trained to provide information related to both climate and agricultural practices and help household formulate cropping calendar to suit the changing climate patterns. The influences of membership and training highlights that while membership in organizations is important to receive services like seeds of hybrid maize varieties and support for water tank construction, when it comes to implementing skill-oriented adaptation options like cash crops or off-farm jobs simply membership is not sufficient but need to be supplemented by skill development trainings. As expected, compared to other VDCs, the households in Kaule are less likely to undertake four adaptation options out of five.

The estimated correlation coefficients ($\hat{\rho}_{kj}$) among the various adaptation options are significant for five out of ten combinations. Livelihoods diversification is positively correlated with varietal selection, water tank construction and adjustment of sowing time, but negatively correlated with traditional coping strategies. This means livelihood diversification to alternative income sources reduces the dependence on wage laboring and wild foods. Varietal adjustment is complemented by adjustment in sowing time. However, varietal selection is surprisingly negatively correlated with construction of water tank but positively correlated with traditional coping strategies. Construction of water tanks is negatively correlated with adjustment of sowing time as households with access to irrigation are lesser dependent on rainfall. Construction of water tanks is negatively correlated with traditional coping strategies and adjustment of sowing time is complemented by the latter.

8.6 Conclusion and policy implications

Relating adaptive capacity to adaptation practices makes it clear that the inherent adaptive capacity is the minimum necessary condition for adaptation actions to take place. Further comparison of adaptive capacity with adoption rate shows that aggregate adaptive capacity is not the sufficient determinant of adaptation practices. Balance between the components of adaptive capacity, most notably human and financial capital is necessary to translate adaptive capacity into adaptation practices. Households in Bhumlichowk are consequently implementing most of the adoption practices as this VDC not only has the highest aggregate adaptive capacity, but also a balanced possession of all the component asset categories. On the other hand, Mahadevsthan VDC has not been able to translate the existing adaptive capacity into practices, due to the imbalance in human and financial assets. Similarly Kaule VDC also exhibits a low adoption rate as it ranks the lowest in most of the asset categories. The policy implications of these findings is that integrated development support should be provided to these communities focusing on education, vocational trainings, and development of infrastructure. Similarly provisions of easy credit for productive investment can enable the households utilize to the skills developed from vocational trainings for income generation. Among the four VDCs, Kaule and Mahadevsthan need to be prioritized in providing development assistance. Ultimately, the utilization of livelihood asset is also determined by the existing institutions and policies. Future researches analyzing the role of institutions and policies to understand the process by which adaptive capacity is translated into adaptation action is recommendable.

Exploring the existing adaptation practices confirmed many important characteristics of adaptation practices highlighted by previous studies. A single adaptation practice can serve more than one particular risks and it is indeed difficult to isolate the adaptation practices devised solely in response to climate risks. For instance, diversifying to non-farm income sources, cash crops, and livestock could be done either in response to climate risks or purely with economic motivation. Furthermore, livelihood activities like wage labor, collection of wild edibles, soil conservation practices, and borrowing from social networks are integrated components of Chepang livelihoods, and these activities are pursued in the case of any type of disasters. Planned development activities like construction of water collection tanks are implemented primarily with the objective of agricultural development and climate change adaptation might only be a secondary priority. Most of the adaptation practices listed in this paper is implemented spontaneously by the households without any assistance from the government or other development agencies. Assistance for climate change adaptation by the government is virtually non-existent in the study sites. Although the government has prepared detail NAPA and LAPA documents, related projects are still in the formulation stage. Conservation practices like mulching, minimum tillage, and cover crops are currently not widely adopted. These simple adaptation measures can be promoted through government extension services.

The ability of households to perceive rainfall changes is an important determinant of adaptation. Thus, creating awareness of climate change through information dissemination among the community members is an effective way to promote adaptation. The information related to agricultural practices need to be complemented with weather related information. Small landholders are more likely to depend on traditional coping strategies. Provision of collateral free micro-credit aimed at the small holders will assist such households to invest in adaptation options. In order to encourage investment on land improvement and related infrastructure, land related policies must recognize the traditional ownership of land ownership by the indigenous people and facilitate registration of land plots cultivated by the Chepangs. Chepangs seek for credit from informal sources in the community during emergencies or for subsistence consumption. Lack of access to formal sources of credit hinders the productive investment among the Chepangs. Skill development trainings complemented with provision of micro-credit can help the households to diversify their livelihoods from subsistence agriculture to cash crops, livestock, and skilled off-farm works. Such development assistance and extension services by the governmental and non-governmental agencies need to be extended even in the remote areas far away from the marketplace. Future analysis need to focus on the adaptation practices in response to changing temperature. Furthermore, the analysis in this paper is limited for livelihoods diversification in the sense on-farm and off-farm diversification is merged together owing to data problems. Further analysis of determinants of these two categories of diversification separately is also recommendable.

Chapter 9. Conclusion and recommendations

Among the various components of vulnerability to climate change, adaptive capacity is the only factor that can be addressed by the policy makers and development agencies, at least in the short-run. Therefore, the foremost policy aim to address the issues of climate change must be to improve the adaptive capacity of the community. Adaptive capacity is basically improving the possession of or access to various livelihoods assets. However, different categories of assets are complementary to each other in defining the livelihood outcomes. Therefore, balanced development of all assets is a must. Adaptive capacity has important implications on adaptation, sensitivity, as well as resilience of the community. Higher adaptive capacity and a balanced possession of all asset types facilitate adoption of adaptation practices by a household. Further, a balanced improvement in the adaptive capacity is crucial to reduce the sensitivity of the households to the adverse livelihood impacts of climate related shocks. For example, improving households‟ access to irrigation facilities not only facilitates adaptation and livelihoods diversification of the household by enabling commercial agriculture, but also reduces the households‟ sensitivity to uncertain rainfall and droughts. Capacity to adapt is also an integrated component in the resilience of households or communities. Thus improving adaptive capacity also has positive implications in helping the households to build resilience in the face of climatic hazards.

The impact of climate change is widespread across various development sectors, so are the mitigation and adaptation potentials. The impacts of climate change are felt across every sector like agriculture, infrastructure, water availability, health, forest, biodiversity, and so on. In order to address climate change, mainstreaming of climate change into development investments have become a must. For instance, investments on rural roads and irrigation infrastructure have multiple implications in adapting to risks posed by climate change. While irrigation infrastructure helps to minimize the risks of crop failure due to rainfall uncertainties, it also enables rural communities to diversify their livelihoods sources to cash crops thereby generating higher incomes. Similarly, rural roads would not only open markets for the farm produce, but also improve the rural communities" access to information, extension services, institutions and other facilities like input-markets, schools, and hospitals. The long-term impacts of climate change must be taken into considerations especially when making long term infrastructure investments. A very simple example in case of Nepal would be the construction of hydro-power dams which need to consider the possible changes in run-off due to glacial melts upstream. Similarly, development of drought resistant crop varieties will help farmers adapt to increasing frequency of drought, at the same time contribute to the overall goal of reducing hunger. Promotion of agro-forestry, in addition to sequestering carbon, will serve multiple co-benefits like reducing landslides, protecting biodiversity, improving soil health and thereby increasing crop productivity over the long run. A no-regrets approach needs to be adopted while mainstreaming climate change into the development efforts.

Climate change encompasses all the four pillars of sustainable development viz., environmental conservation, economic development, human capacity development, social networks, and institutional factors including policies, good governance, and equity. Natural resources like forest and biodiversity are the primary livelihood resources for the rural communities. These resources are also the sectors which suffer most from the vagaries of climate. Another way around, the same resources have the maximum mitigation potential by carbon-sequestration. Thus environmental conservation and climate change mitigation are intricately interrelated. Next, economic development is the minimum criteria to build adaptive capacity. Economic development represents the physical and financial assets in the asset pentagon of rural sustainable livelihoods framework. Improving the financial income will provide households with multiple choices on how to make use of it. Financial assets can be easily converted to other forms of assets like acquiring natural assets (e.g. land) or productive physical assets (e.g. plastic house for off-season crop production), thereby making it one of the most important categories of assets. Also higher savings can lead to higher productive investments like investing in family education. Therefore, efforts aimed at improving the income and access to physical infrastructure for the marginalized population will enable such communities to cope with the climate related vagaries. However, economic development alone is not sufficient for ensuring adaptive capacity of the community. Development of minimum human capacity is necessary to be able to utilize the existing resources, and also take innovative measures to adapt to constantly changing climate scenarios and build resilience against the underlying uncertainties. Similarly, socio-cultural factors like class and caste hierarchy have been shown to restrain the options of adaptation at the micro level. On the other hand social networks enable the households or community members to improve the adaptive capacity in various ways like improving the access to institutions, information, extension services, and other public services like production inputs, and health benefits. Finally, access to institutions and policy formulations also determine the vulnerabilities, impacts, and adaptation to climate change. It has been found that socio-cultural hierarchies limit the access of communities to institutions and policy formulations, which in turn limit the household livelihoods options and consequently the adaptation choices. For instance, inability of socio-culturally marginalized people to be a part of forest users groups will limit their options to use the forest resources, thereby limiting their livelihood options. Similarly, lack of access to extension and inputs services will deprive such households from relevant information and technologies to respond to the changing climate. Another example is the policy that deprives the indigenous people from utilizing traditionally or communally owned lands and forest resources which hampers their livelihood sources as well as adaptive capacity by degrading their asset holdings. The issues of good governance and equity, thus, play a pivotal role in dealing with climate change issues. The inclusion of marginalized populations at the local level is ultimately necessary, for which good governance and equity is a must. The marginalized are the ones who are expected to be most impacted by climate change, thus they should have a voice in formulating the relevant policies. The issues of good governance and equity are even more relevant in the post-Kyoto protocol era, when forests are getting the maximum attention as mitigation instruments. Voices to ensure the use-rights of forest dependent people, who are also the primary managers of these resources, are already taking a center-stage. In addition to the use-rights, these communities must be the principal benefactors of the revenues earned from carbon finance. The discussion finally brings us back to the asset pentagon in rural sustainable livelihoods framework with a conclusion that balanced access to all the asset types is necessary for sustainable development, which in turn promotes both mitigation of and resilience to adverse impacts of or vulnerabilities to climate change.

Inter-household comparison of vulnerability components highlights that irrespective of the location; poor households are the ones who have the least adaptive capacity but face the highest exposure and sensitivity. Thus, development priorities must target the poorest households in all the locations. Comparative analysis of the four study sites provides insights on the sectors that need to be emphasized by policy makers and development agencies for improving the adaptive capacity and ensuring sustainable development of the corresponding VDC. Among the four study VDCs, the adoption rate of all the adaptation practices is the highest for Bhumlichowk VDC because this VDC has a balanced possession of all the asset categories. On the other hand, despite having higher physical infrastructures and natural resources, Mahadevsthan VDC has comparatively lesser adaptation practices due to the imbalance in human and financial resources. This highlights the importance of human skill and financial capital that is indispensable to be able to utilize the remaining resources for better livelihoods outcome. Paradoxically, the most limiting assets in the rural areas are in fact the financial capital and human capacity. Therefore, in order to improve the adaptive capacity and facilitate adaptation in rural areas, primary focus must be to increase the cash income through livelihood diversification and human capacity development by providing education and vocation training. This corresponds to economic and social factors in the sustainable development framework. Kaule VDC ranks the lowest in majority of asset categories, thus out of the four study VDCs, Kaule VDC needs integrated development assistance that subsequently address all the asset categories. At the same time, Kaule VDC also faces the highest exposure. Thus, measures to address possible incidences of climatic disasters like early warning systems and emergency relief measures must be allocated. In case of Kankada VDC, development of physical infrastructure needs to be prioritized. Kankada VDC is quite far from the motor roads and the irrigation facilities are also less developed in this VDC. Development assistance in these sectors will enable the community to increase their agricultural production and improve their access to markets to procure inputs, dispose their produces, and search for off-farm employments. Kankada VDC also has the highest reported damages in properties due to the occurrences of landslides. Besides strengthening the emergency relief measures, conservation of natural resources (land) through agroforestry, drainage sluices and dikes or walls to prevent landslides is also recommended in this VDC. Physical, natural and social assets are already quite well developed in Mahadevsthan VDC; thus development assistance in Mahadevsthan needs to focus on financial and human assets which, as already discussed, are the most important assets to improve the adaptive capacity of rural households. Bhumlichowk VDC ranks the best in terms of assets possession.

However, exposure is quite high in this VDC thus calling for the need of emergency relief measure to be in place. Besides, both Mahadevsthan and Bhumlichowk VDC report higher occurrences of droughts. Droughts are in fact becoming recurrent in all the study sites. Thus economic development in terms of better irrigation facilities and drought tolerant crops are relevant recommendations for all the VDCs. Lack of access to formal credit sources for productive investment is also a limiting factor in all the four VDCs. Improving the households‟ access to formal credit institutions can be linked to economic and institutional pillars of sustainable development.

9.1 Way forward

As stated earlier, this study builds on the existing literatures and also adds to them. This study has helped to identify several issues that can form an agenda for future researches. Comparison of adaptive capacity with the adoption of adaptation practices is unique to this study. The comparison has been done at the VDC level; however there is scope for future analysis to conduct this comparison at the individual household level. When households within a VDC are averaged together to get a mean value of adaptive capacity and adaptation adoption rate at the VDC level, the existing differences within the households within the VDC gets diluted. Thus, future analysis can be done to account for the differences in the adaptive capacity at the individual household level and see its implications on the sensitivity, vulnerability, and adaptation for the corresponding household.

This study also incorporates the households‟ perceptions in the adaptation framework. Among the existing literatures, only one study has used perception as a determinant of adaptation. But the study does not differentiate between temperature and rainfall perceptions. Distinguishing the perceptions of rainfall and temperature and using those perceptions as variables in the adaptation model has further raised some important issues in this study. Perceptions of temperature have been shown to have lesser implications in the currently reported adaptation choices. Future studies focusing on the temperature perceptions and documenting the corresponding adaptation practices devised to address temperature changes are recommended.

This study attempts to integrate spatial information of the households in perception and vulnerability analysis. The Global Moran"s I Index used for the spatial analysis of perceptions might not sufficiently address the heterogeneity of the households especially when the households are distributed over a small geographical area. There is ample scope to make the use of existing spatial information of the households and conduct additional spatial analysis using more sophisticated geospatial analytical tools that can account for the location specificity and heterogeneity of the households.

This study is largely based on cross-sectional data, thus gives a one-time picture of the existing situation. In other words this study presents a static analysis of livelihood activities and adaptation practices. There is a scope to conduct a follow-up study so as to capture the dynamic aspects of livelihood activities and adaptation practices among the study community. Such studies can present the diachronic processes or transition of how the livelihoods and adaptation practices of this community has been changing over time.

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Appendices

Appendix 1. Classification of 59 indigenous nationalities in Nepal

Region	Classification				
	Endangered	**Highly Marginalized**	**Marginalized**	**Disadvantaged**	**Advantaged**
Mountain (18)		Shiyar (Chumba) Shingsawa (Lhomi, Karbhote) Thudam	Bhote (Bhotiya) Dolpo Larke (Nupriba) Lhopa (Mustang) Mugali (Mugu) Topkegola (Dhokpya) Walung	Barhagaunle (Bargau-le) Byansi (Sauka, Byasi, Rang) Chhairotan (Tamang, Thakali, Panchgaule) Marphali Thakali (Puntan, Punel) Sherpa Tangbe (Tangbedani) Tingaule Thakali (Yhulkosompaimbi)	Thakali
Hill (24)	Bankariya Hayu Kusbadiya Kusunda Lapcha (Lepcha, Rong) Surel	Baramu Chepang Thami (Thangmi)	Bhujel Dura Pahari Phree (Free) Sunuwar Tamang	Chhantyal Gurung (Tamu) Jirel Limbu (Yakthung) Magar Rai Yakkha (Dewan) Yolmo (Helambu)	Newar
Inner Tarai (7)	Raji Raute	Bote Danuwar Majhi (Bhumar)	Darai Kumal		
Tarai (10)	Kisan (Kuntum) Meche (Bodo)	Dhanuk (Rajbanshi, Khumu) Dhungar/Ghangar/ Jhangad/Dhangad Santhal (Satar)	Gangai Rajbanshi (Koch) Tajpuriya Tharu Dhimal		
Total	**10**	**12**	**20**	**15**	**2**

Source: Pokharel, 2005

Appendix 2. Socio-economic characteristics of the sample households

Socio-economic parameters	Aggregate (n=221)	Kaule (n=58)	Kankada (n=56)	Mahadevsthan (n=54)	Bhumlichowk (n=53)
Average years of education of the HHH[8]	1.2	0.8	1.5	0.7	1.9
Education of the HHH					
Illiterate (cannot read or write)	143 (64.7)	38 (65.5)	34 (60.7)	45 (83.3)	26 (49.1)
Non-formal	15 (6.8)	5 (8.6)	5 (8.9)	2 (3.7)	3 (5.7)
Primary (up to grade 5)	50 (22.6)	14 (24.1)	12 (21.4)	5 (9.3)	19 (35.8)
Lower secondary (grade 6 – 8)	6 (2.7)	1 (1.7)	2 (3.6)	-	3 (5.7)
Secondary (grade 9 – 10)	6 (2.7)	-	3 (5.4)	2 (3.7)	1 (1.9)
Bachelors	1 (0.5)	-	-	-	1 (1.9)
Population without citizenship certificate (%)	19.0	18.4	38.0	10.3	11.2
HHs without access to irrigation	139 (62.9)	45 (77.6)	52 (92.9)	22 (40.7)	20 (37.7)
HHs cultivating unregistered land	98 (44.3)	19 (32.8)	32 (57.1)	20 (37.0)	27 (51.0)
Average livestock holding per HH (LSU)	4.8	5.1	3.8	4.7	5.5
Livestock holding by category					
Small (<5 LSU)	138 (62.4)	35 (60.3)	42 (75.0)	35 (64.8)	26 (49.1)
Medium (5 - 10 LSU)	72 (32.6)	19 (32.8)	14 (25.0)	16 (29.6)	23 (43.4)
Large (>10 LSU)	11 (5.0)	4 (6.9)	-	3 (5.6)	4 (7.5)

Source: Field Survey, 2010
Note: Figures in parenthesis indicate percentage

Appendix 3. Average landholding of the sample households by land category (in Kattha)

Land category	Aggregate (n=221)		Kaule (n=58)		Kankada (n=56)		Mahadevsthan (n=54)		Bhumlichowk (n=53)	
	n	Area/ HH	n	Area/ HH	n	Area/ HH	n	Area/ HH	n	Area/ HH
Irrigated paddyland	78 (35.3)	3.9	12 (20.7)	3.9	3 (5.6)	4.3	31 (58.5)	3.6	32 (60.3)	4.2
Unirrigated paddyland	34 (15.4)	4.4	16 (27.6)	5.5	-		7 (13.2)	4.0	11 (20.7)	3.2
Irrigated upland	10 (4.5)	5.6	4 (6.9)	2.5	1 (1.9)	20	3 (5.7)	6.3	2 (3.8)	3.8
Unirrigated upland	201 (90.9)	7.2	52 (89.7)	7.8	48 (88.9)	8.8	50 (94.3)	6.3	51 (96.2)	6.1
Khoriya (unirrigated)	160 (72.4)	3.8	45 (77.6)	3.6	43 (79.6)	4.4	25 (47.2)	4.1	47 (88.7)	3.4
Total	**221 (100)**	**11.7**	**58 (100)**	**12.2**	**56 (100)**	**11.5**	**54 (100)**	**10.6**	**53 (100)**	**12.3**

Source: Field survey, 2010
Note: Figures in parenthesis indicate percentage

[8] Household Head

Appendix 4. Share of different income sources to total income (%)

Income source	Aggregate (n=221)	Kaule (n=58)	Kankada (n=56)	Mahadevsthan (n=54)	Bhumlichowk (n=53)	P-value
Natural resource based sources						
Agriculture	40.85 (22.51)	30.29 (20.32)	40.28 (22.45)	41.99 (21.74)	51.87 (20.67)	0.00***
Livestock	11.65 (14.13)	15.46 (17.21)	11.45 (14.82)	9.88 (11.06)	9.51 (11.75)	0.09*
Forest	6.84 (10.40)	5.23 (9.56)	8.80 (9.75)	7.60 (11.37)	5.74 (10.78)	0.23
Honey	0.32 (0.99)	0.50 (1.60)	0.44 (0.89)	0.20 (0.58)	0.15 (0.33)	0.17
Handicraft	0.58 (2.19)	0.51 (1.79)	0.13 (0.47)	1.63 (3.82)	0.05 (0.20)	0.00***
Non-natural based remunerative sources						
Salaried job	4.95 (15.53)	0.81 (6.17)	13.35 (24.03)	1.79 (9.20)	3.84 (13.22)	0.00***
Remittance	1.38 (8.36)	0.66 (5.02)	0.00 (0.00)	2.08 (11.96)	2.91 (10.81)	0.24
Skilled non-farm job	4.88 (14.64)	8.09 (17.45)	1.25 (5.31)	6.81 (19.23)	3.23 (11.58)	0.04**
Other less remunerative sources						
Wage labor	26.3 (25.85)	35.46 (30.0)	21.3 (25.23)	25.65 (24.89)	22.21 (19.94)	0.01**
Old age allowance	1.51 (5.9)	2.03 (6.07)	2.19 (8.39)	1.52 (5.29)	0.21 (1.12)	0.28
Petty business	0.73 (5.25)	0.97 (7.36)	0.81 (3.38)	0.86 (6.32)	0.28 (2.01)	0.90

Source: Field survey 2010/11

Note: Figures in parenthesis indicate standard deviation

***, **, * indicate significant at 1%, 5% and 10% level of significance respectively

Appendix 5. Coefficients from the probit model of perception analysis

Independent variables	Perceive hotter summer and/or colder winter		Perceive decreasing rainfall	
	Coefficient	P-value	Coefficient	P-value
Respondent"s age	-0.0099	0.118	0.0005	0.929
Respondent"s gender	0.0119	0.952	0.1425	0.466
Respondent"s education	-0.0645	0.100*	-0.0128	0.738
Own radio	0.3068	0.133	0.4035	0.043**
Memberships in groups	0.4835	0.019**	0.3231	0.105*
Participation in trainings	0.1440	0.465	0.1451	0.450
Farm income	-0.0112	0.095*	0.0009	0.892
Cultivate cash crops	-0.2533	0.171	0.3525	0.055**
Non-farm remunerative income	-0.0096	0.183	-0.0005	0.944
Income from wage labor	-0.0149	0.035**	-0.0002	0.974
Constant	0.6281	0.327	-1.2162	0.058**

Note: **, * indicate significant at 5% and 10% level of significance respectively

Appendix 6. Number of reported natural disasters by the households for the last 10 years

Natural Disasters	Aggregate (n=221)	Kaule (n=58)	Kankada (n=56)	Mahadevsthan (n=54)	Bhumlichowk (n=53)	P-value
Floods/Landslide	0.79 (1.18)	0.52 (0.88)	1.34 (0.48)	0.59 (0.71)	0.70 (0.72)	0.00***
Drought	1.01 (0.78)	0.93 (0.65)	0.52 (0.69)	1.35 (0.55)	1.28 (0.45)	0.00***
Hailstorm	0.85 (0.68)	1.21 (0.67)	0.20 (0.40)	1.06 (0.45)	0.94 (0.5)	0.00***

Source: Field survey, 2011
Note: Figures in parenthesis indicate standard deviation
*** indicates significant at 1% level of significance

Appendix 7. Mean values of sub-indices for adaptive capacity for the study VDCs

Indices	Kaule (n=58)	Kankada (n=56)	Mahadevsthan (n=54)	Bhumlichowk (n=53)	P-value
Physical Assets	-0.62 (0.86)	-0.32 (0.90)	0.35 (1.32)	0.67 (0.95)	0.00***
Human Assets	-0.14 (0.96)	0.02 (1.18)	-0.17 (1.23)	0.30 (1.07)	0.10*
Natural Assets	0.13 (1.21)	-0.66 (1.81)	0.52 (1.31)	0.03 (0.89)	0.00***
Financial Assets	-0.46 (0.79)	0.14 (1.13)	-0.17 (0.93)	0.52 (1.40)	0.00***
Social Assets	-0.39 (0.95)	0.06 (1.03)	0.25 (1.02)	0.11 (0.93)	0.00***
Adaptive Capacity	-0.67 (1.07)	-0.11 (1.42)	0.14 (1.47)	0.70 (1.44)	0.00***

Note: Figures in parenthesis indicate standard deviation
***, * indicates significant at 1%, and 10% level of significance respectively

Appendix 8. VDC wise mean values of indices of vulnerability and its components

Indices	Kaule (n=58)	Kankada (n=56)	Mahadevsthan (n=54)	Bhumlichowk (n=53)	P-value
Exposure	1.78 (0.18)	-1.65 (0.46)	-1.58 (0.32)	1.40 (0.15)	0.00***
Sensitivity	-0.46 (0.30)	1.06 (2.80)	-0.26 (0.70)	-0.36 (0.25)	0.00***
Adaptive capacity	-0.67 (1.07)	-0.11 (1.42)	0.14 (1.47)	0.70 (1.44)	0.00***
Vulnerability	1.99 (1.09)	-0.48 (3.26)	-1.98 (1.50)	0.34 (1.50)	0.00***

Note: Figures in parenthesis indicate standard deviation
*** indicates significant at 1% level of significance

Appendix 9. Mean values of indices of vulnerability and its components for the vulnerability quartiles

Indices	Quartile 1 (Most vulnerable)	Quartile 2	Quartile 3	Quartile 4 (Least vulnerable)	P-value
Exposure	1.30 (1.11)	0.87 (1.23)	-0.67 (1.43)	-1.48 (0.99)	0.00***
Sensitivity	0.45 (2.92)	-0.10 (0.73)	-0.20 (0.74)	-0.16 (0.53)	0.10*
Adaptive capacity	-1.19 (0.67)	0.01 (0.85)	-0.04 (1.30)	1.20 (1.60)	0.00***
Vulnerability	2.95 (2.21)	0.76 (0.50)	-0.83 (0.45)	-2.83 (1.09)	0.00***

Note: Figures in parenthesis indicate standard deviation
***, * indicates significant at 1%, and 10% level of significance respectively

Appendix 10. Academic and professional profile of the author

Personal Information

Name: Luni PIYA
Permanent Address: Gahiraa Tol, Bandipur – 4,
Tanahun, Nepal
Email: loonypiya@hotmail.com
Sex: Female
Date of Birth: 1st January 1981
Nationality: Nepalese
Marital Status: Single

Academic Background:

Degree	Major Area of Study	Division / Grade	Year of Graduation	Institution
PhD	Rural Economics	-	2012	IDEC, Hiroshima University, Japan
M.A.	Rural Economics	A	2009	IDEC, Hiroshima University, Japan
M. Sc. Ag.	Agricultural Economics	Distinction	2006	Tribhuvan University / Institute of Agriculture and Animal Sciences (TU/IAAS), Rampur, Chitwan, Nepal.
B.Sc. Ag.	Agricultural Extension	Distinction	2003	TU/IAAS, Rampur, Chitwan, Nepal.
I. Sc.	Biology	First	1999	TU/ St. Xavier's Campus, Maitighar, Kathmandu, Nepal
S. L.C.	Accounts/ Mathematics	First	1996	SLC Board/ Notre Dame School, Bandipur, Tanahun, Nepal.

Areas of Specialization

- Agriculture, livestock, and forestry based rural livelihoods
- Livelihoods of indigenous people
- Rural development
- Socio-economic dimensions of climate change and extreme events

Awards

1. **2011 Hiroshima University Excellent Student Scholarship Award** for excellent academic performance.
2. Awarded the **Aishwarya Vidya Padak (Gold Medal) in Nepal** for the year 2003 for excellent academic performance in B.Sc.Ag. among all the female students in the relevant field in the country.

Employments

S.No.	Employer	Period of Employment	Position	Responsibilities
1	Graduate School for International Development and Cooperation (IDEC), Hiroshima University, Japan	11 April 2011 – 30 September 2012	Research Assistant	Conduct researches related to rural livelihoods, rural development, food security, climate change and rural livelihoods, and indigenous people in South Asian Region.
2	Graduate School for International Development and Cooperation (IDEC), Hiroshima University, Japan	11 May 2009 – 28 February 2011	Teaching Assistant	Assist the resource person in arranging the classrooms, delivering lectures, prepare teaching materials, and other logistics.
3	Forum for Rural Welfare and Agricultural Reform for Development (FORWARD), Nepal	27 August 2006 – 7 September 2007	Project Team Leader (for the project entitled "Chepang Mainstreaming Programme")	Program planning, financial planning, implementation, monitoring, supervision, and reporting.
4	United Nations, World Food Programme (UN/WFP), Nepal	13 March 2006 – 24 March 2006	Enumerator for project entitled "Food and Agricultural Markets in Nepal"	Entry and analysis of collected data of major agricultural markets in Nepal.
5	Dr. Punya Prasad Regmi, Professor, Institute of Agriculture and Animal Science, Tribhuvan University, Nepal	2 March 2006 – 8 March 2006	Enumerator for project entitled "Sustainable Livelihoods through Leasehold Vegetable Farming and Leasehold Forestry; and Financial Intermediation and its Effect on Pro-poor"	Data collection in Makawanpur and Bara districts through household survey.

Journal Articles as First/Second Author (Refereed)

Piya L., Maharjan, K.L., and Joshi, N.P. "Determinants of Adaptation Practices to Climate Change by Chepang Households in Rural Mid-Hills of Nepal". *Regional Environmental Change.* In process.

Piya, L., Maharjan, K.L., and Joshi, N.P. 2012. "Comparison of Adaptive Capacity and Adaptation Practices in Response to Climate Change and Extremes among the Chepang Households in Rural of Mid-Hills Nepal". *Journal of International Development and Cooperation*, 18(4), Special Issue: 55-75.

Piya, L., Maharjan, K.L., Joshi, N.P. 2012. "Perceptions and Realities of Climate Change among the Chepang Communities in Rural Mid-Hills of Nepal" *Journal of Contemporary India Studies: Space and Society*, 2:35–50. [Available at http://home.hiroshima-u.ac.jp/hindas/PDF/2011/Piya_et_al2011_HINDAS.pdf]

Piya, L., Maharjan, K.L., Joshi, N.P., and Dangol, D.R. 2011. "Collection and Marketing of Non-Timber Forest Products by Chepang Community in Nepal" *The Journal of Agriculture and Environment,* 12: 10 – 21. [Available at http://www.moac.gov.np/geed/art2.pdf]

Piya, L., Maharjan, K. L., and Joshi, N. P. 2011. "Livelihood strategies of indigenous nationalities in Nepal: A case of chepangs" *Journal of International Development and Cooperation*, 17 (2): 99 – 114. [Available at http://ir.lib.hiroshima-u.ac.jp/metadb/up/kiyo/AN10482914/JIDC_17-2_99.pdf]

Piya, L., Maharjan, K. L. and Joshi, N. P. 2011. "Forest and food security of indigenous people: A case of chepangs in Nepal" *Journal of International Development and Cooperation*. Vol. 17 (2): 113 – 135. [Available at http://ir.lib.hiroshima-u.ac.jp/metadb/up/kiyo/AN10482914/JIDC_17-1_113.pdf]

Maharjan, K.L., **Piya, L.** and Joshi, N. P. 2010. "Annual subsistence cycle of the Chepangs in mid-hills of Nepal: An integration of farming and gathering" *Himalayan Journal of Sociology and Anthropology*, Vol. 4: 105-133. [Available at http://www.nepjol.info/index.php/HJSA/article/view/4671/3885]

Journal Articles as Co-author (Refereed)

Joshi, N.P., Maharjan, K.L., and **Piya, L.** 2012. "Understanding the relationship between climate change and poverty in Nepal". *Journal of International Development and Cooperation*, 18(4), Special Issue: 21-35.

Joshi, N.P., Maharjan, K.L., and **Piya, L.** 2012. "Determinants of Income and Consumption Poverty in Far-Western Rural Hills of Nepal" *Journal of Contemporary India Studies: Space and Society*, 2:51–61. [Available at http://home.hiroshima-u.ac.jp/hindas/PDF/2011/Joshi_et_al2011_HINDAS.pdf]

Joshi, N. P., Maharjan, K. L., and **Piya, L.** 2011. Effect of climate variables on yield of major food crops in Nepal: A time-series analysis. *Journal of Contemporary India Studies: Space and Society*. Vol. 1: 19-26. [Available at http://ir.lib.hiroshima-u.ac.jp/metadb/up/kiyo/hindas/J-ContempIndiaStud-SpaceSoc-HiroshimaUniv_1_19.pdf]

Joshi, N. P., Maharjan, K. L., and **Piya, L.** 2011. Production economics of rice in different development regions of Nepal. *Journal of International Development and Cooperation*. Vol. 17 (1): 103: 112. [Available at http://ir.lib.hiroshima-u.ac.jp/metadb/up/kiyo/AN10482914/JIDC_17-1_103.pdf]

Joshi, N. P., Maharjan, K. L., and **Piya, L.** 2010. Poverty and food insecurity in Nepal: A review. *Journal of International Development and Cooperation*. Vol. 16(2): 1-19. [Available at http://ir.lib.hiroshima-u.ac.jp/metadb/up/kiyo/AN10482914/JIDC_17-1_113.pdf]

Submitted Journal Article (Refereed)

Joshi, N. P., Maharjan, K. L., and **Piya, L.** Effect of climate variables on rice yield in Nepal: A panel data analysis with regional disaggregation. *Climatic Change*. Under review.

Book Chapter (Refereed)

Maharjan, K.L., Joshi, N.P, and **Piya, L.** 2012. "Sources of climate change, its impact and mitigation issues in Nepal". In Singh, S. and S, M. (eds.), Climate Change An Asian Perspective, pp. 51-77. Jaipur: Rawat Publications.

Research Notes (Refereed)

Kristijo, H., **Piya, L.,** Susetyo, B., Utama, D. N., and Chikaraishi, M. 2011. Promotion of Bus Rapid Transit (BRT) in a Large City: A Case Study of Yogyakarta. *Journal of International Development and Cooperation (Special Issue)*. Vol. 18 (2): 43 – 51.

Piya, L., and K. L. Maharjan. 2009. Protracted people"s war in Nepal: An analysis from the perspective of Azar"s theory of protracted social conflict. *Journal of International Development and Cooperation*, 15(1-2): 185-203. [Available at http://ir.lib.hiroshima-u.ac.jp/metadb/up/kiyo/AN10482914/JIDC_15-1_185.pdf]

Conference Presentations

Piya, L., Maharjan, K.L., and Joshi, N.P. 2012. "Vulnerability of Rural Households to Climate Change and Extremes: Analysis of Chepang Households in the Mid-Hills of Nepal". Paper accepted for The 28th International Conference of Agricultural Economists held from August 18-24 in Rafain Convention Center, Foz Do Iguacu, Brazil.

Joshi, N.P., Maharjan, K.L. and **Piya, L.**, 2012. "Poverty Dynamics in Far-Western Rural Hills of Nepal: Evidences from Panel Data". Poster accepted for The 28th International Conference of Agricultural Economists held from August 18-24 in Rafain Convention Center, Foz Do Iguacu, Brazil.

Joshi, N.P., Maharjan, K.L., and **Piya, L.** 2012. "Can Organic Agriculture be a Sustainable Approach for Food Security in Least Developed Countries?" Paper presented at The Fourth SAS-N (Society of Agricultural Scientists, Nepal) Convention - Agricultural Research for Development, 4-6 April, 2012, National Agriculture Research Institute (NARI) Complex, Khumaltar, Lalitpur, Nepal.

Joshi, N.P., Maharjan, K.L., and **Piya, L.** 2011. "Effect of Climate Variables on Yield of Rice in Nepal: A Panel Data Analysis with Regional Disaggregation". Paper presented at The 7th Asian Society of Agricultural Economists (ASAE) Conference, 13-15 October, 2011, Hanoi, Vietnam.

Piya, L., Maharjan K. L., and Joshi, N. P. 2010. "Collection and Marketing of Non-Timber Forest Products by Chepang Community in Chitwan District of Nepal", Paper presented at The 60th Annual Meeting of the Association of Regional Agricultural and Forestry Economics (ARFE), October 22nd to 24th 2010, Kyoto University, Kyoto, Japan.

Joshi, N. P., Maharjan, K. L., and **Piya, L.** 2010. "Effect of Climate Variables in Yield of Major Food Crops in Nepal – A Time Series Analaysis", Paper presented at The 60th

Annual Meeting of the Association of Regional Agricultural and Forestry Economics (ARFE), October 22nd to 24th 2010, Kyoto University, Kyoto, Japan.

Piya, L., Maharjan, K. L., and Joshi, N. P. 2010. "Forest and Food Security of Indigenous People: A Case of Chepangs in Nepal", Poster presented at The 84th Annual Conference of The Agricultural Economics Society, March 29th to 31st 2010, Edinburgh University, Edinburgh, the UK.

Piya, L., Maharjan, K. L., and Joshi, N. P. 2010. "Livelihood Strategies of Indigenous Nationalities in Nepal: A Case of Chepangs", Paper presented at The Annual Meeting 2010 of Agricultural Economics Society of Japan, March 26th to 29th 2010, Kyoto University, Kyoto, Japan

Joshi, N. P., Maharjan, K. L., and **Piya, L.** 2010. "Factors Affecting Poverty in Rural Mid-western Hills of Nepal: An Empirical Analysis", Poster presented at The 84th Annual Conference of The Agricultural Economics Society, March 29th to 31st 2010, Edinburgh University, Edinburgh, the UK.

Joshi, N. P., Maharjan, K. L., and **Piya, L.** 2010. "Study of Rural Poverty in Far-western and Western Development Regions of Nepal: An Inequality Decomposition Analysis", Paper presented at The Annual Meeting 2010 of Agricultural Economics Society of Japan, March 26th to 29th 2010, Kyoto University, Kyoto, Japan

Maharjan, K. L., Joshi, N. P., and **Piya L.** 2009. "Sources of Climate Change, its Impact, and Mitigation Issues in Nepal", Paper presented at The International Conference on Climate Change, Livelihoods, and Food Security, June 9-10, 2009, Institute of Development Studies, Jaipur, India in collaboration with Association of Asian Scholars, Bangkok.

Thesis

Piya, L., 2009. Role of Forest Resources on the Livelihood of Chepang Community in Nepal: A Case Study of Chitwan and Makwanpur Districts. Unpublished M. A. (Rural Economics) Thesis, Graduate School for International Development and Cooperation, Hiroshima University, Japan.

Piya, L., 2006. Role of Microfinance in Poverty Alleviation of Women: A Case of Small Farmers Cooperative Limited, Kumroz, Chitwan. Unpublished, M. Sc. Ag. Thesis. Tribhuwan University, Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal.

Other Publication (Non-refereed)

Piya, L. 2005. Assessment of Reproductive Health Situation of Married Females in Bandipur Village Development Committee of Tanahun, Nepal. *Smarika* 10: 110-115. Bandipur Social Development Committee.

Scholarships/Grants

1. **Research Grant** from **Global Environment Leaders (GELs)** Education Program for Designing Low Carbon Society Research Grant to undertake research entitled **Vulnerability, Impacts, and Adaptation to Climate Change: Livelihoods of Chepang Community in Rural Mid-Hills of Nepal.** Graduate School for International Development and Cooperation, Hiroshima University, Japan.

2. **Monbukagakusho (MEXT) Scholarship** provided by the Japanese government to pursue **PhD (2009-2012)** at Graduate School for International Development and Cooperation (IDEC), Hiroshima University, Japan.
3. **Monbukagakusho (MEXT) Scholarship** provided by the Japanese government to pursue **Masters (2007-2009)** at Graduate School for International Development and Cooperation (IDEC), Hiroshima University, Japan.
4. **Research Grant** (partial) provided by **The Winrock International,** Naya Baneshwar, Kathmandu, Nepal to undertake research entitled **Role of Microfinance in Poverty Alleviation of Women: A Case of Small Farmers Cooperative Limited, Kumroz, Chitwan**.
5. **Research Grant** (partial) provided by **Decentralized Local Governance Support Programme, United Nations Development Programme (DLGSP/UNDP)**, Kathmandu, Nepal, and **Social Mobilization and Experimentation Learning Center (SMELC)**, IAAS, Nepal to undertake research entitled **Role of Microfinance in Poverty Alleviation of Women: A Case of Small Farmers Cooperative Limited, Kumroz, Chitwan**.
6. Awarded scholarship for four years throughout B.Sc. Ag. from 1999-2003 by **The Winrock International,** Nepal.

Trainings/Courses/Workshops

1. Summer Course 2012 entitled **Development within Low Carbon World: Preparing Professionals for Disaster Risk Management and Climate Change Adaptation** Jointly organized by Global Environment Leader Education Program for Designing Low Carbon Society, Graduate School for International Development and Cooperation; Hiroshima University"s Center for Environmental Cooperation; The School of Urban and Regional Planning, The University of Philippines Diliman; and Lyndon B. Johnson School of Public Affairs, The University of Texas Austin, held in The Philippines from August 6 to 16, 2012.
2. **Postgraduate Courses on Building Resilience to Climate Change, Spring 2011**, UN-CECAR, Institute for Sustainability and Peace, United Nations University Center, Tokyo, Japan
3. Summer Course 2010 entitled **Development within Low Carbon World: Participatory Approaches in Planning and Implementing Climate Change Policies** Jointly organized by Global Environment Leader Education Program for Designing Low Carbon Society, Graduate School for International Development and Cooperation, Hiroshima University and SEAMEO BIOTROP Campus, Bogor Agricultural University, Indonesia from August 5 to 13, 2010.
4. **Global Environment Leader Education Program for Designing Low Carbon Society,** Graduate School for International Development and Cooperation, Hiroshima University.
5. Workshop on **Environmental leader training for sustainable Asia,** organized by Global Environment Leader Education Program for Designing Low Carbon Society, Graduate School for International Development Cooperation, Hiroshima University.
6. **Training on Social Mobilization and Community Development** conducted at Institute of Agriculture and Animal Sciences, Rampur by Social Mobilization Experimentation and Learning Center (SMELC), Chitwan, Nepal.

7. **Workshop on Participatory Rural Appraisal (PRA)** held at Institute of Agriculture and Animal Sciences, Rampur organized by Farmers' Institute for Participatory Research and Development, Rampur Unit, Chitwan, Nepal.
8. **Workshop on Proposal Writing** conducted at Institute of Agriculture and Animal Sciences, Rampur organized by Farmers' Institute for Participatory Research and Development, Rampur Unit, Chitwan, Nepal.
9. **Training on Gender Sensitization** conducted at Institute of Agriculture and Animal Sciences, Rampur organized by Farmers' Institute for Participatory Research and Development, Rampur Unit, in collaboration with Gorkha Bee Keeping Training and Research Centre, Yagyapuri, Chitwan, Nepal.
10. **Workshop on Self-Management and Leadership** conducted at Institute of Agriculture and Animal Sciences, Rampur by Social Mobilization Experimentation and Learning Center (SMELC), Chitwan, Nepal.

Internships

1. **Follow-up Research Internship (February – March, 2010)** at Forum for Rural Welfare and Agricultural Reform for Development (FORWARD), Nepal facilitated by Global Explorers to Cross Borders (Gecbo), Graduate School for International Development and Cooperation (IDEC), Hiroshima University, Japan.
2. **Domestic Internship (August, 2009)** at Satake Corporation, Department of Research and Development, Japan facilitated by Global Explorers to Cross Borders (Gecbo), Graduate School for International Development and Cooperation (IDEC), Hiroshima University, Japan.
3. **Overseas Research Internship (February – March, 2009)** at Forum for Rural Welfare and Agricultural Reform for Development (FORWARD), Nepal facilitated by Global Explorers to Cross Borders (Gecbo), Graduate School for International Development and Cooperation (IDEC), Hiroshima University, Japan.