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Socio-Economic Issues of Climate Change

A Livelihood Analysis from Nepal

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Preface

The research leading to this book was conceived at a time when the social and human dimensions were just beginning to find a space in the climate change arena. The few literatures that existed in the topic were almost exclusively focused on the developed countries. Given the circumstances, the research aimed to contribute to the dearth by exploring the socio-economic issues of climate change among one of the highly marginalized rural communities in a developing country. It took almost a decade to give these findings a book form. Meanwhile, the academia has definitely seen a surge in researches dealing with social, cultural, human, and economic aspects of climate change. However, such researches not only form a small proportion of the total climate change-related researches but are also sparse regarding the issues of the Global South. This book analyzes the socio-economic issues of climate change from a livelihoods perspective, taking the case study of a highly marginalized indigenous community called the Chepangs, living in the remote mid-hills of Nepal. Such rural communities are often the ones who have contributed the least in the anthropogenic climate change yet are one of those whose livelihoods are most adversely impacted by the phenomenon. Their extensive dependence on natural resources for livelihoods makes them the most vulnerable to even small changes in the climate, which is further coupled by their poor adaptive capacities owing to lack of assets and access to institutional supports. In this context, the Chepangs form the appropriate representative of the disadvantaged population whose livelihoods are constantly threatened by adversaries associated with the changing climate. Within the scant literature dealing with this topic in developing countries, those focusing on indigenous communities are even scanter. At the current time when the policymakers and development agencies are looking for ground-level evidences to mainstream climate change for sustainable development worldwide, the authors believe that this book is more relevant than ever before.

The book contains an updated review of how climate change interacts with various aspects of livelihoods including assets and strategies (Chap. 2). Chapter 3 describes the policies and programs related to climate change in the context of Nepal. The conceptual and analytical framework adopted in the book is elaborated in Chap. 4. A brief introduction about the study community and the rationale for selecting this community as our study population are given in Chap. 5. The study settings including the selection of study sites, methodologies of sampling, and data collection are outlined in Chap. 6. In the introductory analytical chapters (7 and 8), the book sheds important details on the livelihood strategies of the study community. These descriptive chapters are important for the readers to understand the backdrop against which the study community is facing the phenomenon of climate change. Chapter 7 describes how farming and gathering are integrated into the subsistence livelihoods of the Chepang community. Chapter 8 looks into the detail livelihood portfolio of the community. The important finding of this chapter is that farming, forestry, and wage laboring are the major livelihood sources adopted by most of the households, despite the fact that these livelihoods yield comparatively lower income. Only few of the Chepang households are able to undertake remunerative livelihoods sources like salaried jobs, nonfarm skilled jobs, and laboring abroad because they lack the basic education, skills, and capitals required.

The book deals in depth with various aspects of climate change like community perceptions, local-level vulnerability, livelihood impacts, adaptive capacity, and community-based adaptations. Each of these aspects of climate change is discussed in the subsequent chapters, keeping the livelihoods at the center. Chapter 9 on perceptions shows that the majority of the communities are able to correctly perceive the trends of changing climatic variables for the short run of the last 10 years. Analysis of factors affecting perceptions reveals that the access to relevant information is the most important factor enabling correct perceptions for which extension services must be strengthened. Indicator-based vulnerability analysis conducted in Chap. 10 highlights the fact that when households in a locality are exposed to the same climate adversities, those households with least adaptive capacity exhibit the highest sensitivity, thereby resulting in higher vulnerability. Since adaptive capacity is the only component with direct policy implications, efforts should be geared towards improving the community-level adaptive capacity so as to reduce the sensitivity as well as the vulnerability to climate change. Chapter 11 provides evidences of the livelihood impacts of climate change and extreme events experienced by the community. The smaller less dramatic climatic events like mid-season droughts, hails, shifting rainfall patterns, and declining rainfall quantity are very significant for the Chepangs who predominantly depend on subsistence rainfed farming for livelihoods. This chapter provides insights for scientific studies and mitigation policies to focus on the impacts of such climatic events on the livelihoods of highly marginalized communities living in geographically vulnerable areas. The comparison of adaptive capacity and adaptation practices in Chap. 12 reveals that the aggregate adaptive capacity is not the sufficient determinant of adaptation practices. The balanced possession of the different types of assets is a must for households to build their adaptive capacity. Further, without improved human capability and financial capital, it was found that households are unable to utilize other assets efficiently. Thus, to ensure that the inherent adaptive capacity is translated into effective adaptation actions, human and financial capitals must foremost be strengthened. The analysis presented in this chapter also sheds light on the factors determining the choice of adaptation practices by the households. Ability to correctly perceive rainfall changes, access to information, secure land tenure, access to credit facilities, and skill development training are the most important determinants of adaptation. The concluding chapter discusses why the mainstreaming of climate change into policy and development interventions is a must for sustainable development.

This book will be of relevance to a multitude of audiences from various backgrounds. The information presented herein is of use for academicians, policy-makers, and development workers dealing with rural livelihoods, indigenous communities, and climate change. The book can be used as a source of teaching materials for graduate students. The findings and recommendations provided can form a basis for policy formulations and design of development projects.

We thank the Global Environmental Leaders (GELs) Education Program for Designing a Low Carbon Society and Hiroshima University TAOYAKA Program for creating a flexible, enduring, peaceful society funded by the Program for Leading Graduate Schools, Ministry of Education, Culture, Sports, Science and Technology for providing research funds. We are also grateful to FORWARD Nepal and Nepal Chepang Association for logistic supports in Nepal during fieldworks. Lastly, we are obliged to the Chepang community for their cooperation in our research activities.

Higashi Hiroshima, Japan
December 2018

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Contents

About the Authors

Luni Piya (Ph.D., Hiroshima University) is currently a Researcher at the Graduate School for International Development and Cooperation, Hiroshima University, Japan. Her academic expertise lies in issues related to the livelihoods of rural households in developing economies. Her researches have covered specific topics of rural livelihood trajectories; socio-economic issues of climate change; religio-cultural dynamisms of indigenous communities; migration; and remittances. Her research works have been published in several SCI/SSCI journals. She has co-authored two books and a book chapter namely, *Role of Microfinance in Poverty Alleviation of Women: A Case of Small Farmers Cooperative Limited in Kumroz, Chitwan, Nepal*, Lambert Academic Publishing (2013); *Understanding Maoist Conflict in Nepal: Initiatives of Civil Societies on Social Capital Development for Peacebuilding in Hills*, Lambert Academic Publishing (2013); and *Sources of Climate Change, its Impact and Mitigation Issues in Nepal*, Rawat Publications (2012). She is one of the contributing authors for the book chapter *Adaptation to Climate Change in the Hindu Kush Himalaya: Stronger Action Urgently Needed*, Springer Nature (2019).

Keshav Lall Maharjan (Dr. of Agriculture in Agricultural Economics, Kyoto University, Japan) is currently a Professor at the Graduate School for International Development and Cooperation (IDEC), Hiroshima University, Japan, where he has been teaching, conducting research and chairing various steering and decision-making committees since its foundation in 1994. He gives lectures for graduate students on subjects including Rural Economics, Rural Development, South Asian Studies, International Development and Cooperation Studies. He conducts weekly seminars at the graduate school that address pertinent issues in Agricultural Economics, Rural Development, Sustainable Development, Climate Change and Rural Livelihood Strategies in developing countries. At IDEC, he is also in charge of planning, execution and monitoring of International Explorers to Cross Borders (i-ECBO) program, a unique sandwich-type internship program, in which students after competitive selection process are sent to various institutions such as universities, international organizations, government agencies, INGOs, local NGOs and developing agencies, including private companies around the world. He offers support for graduate students writing their Master's theses and doctoral dissertations on the related topics at Divisions of Development Sciences, and Educational Development and Cultural and Regional Studies, and at Cultural Creation Course of Taoyaka Program, a special Ph.D. program for leading graduate schools at Hiroshima University, aiming to nurture the graduates who can contribute to flexible, enduring and peaceful society of coexistence among the mankind and the nature, with special attention to disadvantaged regions. The issues concerning natural resource management, food security, poverty dynamics, local governance, rural society and community dynamics are some of the main topics of his expertise. In doing so, he considers agriculture and rural regions as not only the source of cheap labor, cheap food and cheaper intermediate inputs, and subordinate to urbans and centers as marginal sector and peripheral region but also as a dignified way of life for people who are guardians of nature and are more conscious about the earth, humans and their interaction, so as to sustain this culture and civilization for generations hereafter. Rural regions are such places that make these things happen. Hence, fieldwork to grasp the diverse realities of rural regions location specifically before generalizing the research is given importance in his research, lectures and in educating the graduate students in terms of their research, writing journal articles and dissertations. Some 30 students have received their Ph. D. from Hiroshima University under his guidance. He regularly receives research funds from various funding agencies to conduct research.

In order to disseminate research findings, consolidate ideas and concepts, and share knowledge with other professionals, he regularly participates in local, national and international seminars and conferences organized by academic societies, research institutions, various organizations and like-minded individuals, including agricultural economists, development economists, agronomists, ruralogists, sociologists, environmentalists, anthropologists, educationalists, policy makers, development practitioners, farmers, local leaders and opinion shapers.

Some of his earlier books in English include *Sustainability of Organic Farming in Nepal*, Singapore: Springer Nature, 2017; *Assessing Community-Based Adaptation in Central and Far-Western Nepal,* Balti: LAMBERT Academic Publishing, 2017; *Decentralization and Rural Development in Indonesia*. Singapore: Springer Nature, 2017; *Community Seed Production Sustainability in Rice-Wheat Farming*. Tokyo: Springer Japan, 2015; *Communities and Livelihood Strategies in Developing Countries.* Tokyo: Springer Japan, 2014; *Climate Change, Agriculture and Rural Livelihoods in Developing Countries*, Tokyo: Springer Japan, 2013; *Understanding Maoist Conflict in Nepal: Initiatives of Civil Societies on Social Capital Development for Peacebuilding in Hills*, Germany: Lambert Academic Publishing, 2013; *Peasantry in Nepal: A Study on Subsistence Farmers and Their Activities Pertaining to Food Security*, Hiroshima: Research Center for Regional Geography, Hiroshima University, 2003; and *Impacts of Irrigation and Drainage Schemes on Rural Economic Activities in Bangladesh,* Hiroshima: Research Center for Regional Geography, Hiroshima University, 1997. He has also contributed chapters to publications including *Microfinance, Risk-taking Behaviour and Rural Livelihood*, New Delhi: Springer India, 2014, *Geography of governance: Dynamics for local development*. International Geography Union Commission on Geography of Governance, Slovakia, 2013, *Climate Change: Asian Perspective*, Jaipur: Rawat Publication, 2012; *Globalization and Cultural Practices in Mountain Areas: Dynamics and Implication*. Sikkim: INDUS, 2012, *Public Policy and Local Development – opportunities and constraints*, International Geographical Union Commission on Geography and Public Policy, 2008; *Political and Social Transformation in North India and Nepal*, New Delhi: Manohar Publishers, 2007; *Contentious Politics and Democratization in Nepal*. New Delhi: Sage Publications, 2007, *Small-Scale Livelihoods and Natural Resource Management in Marginal Areas of Monsoon Asia*, Dehra Dun: Bishen Singh Mahendra Pal Singh, 2006; *New Challenges Facing Asian Agriculture under Globalization.* Selangor: Malaysian Agricultural Economics Association, 2005; *Translating Development: The Case of Nepal*, New Delhi: Social Science Press, 2003; and *Sustainable Agriculture, Poverty and Food Security*, Jaipur: Rawat Publications, 2002. He contributes to various related academic journals including SCI, SSCI journals and has more than hundred and eighty-five peer reviewed articles to his credit. He has also produced numerous books and journal articles in Japanese. He was awarded **Jyapu Ratna**, Gem of Jyapu, for his achievements and contribution to the society by K. P. Sharma Oli, the prime minister of Federal Democratic Republic of Nepal on December 12, 2015.

Niraj Prakash Joshi (Ph.D., Hiroshima University) is currently working as an Associate Professor (Special Appointment) at Hiroshima University under the TAOYAKA program. He is involved in teaching and conducting research. He gives lectures for graduate students on subjects including rural economics, developing debating skills/developing designing ability and onsite education related courses. He is involved in designing and implementing overseas onsite-trainings for post-graduate students of Hiroshima University in collaboration with the University of Texas at Austin and Tribhuvan University, Nepal. He has also been advising students on research project development and implementation. He is engaged in researches related to poverty, food insecurity, rural livelihoods and climate change in developing countries, with a particular focus on poverty-ridden region of the far-western rural hills of Nepal as well as the impoverished and marginalized Chepang community in Nepal's remote central hills. Besides, he is also engaged in research on production and trade of agricultural commodities in the Northern Indian subcontinent.

He has presented the related research outcomes in several national and international conferences and seminars. He has published several papers in various peer-reviewed journals. He has also published some books. Some of his earlier books include *Climate Change, Agriculture and Rural Livelihoods in Developing Countries,* Springer Japan (2013); *Understanding Maoist Conflict in Nepal: Initiatives of Civil Societies on Social Capital Development for Peacebuilding in Hills*, Lambert Academic Publishing, (2013); *Role of Microfinance in Poverty Alleviation of Women: A Case of Small Farmers Cooperative Limited in Kumroz, Chitwan, Nepal*, Lambert Academic Publishing, (2013) and *Poverty and Food-Insecurity Analysis in Far-Western Hills of Nepal: A Case of Baitadi District,* Lambert Academic Publishing (2011). Besides, he has also contributed chapters to publications including *Climate Change: An Asian Perspective,* Rawat Publication (2012).

Acronyms and Abbreviations

˚C	Degree Centigrade
AE	Adult Equivalent
ANOVA	Analysis of Variance
AR4	Fourth Assessment Report
AR5	Fifth 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
Chap.	Chapter
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
FCPF	Forest Carbon Partnership Facility
FORWARD	Forum for Rural Welfare and Agriculture Reform for Development
GCM	General Circulation Model
GELs	Global Environmental Leaders Education Program for Designing a Low Carbon Society
GHG	Greenhouse Gas
GLOF	Glacial Lake Outburst Flood
h	hour
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 for Action
LI-BIRD	Local Initiatives for Biodiversity, Research and Development
LSU	Livestock Standard Unit
LUCF	Land-Use Change and Forestry
LULUCF	Land Use, Land-Use Change, and Forestry
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 Sample Households
N_2O	Nitrous Oxide
NAP	National Adaptation Plan
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 Cooperation
NPC	National Planning Commission
NRs.	Nepali Rupees
NTFP	Non-Timber Forest Product
PASW	Predictive Analytics Software
PCA	Principal Component Analysis
PDD	Project Design Document
RCM	Regional Circulation Model
RCPs	Representative Concentration Pathways
REDD	Reduced Emissions from Deforestation and Forest Degradation
R-PP	Readiness Preparation Proposal
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

List of Figures

List of Tables

Chapter 1
Introduction

Abstract Anthropogenic global warming is unequivocal. Climate science has progressed tremendously in terms of the understandings of the related biophysical processes. However, studies of the human and social dimensions of climate change are gaining pace only recently. Climate change is a global phenomenon with local manifestations and impacts. This calls for the need of an assessment of local vulnerabilities, impacts, and adaptation options at the micro-level. Climate change also has glaring inequities in terms of its causes and impacts. Rural marginalized communities in developing countries are one of the most affected communities due to higher dependence on natural resources compounded by their limited adaptive capacity. In this regards, this book focuses on the Chepang community, one of the highly marginalized indigenous nationalities from the remote mid-hills of Nepal.

Keywords Anthropogenic climate change · Intergovernmental Panel on Climate Change (IPCC) · Human and social dimensions · Nepal · Chepang

1.1 Evolution in Climate Change Studies

As per the assessments presented by the Intergovernmental Panel on Climate Change (IPCC), it is unequivocal that the Earth's climate system is warming (Burkett et al. 2014), 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 six decades (IPCC 2014, 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). The fourth assessment report (AR4) of the IPCC established the anthropogenic activities as the major cause of current climate change with very high confidence. The evidences have further been strengthened in the fifth assessment report (AR5), which states that the impact of anthropogenic causes on

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climate change have increased substantially than the estimates reported in AR4 (Myhre et al. 2013).

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. The temperature rises for the immediate time period of 2016–2035 relative to 1986–2005 is projected to be in the range 0.3–0.7 °C over various scenarios of Representative Concentration Pathways (RCPs) (Kirtman et al. 2013). The rate of warming will of course be higher with the higher rate of GHG emissions. This will have adverse impacts on every sector like water availability, food production, terrestrial ecosystems, marine biodiversity, coastal ecology, health, and livelihoods (Field et al. 2014; IPCC 2007b; Rosenzweig et al. 2007). Climate change is a global phenomenon; however, its manifestations and 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. As a result, recent literatures have linked climate change with the issues of climate justice and human rights (Levy and Patz 2015; Cameron et al. 2013, 2010).

With the establishment of 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 are now crosscutting issues and are research interests 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 have 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 and aerosol-cloud interaction are yet to be completely understood. Models have not been able to simulate or project climate at a finer spatial scale compared to the global and continental scales, and projecting precipitation with equal confidence as temperatures is still a challenge for the scientists (Stocker et al. 2013). 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. While 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, a couple of early literatures 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 understanding of the interface between human, natural, and climate systems has greatly expanded over the last decade. The working group II of the AR5 provides a "large body of evidence from the social sciences about human behavior and the human dimensions of climate change" (Burkett et al. 2014, p. 180). The AR5 also explores the interaction of climate change with livelihoods and poverty, which is a novelty in the IPCC (Olsson et al. 2014). The AR5 rightly emphasizes the need to discuss poverty and livelihoods from a multidimensional aspect to understand the context-specific conditions of marginalization that shape vulnerability and impacts. This book looks into the interaction of climate change and the livelihoods of a highly marginalized community in Nepal, presenting a holistic analysis of the context-specific marginalization (based on social, cultural, economic, political, physical, geographical, and demographic factors) that shape perceptions, vulnerabilities, impacts, and adaptation strategies of the community.

1.2 Grounds for This Research

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 (Field et al. 2014; 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 (Dasgupta et al. 2014; 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 countries to climate change (Oxfam 2009). Nepal is already a country vulnerable to natural disasters particularly floods and landslides. With an increased intensity in monsoon rain, 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 and 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 microclimatic 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 (Merrey et al. 2018; Charmakar 2012; Maharjan et al. 2011; 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, b). 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 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 from 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 mainly 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 2003/2004, hilly indigenous people (besides Newar and Thakali[2]) have higher poverty incidence of 43% compared to the Terai 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 Nepal Federation of Indigenous Nationalities (NEFIN) and National Foundation for the Development of Indigenous Nationalities (NFDIN). The Chepangs qualify as an appropriate representative of the marginalized group of people in Nepal and are thus selected as the population for

[1] According to the National Foundation for Development of Indigenous Nationalities Act 2002, the term indigenous nationalities refers 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.

this study. A detailed description about the Chepang community is given in Chap. 5 of this book. Studies related to the impacts of climate change should focus on such 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.

In the initial years, actions on climate change adaptation and mitigation in Nepal was hampered by a lack of technical capacity, low awareness, and less prioritization of climate change at all levels. Nepal was the last signatory countries to the United Nations Framework Convention on Climate Change (UNFCCC) to complete the National Adaptation Program of Action (NAPA) process. In the recent years, Nepal is in the process of mainstreaming the issues of climate change adaptation in various development interventions. Nepal is the pioneer country in implementing Local Adaptation Program of Action (LAPA). However, many key ministries overlooking important sectors like agriculture, forestry, soil conservation, health, and water resources are still implementing only a very few, nascent activities to deal with the vulnerabilities and impacts of climate change. 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 book will contribute to policy formulations by making suitable recommendations, both short-term response to changing weather patterns and longer-term sustained adaptation strategies.

1.3 Chapters

The next two chapters of this book are based on literature review to furnish the general information related to the socio-economic and livelihoods issues of climate change. Chapter 2 documents the researches related to climate change and livelihoods in the global context. Chapter 3 focuses in the Nepalese context. The chapter discusses the government policy and programs (both formulation and implementation) at national, district, and local level. This chapter also describes the GHG emissions scenario of Nepal and analyzes the trends of temperature and rainfall for the last 38 years (1978–2015). Furthermore, this chapter presents an analytical review related to vulnerabilities and impacts in the context of Nepal.

Chapters 4, 5, and 6 are dedicated to set a background for the research work and the analysis of results. Chapter 4 presents the conceptual and analytical framework of the study. The sustainable rural livelihoods framework given by the Department for International Development (DFID) has been adopted as the conceptual framework for this research. An analytical framework specific to this research has been developed based on the conceptual framework, whereby the indicators for each of the components in the framework have been chosen to suit the context of the research. Chapter 5 presents a description of the community in focus for this book, the Chepangs. This chapter briefly presents the geographical distribution of the Chepang settlements, the key socio-economic-demographic features of the community, and the transition of their livelihoods over the last centuries. Chapter 6 deals with the study settings, which includes the selection of study sites, sampling procedures, and data collection. This book is an outcome of continuous research activities conducted since 2008. The quantitative findings presented in this book are based on two household surveys, whereas the qualitative descriptions are based on numerous firsthand interactions made with the community.

Chapters 7, 8, 9, 10, 11, and 12 represent the analytical chapters, presenting qualitative and quantitative results pertaining to the Chepang livelihoods in general and in the context of ongoing climate change and extreme events. Chapters 7 and 8 present the various aspects of the Chepang livelihoods in general without any specific reference to climate change. These chapters are important to understand the basic demography and socio-economic characteristics of the community along with the strategies that are adopted to make a living. The seventh chapter describes the annual subsistence strategy of the Chepang community, mainly focusing on the complementarity of farming and forest resources in fulfilling the annual food supply. Chapter 8 presents a portfolio of the activities that form the sources of livelihoods for the Chepang community. The chapter also analyses the patterns of diversification adopted by the households and analyses the factors that constrains most of the Chepang households from choosing the remunerative livelihoods sources.

Chapter 9 onward, the analysis is focused on the interaction of the Chepang livelihoods with various aspects of climate change. These chapters analyze the livelihoods of the Chepang community from the perspectives of vulnerabilities, impacts, and adaptations to climate change. In order to formulate any coping or adaptation strategies, first of all the communities facing climate change should perceive that the changes are indeed taking place. Chapter 9 deals with how the Chepangs perceive climate change, and the community responses are triangulated with the actual trends of temperature and rainfall recorded in the meteorological stations located near the study sites. The latitude-longitude-altitude data of the sample households are used to examine the spatial clustering of the perceptions. The chapter further analyzes the socio-economic characteristics that differentiate the respondents who perceive the changes in line with the recorded data from those who do not.

Chapter 10 deals with the vulnerability analysis of the Chepang communities based on indicator-based indices constructed for various components of vulnerability, viz., exposure, sensitivity, and adaptive capacity. The chapter presents a comparative vulnerability analysis at two scales: inter-village and inter-household to demonstrate how the scenario changes with different scales under consideration.

Chapter 11 presents a qualitative description of the impacts of climate change and extreme events on the livelihoods of the Chepang community. The climatic hazards most frequently occurring in the study area are landslides, droughts, and hailstorms. However, even less dramatic events like changing rainfall patterns are seen to impact the livelihood activities and outcomes of the community in a significant way.

Chapter 12 documents the ongoing adaptation practices, which are categorized based on risk pooling across space, time, assets, households, and markets. The adoption rates of these practices are compared with the adaptive capacity across the study sites. The chapter further analyzes the determinants influencing the households' choices of the adaptation practices.

The last chapter concludes the book with the note that livelihood vulnerabilities and adaptation to climate change are intricately related to sustainable development issues, thereby calling for the need to mainstream climate change into development interventions.

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Chapter 2
Climate Change and Rural Livelihoods in Developing Countries

Abstract This chapter reviews the interaction of climate change and livelihoods focusing on the rural communities in developing countries. Climate hazards cause disproportionate impacts on the limited assets of disadvantaged communities, thereby increasing their exposure and vulnerability. However, agricultural wage laborers in food-exporting countries are expected to benefit from the rise in global food prices owing to climate change. In the rural areas of developing countries, climate change has shifted livelihood trajectories from farming to a more diversified one. Planned adaptation and mitigation responses to climate change are mostly found to have adverse impacts on rural livelihoods, especially for those communities whose livelihoods depend on land and forest. Impacts of climate change on mountain livelihoods are directly felt on agriculture, water resources, livestock, and forests.

Keywords Livelihood assets · Social vulnerability · Livelihood trajectories · Mountain livelihoods

The IPCC AR5 presents the first comprehensive review of the dynamic interactions between climate change and livelihoods. 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 the 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. The AR5 addresses the limitations of previous assessment reports, as it utilizes evidences from social sciences about human behavior and human dimensions of climate change (Burkett et al. 2014). Previous IPCC reports presented a generalized view that all poor people were vulnerable to climate change, without considering the context-specific differential vulnerabilities, which in turn shape the differentiated impacts of climate change on individuals and societies. The AR5 on the other hand discusses how climate change, as one of the many stressors, shapes dynamic

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and differential livelihood options and trajectories. The chapter by Olsson et al. (2014) in AR5 presents an extensive review on the past and projected impacts of climate change on livelihoods, particularly focusing on the assets and the trajectories. This chapter builds upon the information provided in AR5 by conducting an updated literature review after the publication of AR5 and focuses on the interactions of climate change with livelihood assets and trajectories in the context of rural areas in developing countries. 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 (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.

2.1 Climate Change and Livelihood Assets

The AR5 notes that the impact of climate change on livelihood assets is poorly documented (Olsson et al. 2014). The same report also mentions that the most commonly used approach to analyze climate change vulnerability uses the concepts of livelihoods, particularly focusing on assets and adaptive capacity (Dasgupta et al. 2014). In the recent years, the majority of climate change-related literature focusing on livelihoods base their analysis on the interaction of climate with the five capitals/ assets (Trung 2018). Climate hazards disrupting economic activity and production factors cause disproportionate impacts on the limited assets of disadvantaged communities. Such adverse changes in the production factors, even though marginal, further increase the community's exposure and vulnerability to climate hazards, thereby forming a causal loop (Sanchez 2018). A study by Rahman et al. (2018) looks into the interconnectivity of the capitals/ assets and how that contributes to reduce the livelihood sensitivity to climatic stresses. Their study demonstrates that the assets are organized in diverse ways to secure the livelihoods against the climate stresses. This subsection summarizes the findings of recent literatures on how various livelihood assets interact with climate change.

2.1.1 Financial Assets

Evidently, studies across the globe report losses in financial assets owing to climate change but with few exceptions. In Sri Lanka, the financial losses from floods and droughts, measured in terms of the percentage of annual household income, are higher for households that have lower per capita income and those that depend on agriculture for their livelihoods. This was the case despite the fact that the exposure to those disasters was not necessarily higher for the poor households. The loss recovery period was also longer for the poorer households (De Silva and Kawasaki 2018). Sanchez (2018) forecasts that income poverty will rise in Bolivia due to the adverse impact of climate-related shocks on labor wages. The average wage relative to the average capital return is expected to decrease by nearly 18% in 2080 compared to the baseline in 2017. Keeping other factors constant, it was found that changes in temperature and precipitation owing to climate change depress people's incomes in Chile (Andersen and Verner 2010). Similar analysis in Peru interestingly shows that while the already hotter coastal areas will face income losses, the highlands will actually benefit from warmer temperatures (Andersen et al. 2009).

The AR5 emphasizes that wage labor-dependent households that are the net buyers of food will be adversely affected due to food price increases owing to climate change, particularly in regions with high food insecurity and inequality (Field et al. 2014). Andersen et al. (2016) model the impact on welfare caused by the combination of global increase in food prices and local decrease in crop yields owing to climate change in Latin America. Interestingly the results vary among countries depending on their trade orientation. Beneficial impacts on income have been projected for Brazil where higher food prices leading to improving terms of trade for agricultural exports will lead to higher remuneration for land rents and wages for lower-skilled labor. Thus, welfare is projected to slightly improve for the lowest-income households who mainly earn from land use and labor supply. On the other hand, welfare loss has been reported for Mexico because the agricultural economy is comparatively less export-oriented compared to Brazil, thereby gaining lesser from the global rise in food prices, while local yield losses are higher. For Peru, the same analysis shows that welfare effects are positive for rural households because agriculture is the main source of their income. Conversely, urban households will face welfare losses due to the decrease in real income caused by increasing agricultural prices and increase in the input costs for manufacturing. Sanchez (2018) also projects that a rise in food prices will be an opportunity for net food-exporting countries like Bolivia. Many unskilled small farmers and self-employed workers employed by the food production sector in Bolivia will benefit from such price hikes.

While many studies report on income as the major financial asset, few studies also focus on the role of savings, insurance, and microcredits as means of adaptation to climate change. Hlahla and Hill (2018) report that access to savings and insurance schemes helped households in adopting adaptation measures; however, access to such schemes is often hindered by poverty in the case of urban South Africa. In contrast, Rahman et al. (2018) reported a positive relationship between microcredits and livelihood sensitivity to climatic stresses in the floodplains of Bangladesh because the microcredits are almost exclusively invested in agriculture, which is in turn heavily impacted by climate stressors.

The AR5 reports with very high confidence that the lack of financial resources, particularly credit, is one of the major factors that hinder adaptation for farmers in Africa and Asia (Dasgupta et al. 2014). For instance, sustainable land management practices that are potential coping/adaptation strategies are not always adopted by farmers in Ethiopia mainly due to lack of financial resources needed for the purchase and to some extent due to limited access or availability of the said option (Cholo et al. 2018).

2.1.2 Human Assets

Impacts of climate change on human assets have been studied in terms of health, psychology, and life expectancy among others. Higher temperatures and erratic weather changes are reported to increase health hazards like skin rashes, influenza, and headaches, thereby impacting the general well-being and comfort in South Africa (Hlahla and Hill 2018) and coastal Vietnam (Trung 2018). Keeping other factors constant, changes in temperature and precipitation due to climate change reduce the overall life expectancy in Peru. Interestingly however, district-level analysis shows that life expectancy decreases for already hot districts, while highland districts actually gain life expectancy due to more favorable warmer temperatures (Andersen et al. 2009). Delisle and Turner (2016) report psychological impacts of extreme weather events from emotional distress over losing assets or feeling of helplessness about reducing their exposure. Age is an important factor that defines the vulnerability to climate change. For instance, children were found to be more vulnerable to climate stresses in urban South Africa (Hlahla and Hill 2018).

The AR5 points out with very high confidence that access to knowledge and information are the fundamental requirements for adaptation, which is in turn affected by human resources and social characteristics (Dasgupta et al. 2014). Individual's knowledge about climate change also defines the type of actions taken in response to climate change. Hlahla and Hill (2018) report that lack of knowledge about climate change among poor urban communities in South Africa has led to the belief that weather and climate are beyond the influence of human and that the God is responsible for related disasters and He is the one who solves the problem. The same reason leads to the lower prioritization of climate stress against other pressing issues like poverty, especially in developing countries.

Gender is another dimension of human asset, which has received a lot of attention in climate change literature in the recent years. The gendered aspect of climate change is discussed in a separate subsection later in the chapter.

2.1.3 Social and Institutional Assets

Both formal organizational networks and informal social networks are important assets that can be called upon to cope with livelihood stressors, including climate change. Delisle and Turner (2016) demonstrate that social network is the most important factor that helps the rural households in Northern Vietnamese uplands to cope with the events of extreme weather. The same study emphasizes that if the stress is of wider scale affecting a large area, then such social networks are not dependable unless the household has extensive networks beyond the locality. Unlike in rural areas, there is very little reliance on social networks to cope with climatic disasters in urban South Africa (Hlahla and Hill 2018).

Formal institutions are increasingly playing an important role, especially to aid households adapt to climate change. Non-governmental Organizations (NGOs) played an important role in Nepalese mountains to introduce new technologies like plastic tunnels for vegetable production, which was important to protect the crops from climate variabilities (Merrey et al. 2018). NGOs were also reported to be more prominent institutions compared to the government agencies in rural Ghana supporting farmers to tackle with climate change impacts (Assan et al. 2018). Interventions from external agencies like government, nongovernmental organizations, and market institutions are important to reduce livelihood sensitivity to climatic stresses in the case of Bangladesh (Rahman et al. 2018). Interestingly the same study reports community organizations to be positively related to climate sensitivity in the floodplains of Bangladesh mainly because of less effective organizational structure to support community needs and the potential for elite dominance in decision-making.

As important as the institutions are in assisting adaptation, there are ample studies reporting shortcomings in their role. As is the case in urban South Africa, although the communities in developing countries agree that it is the responsibility of local government to address the issue, they do not believe the government and other community-based organizations (CBOs) or NGOs are providing adequate support during climate disasters (Hlahla and Hill 2018). Policies and programs related to climate change are often designed top-down, thereby creating a mismatch from what is actually needed at the ground level. Nigussie et al. (2018) demonstrate that adaptation priorities of farmers are often weakly or even negatively correlated with those prioritized by experts alone. While experts do have an updated knowledge about alternative technologies, farmers include the local applicability and socio-economic feasibility to the assessments. This shows the importance of multistakeholder participation in the formulation of climate change-related policies and programs. In the same line, Sanchez (2018) emphasizes the importance of including communities' feedbacks not only in policy dialogues but also in modeling the impacts of climate change.

2.1.4 Natural Assets

Livelihoods based on natural assets like farming, fisheries, and forestry are the ones that are most affected by climate change. The AR5 reports with very high confidence that the impacts will be substantial especially for developing countries because of their high economic dependence on agriculture and natural resources, low adaptive capacity, and geographical locations (Dasgupta et al. 2014). Bauer et al. (2018) report the case of Tacana ethnic group in Bolivia where natural resource-dependent households (depending on subsistence farming or farming combined with local business or timber) were the ones most affected by the extreme flood incident in 2014, thereby confirming the link between natural resource dependence and vulnerability to climate extremes. The impact of climate-related vagaries on farming livelihoods has been widely documented, especially in developing countries. The impacts of climate change on crop yields are mostly reported to be negative, and this is expected to continue for all major crops in tropical and temperate regions unless adaptation measures are taken into consideration (Field et al. 2014). Major impacts are expected to be exerted on water availability and supply, food security, agricultural incomes, and shifts in production areas of food and non-food crops across the world especially in rural areas (IPCC 2014). Increasingly frequent droughts in the Vietnamese uplands have drastically reduced the maize and cardamom harvests, the two most important crops that the ethnic minorities depend on for their livelihoods (Delisle and Turner 2016). The same study reports that intense cold spells are also increasing, again killing cardamom plants and causing the deaths of water buffalo, which is very important for their livelihoods for plowing as well as a buffer that can be sold for cash during the period of stresses. There are few reports of increased crop productivity in highlands owing to rising temperature. Increase in the productivity of potato and barley are reported in few localities of Nepalese mountains due to higher rainfall and warmer temperatures. However, the majority of localities reported decreased crop productivity and higher pest incidences due to unpredictable precipitation, increased incidences of foggy days, and hailstorms (Merrey et al. 2018). Beneficial impacts of frequent floods have also been reported in the low-lying coastal areas of Vietnam whereby minor floods bring wild fish and shrimps into rice farms, enrich the soil with fertile deposition, and reduce the impact of salinization by washing away salt from the soil. The same locality also reports that shorter and warmer monsoon has benefitted the farmers by enabling earlier preparation of rice seedlings and extension of growth period for shrimps (Trung 2018).

2.1.5 Physical Assets

Very few livelihood-related studies explicitly discuss the interaction of climate change and physical assets. Trung (2018) reports that repeated floods in the coastal Vietnam have damaged infrastructures like dykes, bridges, roads, wells, and houses. Olsson et al. (2014) offer a review of literature that establishes the impacts of climate-related disasters on settlements, agricultural lands and public infrastructures like roads and embankments. As per the AR5, there is very high confidence that the lack of physical resources particularly land is the main factor that hinders adaptation among farmers in Africa and Asia. In addition, rural households' lack of access to technology, infrastructure, and market are other barriers to adaptation (Dasgupta et al. 2014).

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 architecture 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 subnational 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 focused on household-level data to analyze vulnerability. Deressa et al. (2009a) employed the “vulnerability as expected poverty” approach given by the 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 agroecological setting.

Vincent and Cull (2010) take vulnerability as a function of the possession of five livelihood assets under the sustainable livelihoods framework given by the Department for 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 a 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. (2010a). These studies cover all the three components of vulnerability, viz., exposure, sensitivity, and adaptive capacity, as given by IPCC and adopt 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 subnational 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.

2.3 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 2007). 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 and 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 the amount of snowfall is very important to determine the fulfillment of chilling requirements to break the winter dormancy in apples. Similarly, the 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 irrigation 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.

2.4 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 the 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 preselected 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 the 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 are done after the publication of IPCC third assessment report (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). An assessment of the current adaptive capacity of a system provides useful insights on the existing potential of the system to cope with climate disasters and also points out the shortcomings which need to be addressed to improve the adaptive capacity of the system 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 focused at the subnational level (Jakobsen 2011; Nelson et al. 2010b; Gbetibouo and Ringler 2009). The earlier national-level studies are aimed at comparative assessments to identify the countries with lowest adaptive capacity, thereby assisting in the adaptation-related investment decisions under the 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 are important to make comparison across nations, such studies are lesser relevant at the subnational 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 subnational 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 the possession of diversified set of assets enables the households to choose from various livelihood 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) identify that the current adaptive capacity is the best proxy for future adaptive capacity, Brooks et al. (2005) seek 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 change drastically when sociopolitical goals of national governments are taken into consideration. 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 the 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) take 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.

2.5 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 AR4 focuses 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 has 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, b; Bhandari and Gurung 2008; Regmi et al. 2008; Nhemachena and Hassan 2007; Adger et al. 2007; FAO 2007; Gautam et al. 2007a, b).

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, rural healthcare 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/groundwater/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 the 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 have been categorized into 21 different strategies like appropriate crop selection, alternative cropping methods, postharvest 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, the 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 are 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 initial researches on the determinants of adaptation choices among the rural farming communities have been done in the context of Africa (Below et al. 2012; Deressa et al. 2009b, 2011; 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 2008). The analyses done in various African countries have shed light on the factors that enhance or limit the ability of the households to adapt to climate change and related vagaries. The adaptation choices by the households in a particular locality are determined not only by the climate variables (e.g., rainfall, temperature) or geographical features (e.g., soil, slopes) but also by the households' 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, and gender equity; and finally the way climate change is perceived by the community. Caste hierarchy and gender restrictions have been found to act as barriers 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.

2.6 Impacts of Climate Change on Livelihood Trajectories

The AR5 reports several shifts in livelihood trajectories, especially within the farming sector or those involving a shift away from agriculture. This is basically because farming is the major source of livelihood in rural areas, and in turn this sector is the one that is directly impacted by any small or large changes in climate. As per the AR5, there is a relative scarcity of literature on the interactions of non-farm livelihoods with climate variability and climate change (Dasgupta et al. 2014). Some of the major livelihood shifts described in the AR5 include changes in crops (or varieties), moving on to more lucrative (non-farm) income-generating activities instead of farming, shift in livelihoods from water-based to agro-sylvo-pastoral systems, higher precipitation uncertainty leading to increased reliance on livestock and poultry (instead of crops), migrating to coasts to switch from farming to marine livelihoods, and switching from coffee farming to day laborers and subsistence farmers, among others (Olsson et al. 2014). Recent literatures also corroborate similar trends. For instance, in the Nepalese mountains, communities increasingly cultivated drought-resistant traditional crops like millet as a response to the increasing precipitation unpredictability. Similarly, increasing integration of cattle in the farming system was done as a buffer against climate variabilities (Merrey et al. 2018). Many literatures show that the diversification of livelihood activities is a commonly adopted strategy for reducing vulnerability from climate change as in the case of traditional fish farmers in coastal Bangladesh diversifying to previously unfamiliar activities like rickshaw pulling (Hossain et al. 2018). De Silva and Kawasaki (2018) also demonstrate that income sources beyond agriculture could be helpful to minimize losses from such climate-related disasters in the context of Sri Lanka. In the context of Bolivia, urban households were found to be more vulnerable than the rural counterparts due to less diversified income (Sanchez 2018); and livelihood diversification to options not relying directly on natural resources like wage laboring played a vital role in coping with extreme weather events and contributed to a fast recovery in the context of extreme flood incident of 2014 (Bauer et al. 2018).

2.7 Gendered Aspects of Climate Change

The AR5 reports high agreement on the association of gender inequalities with vulnerability to climate change (Dasgupta et al. 2014). In the recent years, the literature dealing with the gender aspect of climate change is on the rise. While it is generally accepted that males and females show typical vulnerabilities to climate change owing to the sociocultural constructs, these studies have revealed surprising ways of how the climate phenomenon can lead to gendered impacts. For instance, in Bangladesh, gendered impact of cyclone was clearly seen in the case of availability of cooking fuel. Fuelwoods like bamboos were damaged by the cyclone. Meanwhile, increase in salinity rendered rice cultivation impossible, thereby causing scarcity of rice straw that could be used as cooking fuel. Also, loss of vegetation made cattle raising impossible, which used to provide dung – another source of cooking fuel. As a result, women now faced additional burden of managing cooking fuel, while men were exclusively non-participating in this new problem (Hossain et al. 2018). On a different light, female-headed households in Latin America are reported to be less vulnerable to the effects of climate change because such households have higher and more diversified income, thereby highlighting the roles that women can play in building household resilience (Andersen et al. 2016). Assan et al. (2018) elaborate how male and female farmers differ in their knowledge and agency that they draw upon to tackle with adverse climate change in the context of Ghana. The study also corroborates the pre-existing argument that gender, culture, and social class interact with one another, thereby restricting the female farmers' access to and control over critical resources that are important for climate change adaptation. On the other hand, male farmers by virtue of their social responsibility could be forced to undertake works under potentially hazardous conditions, thereby affecting their well-being.

2.8 Livelihood Impacts of Climate Change Responses

Olsson et al. (2014) in the AR5 succinctly summarize the impacts of mitigation and adaptation responses on poverty and livelihoods. Taking the case studies of few mitigation responses like clean development mechanism, REDD+, and large-scale land acquisition, among others, the AR5 presents a deep concern that the livelihood impacts of such mitigation responses are worrisome in terms of poverty alleviations, livelihood security, social goals, and gender equality. A couple of studies conducted in the recent years have further confirmed this concern. A longitudinal study of subnational REDD+ initiatives in six countries reveal that well-being declined in general in REDD+ villages, and the decrease was much worse for women. This study has strengthened the fact that REDD+ projects have failed to address the well-being of the communities in general. Furthermore, attention to gender equality and women's rights is repeatedly overlooked in such initiatives (Larson et al. 2018).

Village land forest reserves that are allocated under the village participatory land-use plans are implemented within the REDD+ initiative in Tanzania. Based on the community perceptions, such programs have benefitted the forest conservation. However, it has negative implication for local forest-based livelihoods like shifting cultivation and livestock grazing as the access to forest is now restricted (Uisso et al. 2018a). There are also cases where locals have to be relocated, despite their unwillingness, as their ancestral lands are now included under the newly allocated reserves (Uisso et al. 2018b). However, the issues of forced relocation receive less priority in the discussion and are even dismissed as uncooperative because the affected households are minority in numbers. Such attitude poses the risk of biological conservation of forests being prioritized against the livelihoods of forest-dependent marginalized communities. It blames the shifting cultivation practices as a cause of deforestation, which is more based on biased opinion, rather than facts. Scheidel and Work (2018) highlight the serious issue of how the reforestation project awarded with the goal of carbon sequestration for climate change mitigation has enabled "green" grab that is larger than the ones already existing in Southeast Asia. Not only does such reforestation award convert diverse forest landscapes into monoculture tree plantations thereby depleting the biodiversity, but it also puts the livelihoods of customary forest users at stake. The paper suggests revisions of several problematic assumptions regarding forests and climate change discourses including the UNFCCC definition of forest that is unable to capture their diverse social, economic, and ecological qualities.

2.9 Climate Change and Livelihoods of Mountain Communities

The AR5 identifies mountains around the world as extremely vulnerable to climate change; however, detailed understandings of climate change and mountain livelihoods are lacking owing to physical inaccessibility and scarcity of resources for research (Dasgupta et al. 2014). Livelihoods in mountain areas are highly dependent on natural resources, thereby facing a direct impact from even small changes in the climatic variables. Furthermore, limited livelihood options and low adaptive capacity add to their livelihood vulnerabilities. Palomo (2017) highlights the fact that most of the studies related to climate change in the mountains are biophysical studies focusing on topics like glacier retreats. The same study also points out that out of the few studies focusing on social realms, very few are conducted in the global south with the exception of Nepal, China, and India. This extensive literature review importantly points out that the negative impacts of climate change in the mountains outweigh the few positive ones. As Dasgupta et al. (2014) point out, mountain communities are adapted to live in harsh environmental conditions and therefore possess indigenous knowledge to adapt and foster resilience to changing climatic conditions. However, the knowledge dynamics has been altered in the context of changing climatic conditions. Valdivia et al. (2010) and de la Riva et al. (2013) point out that indigenous systems for dealing with climate risks are failing in the context of Andean ecosystems in Bolivia. With unexpected changes in climatic patterns, this is possibly true for any other mountain ecosystems around the world. This further strengthens the need for collaborative climate change-related assessment, planning, and implementation among the scientists and indigenous communities. The scientific knowledge generation about climate change in the high mountains is often hampered by the lack of climate data, be it in the Andean Altiplano (Valdivia et al. 2010) or in the Himalayas (Tiwari and Joshi 2015).

Mountain topographies are often vast and diverse, thereby giving rise to many microclimatic pockets within a small geographical range. Valdivia et al. (2010) report that within the Andean Altiplano, the minimum temperature trend within the last 50 years shows significant cooling trends in the south, while a significant warming trend is reported in the central and northern Altiplano. In general, however, mountains exhibit a faster rate of warming be it in the Himalayas (Gentle and Maraseni 2012), Central Asian mountains (Reyer et al. 2017), Andes (Lasage et al. 2015), or the African highlands (Kangalawe 2017). Based on the same studies, precipitation is reported to be increasingly erratic, onset being highly unpredictable, and quantity overall declining. The extreme events like drought, frost, intense rain, and hailstorms are reportedly occurring more frequently, thereby damaging livelihood assets and infrastructures (Rautela and Karki 2015; Bhatta et al. 2015; de la Riva et al. 2013).

Impacts of climate change on the mountain livelihoods are most directly felt in the sectors of agriculture, water resources, livestock, and forests. In the Andean Altiplano, increased losses due to drought, frost, disease, and pests have resulted in the reduction of available dietary plant proteins (quinoa and fava beans), thereby increasing food insecurity (Valdivia et al. 2010). Risks of food insecurity will also likely increase in the mountains of Central Asia not only due to unfavorable climate regimes and water availability but also due to rise in international food prices (Reyer et al. 2017). Bhatta et al. (2015) and Gentle and Maraseni (2012) report a massive decline in food production in the Nepalese mountains due to erratic precipitation, thereby forcing rain-fed farmers to quit cultivation of summer crops like paddy as well as winter crops like wheat. Agricultural production has also been impacted due to increasing pests and weeds due to higher temperatures (Rautela and Karki 2015; Byg 2014). There are a few positive impacts of climate change reported in the mountains. Warmer temperatures have enabled the cultivation of crops in higher altitudes. For instance, garlic, potato, and apple can now be cultivated at higher altitudes in the Himalayas (Rautela and Karki 2015). Similarly, in the case of irrigated agriculture in Central Asia, wheat yield is projected to increase due to warmer winter and spring.

In the context of highlands of Southern Tanzania, Kangalawe (2017) reports declining rainfall has adversely impacted water resources evident in terms of declining water flows in rivers, streams, and natural springs and drying up of wetlands subsequently hampering agriculture in the dry seasons, thereby affecting the local food security. Declining water resources for agricultural purposes (Bhatta et al. 2015) and increasing water-related conflict (Sujakhu et al. 2018) due to declining rainfall have been reported in the highlands of Nepal. Increasing water scarcity is also reported by Rautela and Karki (2015) in the Indian Himalayas. Decreasing water availability has also been reported in the Central Asian mountains, thereby hinting to a possible water conflict between agriculture and hydropower (Reyer et al. 2017). Similarly, winter precipitation recently is seen more as rain and less as snow in the Himalayas (Bhatta et al. 2015; Rautela and Karki 2015) and the Andes (Lasage et al. 2015) because of which water availability for winter crops has declined considerably.

Increasing droughts and limited winter/spring rain have also affected the grazing land for livestock and non-timber forest products in the Nepalese mountains, thereby affecting the livelihoods dependent on these sources as supplementary to farming (Bhatta et al. 2015; Gentle and Maraseni 2012). Bhatta et al. (2015) present a case of Upper Koshi in Nepal where sheep and Himalayan goats are less kept due to the impact of climate on forages. Similar impacts have been reported in Uttarakhand of India (Rautela and Karki 2015).

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Chapter 3
Climate Change in Nepal: Policy and Programs

Abstract This chapter sums up the climate change policies and programs, status of greenhouse gas emissions, trend of weather variables and other aspects of climate change in Nepal. Nepal started addressing the issues of climate change in its policy documents from 2002, however it has been struggling to develop specific policy instruments to implement the climate policy paradigms. The country achieved reduction in the GHG emission in recent years mainly through the promotion of alternative energies and forest conservation facilitated by international climate regimes. There is a consistent increase in temperature with marked spatial differences in its trend. Precipitation, however, shows large interannual variations with negative trend. Precipitation is expected to get more intense in the future. The increased temperature and more erratic precipitation are expected to impact the glacier in the Himalayas, livelihood assets through increased incidence of water-related disasters, human health, and agriculture sector.

Keywords Emission · Mitigation · Trend · Projection · Impact

3.1 Climate Change Policies and Programs in Nepal

Climate change is a global phenomenon and Nepal is not an exception to it. The latest data suggests that Nepal shares only 0.044% of the total global greenhouse gas (GHG) emission (World Resources Institute 2017). In 2014, the GHGs equivalent emitted by one Qatari national was equivalent to that emitted by about 56 Nepali nationals (Boden et al. 2017). 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 3-Year Interim Plan (2007–2010) to promote carbon trade by participating in

L. Piya et al., *Socio-Economic Issues of Climate Change*,
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the Clean Development Mechanism (CDM). Alternative energy and forest management were recognized as the potential resources for carbon trading (NPC 2007). Climate change was explicitly mentioned only from the 3-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). Recently, the government also passed the Climate Change Policy 2011.

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 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 to spend in the 14 least developed districts in the mid- and far-western regions of Nepal under the program 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). Channeling of climate finance to the field level activities was further emphasized through the endorsement of Climate Change Budget Code 2013 (MoPE 2017).

Following the decision made by the 16th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP16), currently the Government of Nepal is involved in the process to formulate “National Adaptation Plan” (NAP). The process was launched on September 18, 2015 with the overall objective to formulate Nepal NAP and improve institutional capacity of the government to implement climate resilient development plan in Nepal (MoPE 2017).

The paradigm of broader and specific climate or climate-related policies in Nepal is shifting from their earlier focus on disaster response and relief (1997–2002) to disaster risk reduction (2003–2008) and to climate change adaptation (2009–2011). The recent policy focus from 2012 till date is on localized action for climate change adaptation and disaster risk reduction (Vij et al. 2018). However, the government of Nepal is struggling to develop specific policy instruments to implement the paradigms. It is mainly because of “layering” mode of changes in paradigms. Such mode creates fragmentation of policy efforts leading to the possibility of overlapping efforts, confusion, and competition within various paradigms as it adds more actors and instruments. Unstable political situation, lack of financial support, influence of national and international nongovernmental organizations, and global policy frameworks can be attributed for the “layering” of different climate policy paradigms (Vij et al. 2018).

3.2 Greenhouse Gas Emissions in Nepal: Prospects for Mitigation

The government of Nepal has prepared only three GHG inventories till date, the first for 1990/1991, the second for 1994/1995, and the third one for 2000/2001 (MoSTE 2014). Methane emission from energy, land use change and waste, N_2O emission from energy and waste, and emission/sink from Land Use, Land Use Change, and Forest (LULUCF) were included in the GHG emission inventory for 2000/2001. However, these items were excluded in Fig. 3.1 in order to make the figures comparable with only the items listed in the GHG emission inventory in 1990/1991 and 1994/1995. In the figure, CO_2 is the sum of fossil fuel and cement production; CH_4 is the sum to rice cultivation, livestock and biomass burning; and total CO_2 is the sum total of CO_2, CH_4, and N_2O. CH_4 and N_2O is calculated in terms of CO_2 equivalent (CO_2-eq).

Between 1990/1991 and 1994/1995, 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 periods increased at an annual rate of 5.8% (Fig. 3.1), with agriculture contributing a significant 69% of total CO_2-eq emission, followed

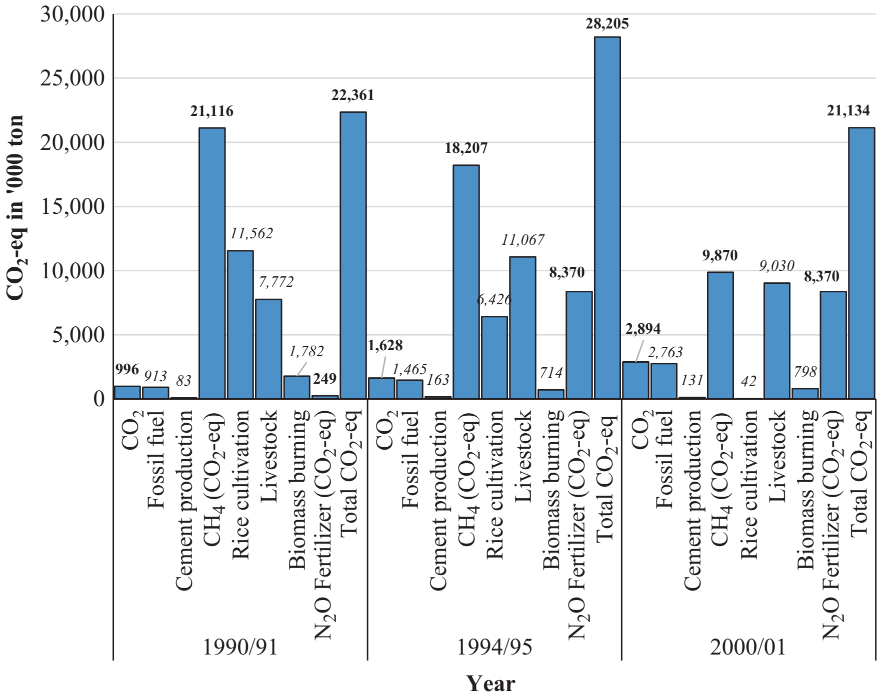

Fig. 3.1 Different forms of GHG emission from various sectors in Nepal in different years (Sources of data: MoSTE 2014; Joshi 2011; IPCC 2007; MoPE and UNEP 2004; DHM 1997 (cited in Dhakal 2001))

by land use change and forestry contributing around 21% in 1994/1995 (MoPE and UNEP 2004; Dhakal 2001). The total CO_2-eq emission in 2000/2001 declined mainly driven by a sharp decline in CH_4 emission from rice cultivation and livestock. Besides the achievements made through promotion of System of Rice Intensification (SRI) (Joshi 2011), some discrepancy in the emission reporting can be attributed to such sharp decline. For instance, in the previous inventory, whole of paddy area in the country was considered to be grown under continuous flood despite the fact very limited proportion of cultivable land is irrigated. However, this fact was realized in later inventories; thus, it was considered that most parts of the country rice are grown under water stress, and multiple aeration is very common (MoSTE 2014). There is a decline in emission from cement production (industrial process). Similarly, manure management as well as replacement of fuelwood achieved through the installation of biogas plants between the years 1992/1993, 1994/1995, and 2000/2001 could be the reason behind significant reduction in CH_4 emission from biomass burning (Joshi 2011).

The recent calculation by World Resources Institute also suggests the decline in the total national GHG emission of Nepal. The decline can be observed from 2005 (Fig. 3.2). The year coincides with the year when Nepal ratified the KP and in the same year entered into the force. This has opened the windows of opportunities for Nepal to realize financial benefits from the tools, namely, CDM, provisioned in the KP. Nepal's initiatives in the promotion of renewable energies resulted in the mitigation of GHG as its positive externality. Biogas, micro-hydro, improved cooking stoves, and improved water mills are some of the alternative energies having

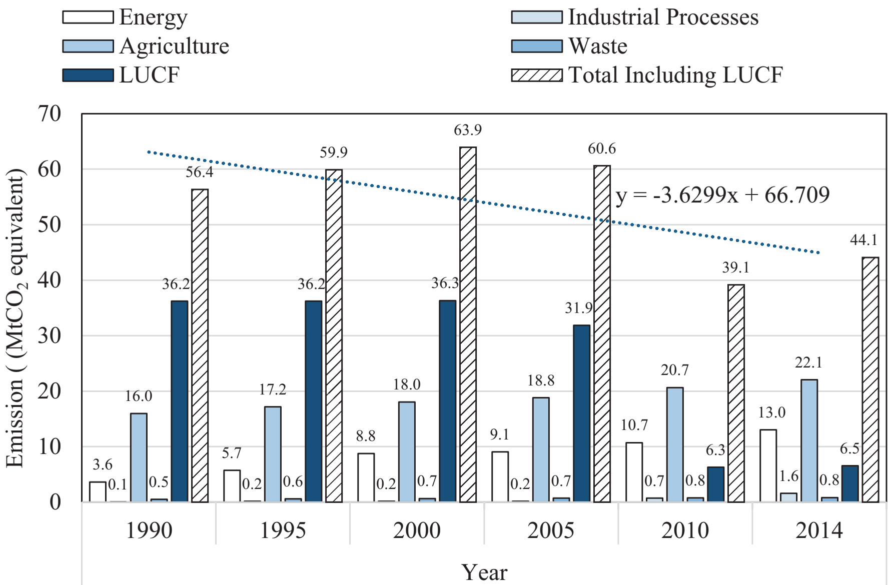

Fig. 3.2 GHG emissions by sectors in Nepal in different years (Source of data: World Resources Institute 2017)

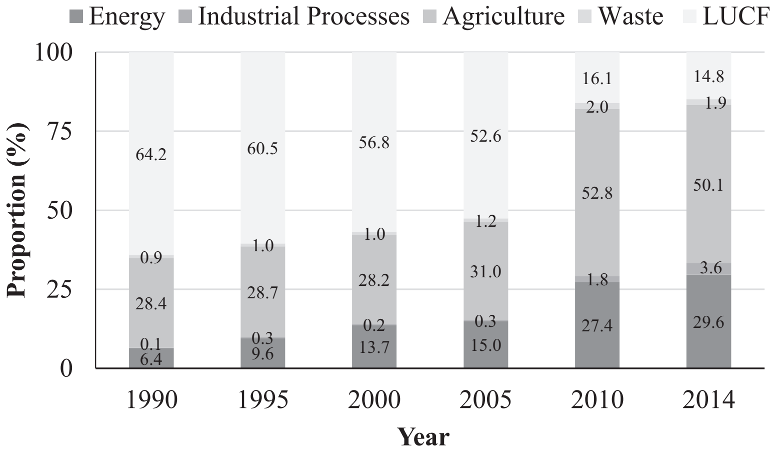

Fig. 3.3 Share of different sectors in the total GHG emission of Nepal in different years (Source of data: World Resources Institute 2017)

prospects to generate revenue from the CDM. Some of these projects such as biogas have already generated the revenue, some of them are already registered (biogas and micro-hydro projects), some of them are under the process of validation (biogas, improved cooking stoves, and improved watermills), and the project design document (PDD) is already prepared for solar home system (MoSTE 2014).

In 2014, agriculture sector shares 50.1% of total national GHG emission followed by energy sector, Land Use Change and Forest (LUCF), industrial process, and waste (Fig. 3.3). The majority of mitigation-related actions are focused on the energy sector, especially through the promotion of alternative energies. Yet, the share of energy sector has continuously increased from 6.4% in 1990 to 29.5% in 2014. Similarly, the share of agriculture sector has increased from 28.4% in 1990 to 50.1% in 2014. Organic farming and System of Rice Intensification is the practice in agriculture which can contribute in mitigating GHG emission from agriculture sector and also could generate revenue through CDM (Joshi 2011). Similarly, livestock feed management is another aspect in mitigating GHG emission from agriculture sector in Nepal.

The management of natural resources especially forest, which can mitigate the GHG emission through its role in carbon sequestration, can be related with the GHG emission from LUCF. Any initiative in realizing the carbon sequestration benefit has also been identified as a means for generating financial resources in long term through carbon trading. The CDM and Reduced Emissions from Deforestation and forest Degradation (REDD) are two international legal framework related with such carbon trading (Joshi 2011). Nepal is a signatory of both of these legal frameworks.

The government of Nepal established REDD forestry and climate change cell (REDD Cell) led by the Joint Secretary of the Ministry of Forests and Soil Conservation. The REDD cell is responsible for preparing and submitting the Readiness Preparation Proposal (R-PP) to the World Bank's Forest Carbon Partnership Facility (FCPF). Nepal's R-PP was submitted to the FCPF on September

2010. Further, Nepal submitted a midterm report on R-PP progress. A readiness package prepared by Nepal was endorsed by the FCPF in 2016, which enabled access to an additional grant to complete readiness activities and achieve the mitigation reduction target. At present the REDD Implementation Center is established under the Ministry of Forests and Environment (MoFE) as the coordinating entity. Besides, there is also a REDD+ multi-sectoral and multi-stakeholder coordinating and monitoring committee, which is called the apex body and REDD working group under the MoFE to oversee and implement REDD+ in the country. On April 19, 2018, the government of Nepal endorsed Nepal National REDD+ Strategy with the vision to enhance carbon and non-carbon benefits of forest ecosystems in order to contribute to the prosperity of the people of Nepal. The strategy was developed to align with the principles of the Forest Policy, Forestry Sector Strategy 2016 and Nationally Determined Contribution 2016 (MoFE 2018).

All these initiatives have put Nepal in the position to implement a prototype of REDD+, gain experience, and build capacity to operationalize REDD+ in the community forests of Nepal in an experimental way under the FCPF. With the implementation of first-ever pilot Forest Carbon Trust Fund, Nepal successfully started generating revenue from the community forests of three watersheds in Dolakha, Gorkha, and Chitwan. Besides, the community forest users' groups in various districts of Nepal have started to earn revenue for their role in carbon sequestration from international donor agencies like Norwegian Agency for Development (NORAD) (Acharya 2012; Tripathi 2011). Joshi (2011) estimated the possibility of generating as much as US$42.7 million from community forests and US$82.4 million from protected areas (excluding buffer zones) annually with any successful initiative to implement REDD+. All these could have contributed in the sharp decline of LUCF's share from 64.2% in 1990 to 14.8% in 2014 (Fig. 3.3).

3.3 Trend of Climate Variables in Nepal

Climate change related studies in Nepal are restricted due to the limited availability of weather data. There are 282 meteorological stations recording meteorological data in Nepal (DHM 2018). However, 32 of them were closed before 1970s. The data for precipitation are consistently available for more than 35 years in 222 stations, while the same data for minimum and maximum temperature are available only for 59 stations. These stations are scattered across the country, although the stations are more concentrated in the central areas and further scarce in the mountains (Fig. 3.4). The monthly precipitation data recorded in 222 stations and monthly temperature (both minimum and maximum temperature) data recorded in 59 stations between 1978 and 2015 were purchased from the Department of Hydrology and Meteorology, Nepal. The data were then compiled and analyzed to assess the trend of temperature and precipitation in Nepal. The results are presented in the successive subsections hereafter.

Missing data is an important issue to be dealt with while studying the trend of weather data. There are many missing weather data in the case of Nepal as well. The

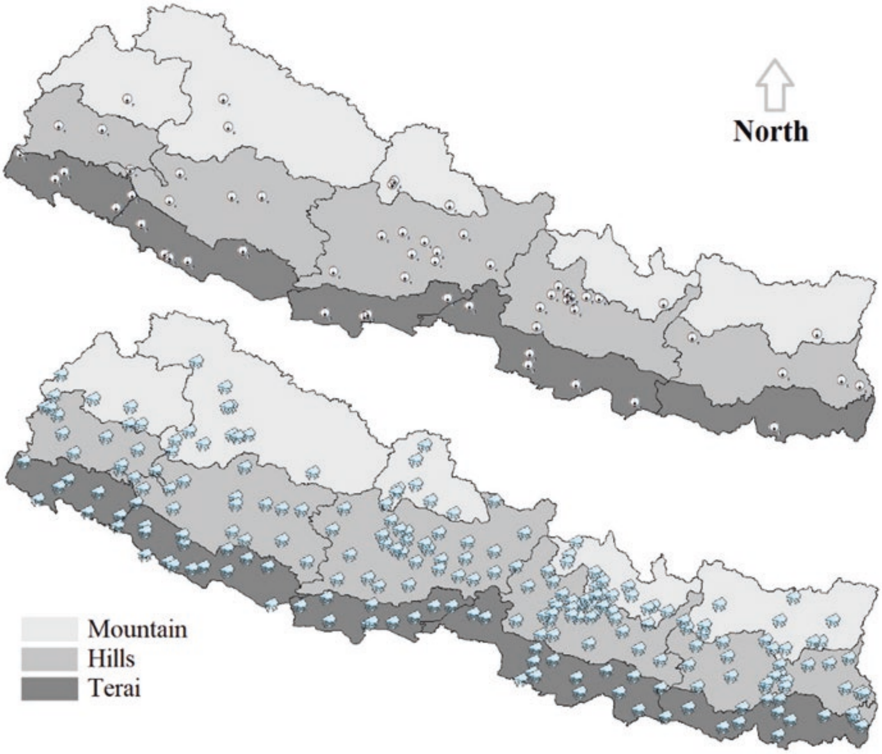

Fig. 3.4 Distribution of rainfall (above) and temperature (below) stations in Nepal (Source of data: DHM 2018)

proportion of missing data is 5.7, 7.3, and 6.3 for precipitation, minimum temperature, and maximum temperature, respectively. Multiple linear regression analysis is one of the effective methods to estimate the missing value (Kashani and Dinpashoh 2012). The coefficients of five closest (neighboring) stations obtained through multiple linear regression analysis and the observation of respective year were used to estimate the missing values. The trend analysis done in this chapter is complemented by the similar analyses done for a relatively shorter time frame in previous studies (see DHM 2017; Practical Action 2009).

3.3.1 Temperature Trend in Nepal

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). Our analysis for the data between 1978 and

2015, however, suggests that the annual mean temperature in Nepal is growing at the rate of 0.02 °C annually (Fig. 3.5). This rate is relatively low compared to the estimations reported earlier.

The temperature trend varies spatially and seasonally across the country (Figs. 3.6, 3.7, 3.8, 3.9, and 3.10). Practical Action (2009) reported for the period of 1976–2005 that the average annual maximum temperature is increasing faster than the minimum temperature at 0.05 °C and 0.03 °C, respectively. Our data also suggests similar tendency, but the rate is relatively low. Between 1978 and 2015, the average annual maximum temperature is increasing at 0.04 °C, and average annual

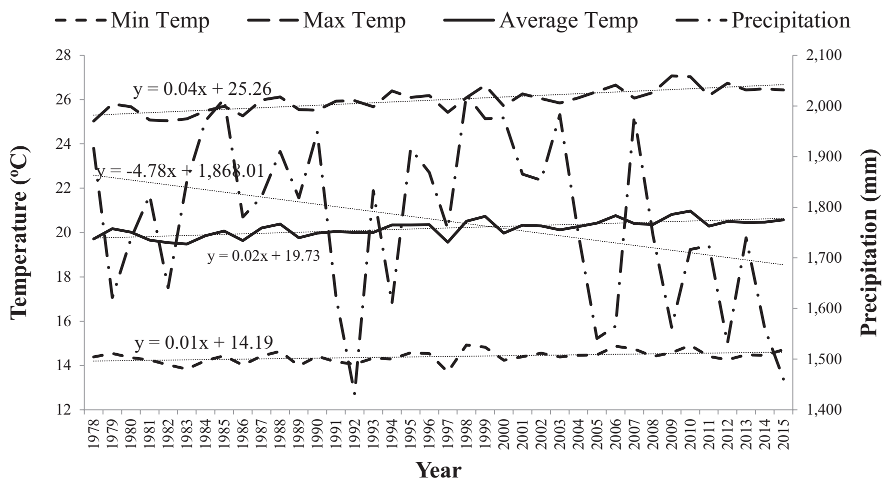

Fig. 3.5 Trend of average annual weather variables in Nepal (Source of data: Raw data from DHM)

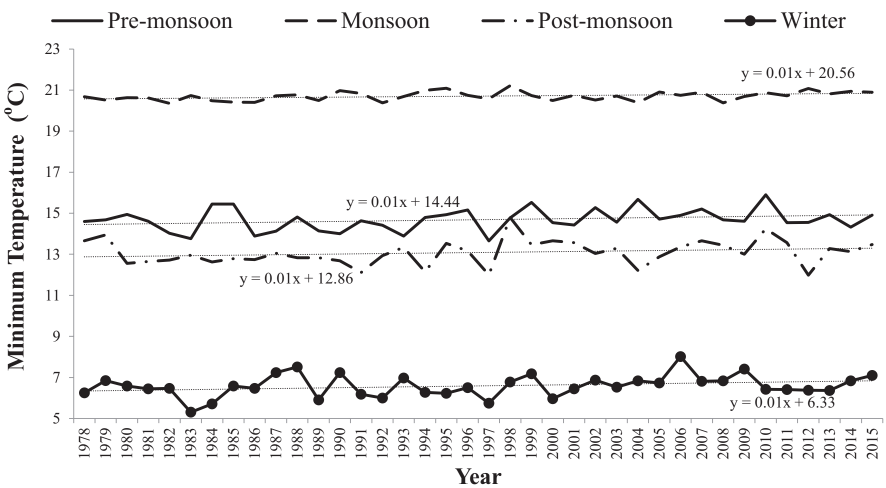

Fig. 3.6 Trend of average seasonal minimum temperature in Nepal (Source of data: Raw data from DHM)

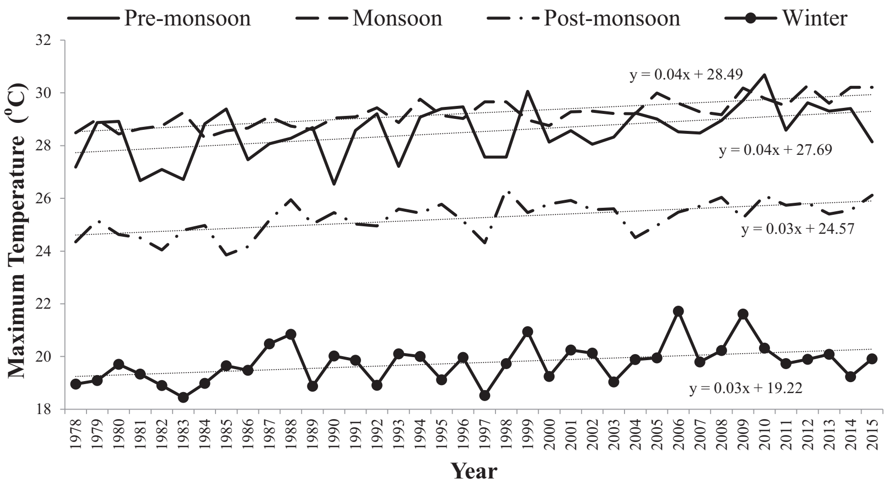

Fig. 3.7 Trend of average seasonal maximum temperature in Nepal (Source of data: Raw data from DHM)

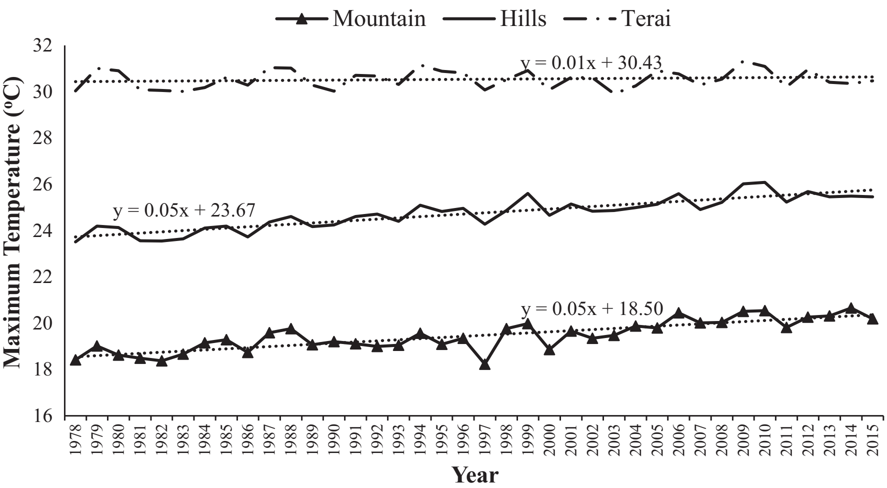

Fig. 3.8 Trend of average annual maximum temperature in the three ecological regions of Nepal (Source of data: Raw data from DHM)

minimum temperature is increasing at 0.01 °C (Fig. 3.5). DHM (2017) also reported similar tendency that the annual average maximum and minimum temperature are increasing at the rate of 0.056 °C and 0.002°, respectively, between 1971 and 2014. There is, however, not much difference in the rate of increase of seasonal average minimum and maximum temperature across the season. The similar result was also reported by DHM (2017). The average seasonal minimum temperature is increasing at the rate of 0.01 °C per annum in all four seasons (Fig. 3.6), and seasonal average maximum temperature is increasing at the rate of 0.03 °C in post-monsoon and

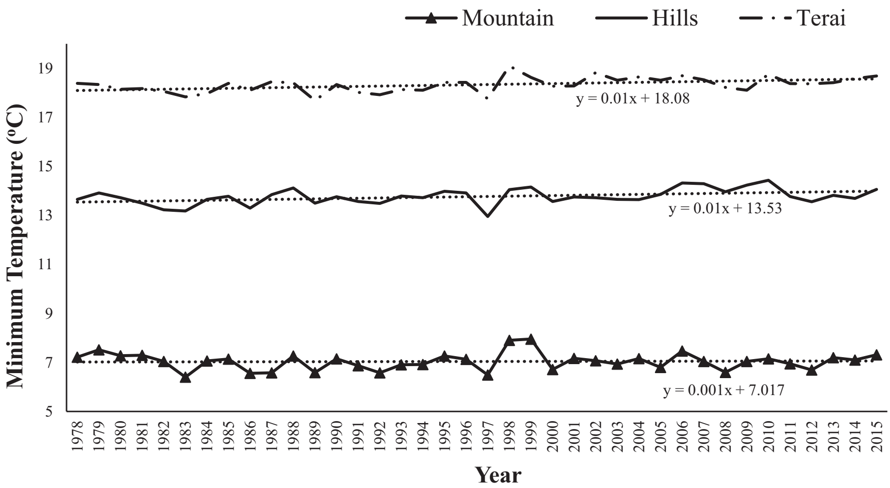

Fig. 3.9 Trend of average annual minimum temperature in the three ecological regions of Nepal (Source of data: Raw data from DHM)

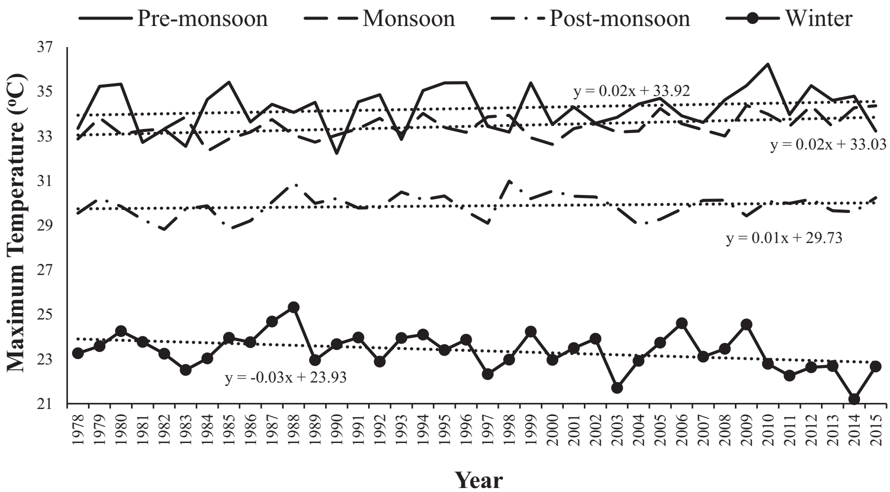

Fig. 3.10 Seasonal trend of maximum temperature in Terai, Nepal (Source of data: Raw data from DHM)

winter season and 0.04 °C in pre-monsoon and monsoon season (Fig. 3.7), which are relatively lower compared to the ones estimated by DHM (2017).

The rate of temperature increase was reported to be greater at higher altitudes by Practical Action (2009). Our latest data also reflects the similar trend in case of the average annual maximum temperature. The increase rate is 0.05 °C per year in mountain and hills compared to 0.01 °C in Terai (Fig. 3.8). This is supposed to increase the risk of glacial lake outburst floods (GLOFs). Increasing incidence of GLOFs in recent decade and subsequent losses are evident (Joshi 2011). On the contrary, the rate of increase of average annual minimum temperature is lesser in the mountains at 0.001 °C compared to that in the Terai and hills, which is increasing faster at the rate of 0.01°C (Fig. 3.9).

A disaggregated analysis of seasonal maximum temperature trends in different ecological zones reveals some interesting features. The trends of seasonal maximum temperature in mountains suggest that the winter temperature is increasing at the rate of 0.07 °C per annum compared to other seasons, namely, pre-monsoon (0.05 °C per annum), monsoon (0.03 °C per annum), and post-monsoon (0.05 °C) (not shown in figure). In the hills, the increase rate of seasonal maximum temperature is higher for winter and post-monsoon (0.06 °C) compared to pre-monsoon and monsoon (0.05 °C) (not shown in figure). Interestingly, similar disaggregated analysis of seasonal maximum temperature in Terai shows that the winter maximum temperature is decreasing (Fig. 3.10). It is reportedly severe in certain pockets of the Terai, caused due to the cold waves and resulting foggy conditions in winter along the Northern Gangetic Plain including the Terai of Nepal (Practical Action 2009). This means that winter is getting warmer in the mountains and hills, while it is actually getting colder in the Terai.

3.3.2 Precipitation Trend in Nepal

Analysis of historical precipitation trend shows that precipitation is highly variable across the country both spatially and seasonally (Practical Action 2009; DHM 2017). Precipitation is very erratic with large interannual variations, thereby resulting in no significant trend of precipitation over the years (Fig. 3.5). The data suggest that the annual precipitation is decreasing at the rate of 4.78 mm per year. DHM (2017) reported the decline rate of 1.33 per year between 1971 and 2014. Similar variations can be observed in the trend disaggregated into four different seasons and the three ecological regions (Figs. 3.11 and 3.12, respectively). Average precipitation is declining in all seasons, with the highest rate of decline for monsoon at nearly 4 mm per year.

Similarly, all three ecological regions experienced the decline in annual precipitation with the highest decline in hills (5.6 mm per year) followed by mountain (4.5 mm per year) and Terai (4.4 mm per year). Despite this decreasing trend of precipitation, concentration of precipitation in certain season remains the major concern for Nepal. Close to 80% of annual precipitation is received in monsoon (June–September). This share is as high as 84.4% in 1984. The share of monsoon rain in total annual precipitation is increasing over the years at the rate of 0.03% per year (Fig. 3.13). The increase in the share of monsoon rain in annual precipitation is the highest in the mountain, which could also contribute in further swelling of glacier lakes in the mountain, besides the swelling contributed by snow melt caused by higher rate of average maximum temperature increase. This remains the main cause for flash floods, subsequent landslides, and GLOFs in Nepal during the monsoon.

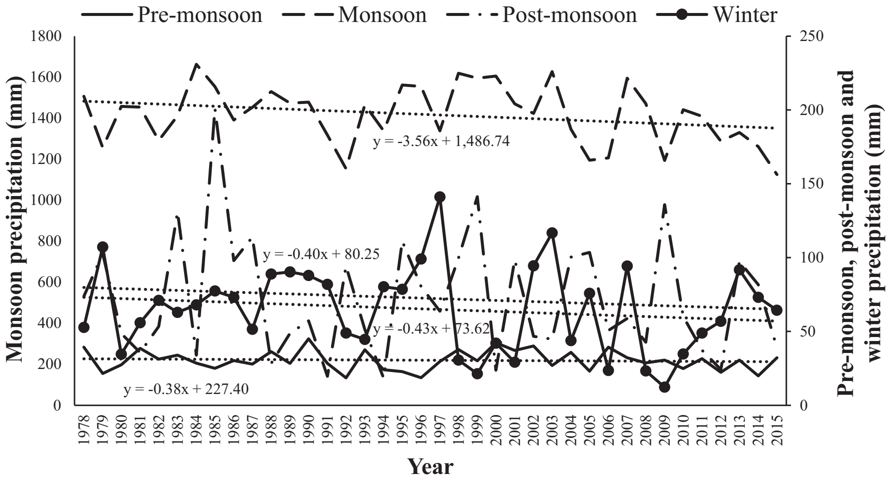

Fig. 3.11 Trend of seasonal precipitation in Nepal (Source of data: Raw data from DHM)

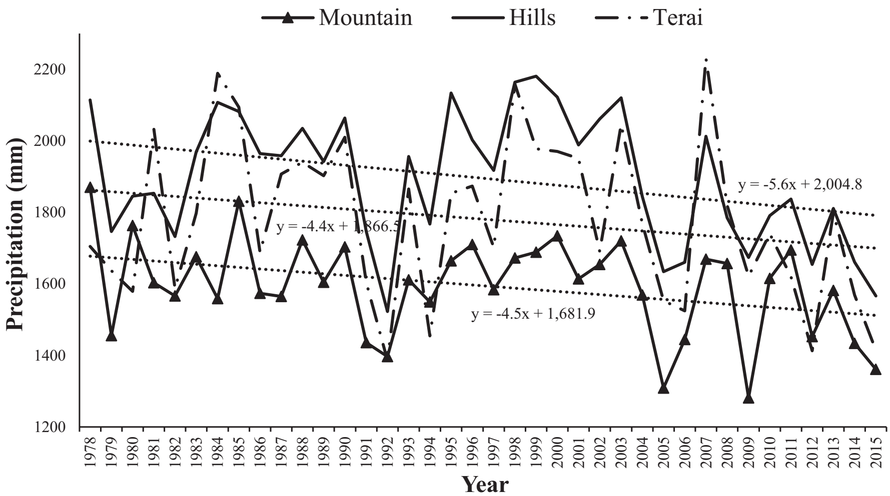

Fig. 3.12 Trend of annual precipitation in the three ecological regions of Nepal (Source of data: Raw data from DHM)

The trend analysis of weather variables presented in this chapter is done as an average for all the weather stations across the country. This analysis, however, is not representative of the changes observed at smaller scales. Historical trend analysis of temperature and precipitation done by Practical Action (2009) at the subnational levels shows that there are many microclimatic pockets scattered spatially along the country and the weather trend varies significantly even within small geographical area. It is difficult to make a single conclusion for the whole country, thereby necessitating studies at a micro-spatial scale.

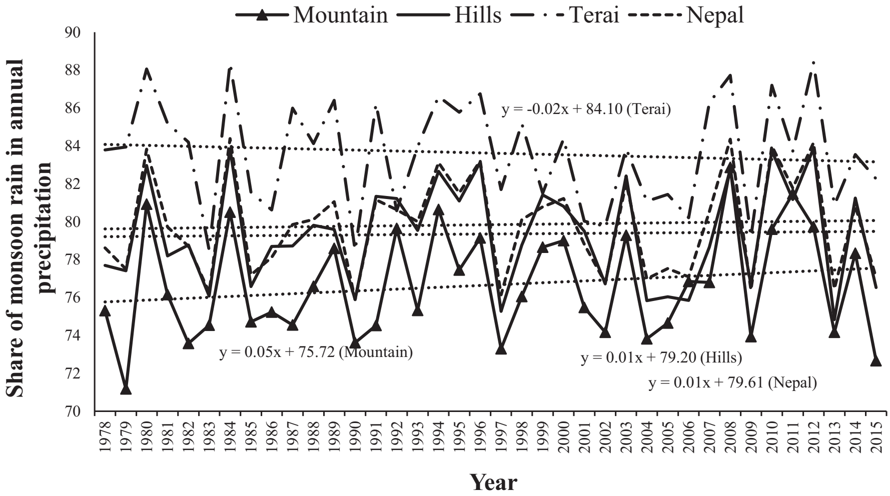

Fig. 3.13 Share of monsoon rain in the total annual precipitation in the three ecological regions of Nepal and its trend (Source of data: Raw data from DHM)

3.4 Projection of Temperature and Precipitation in Nepal

Future projections of temperature for Nepal by Global Circulation Model (GCM) and Regional Circulation Model (RCM) show an increase in average annual temperatures by 3–4.7 °C by the end of this century (Agrawala et al. 2003). The recent estimate suggests the increase to be 4.2 °C (The World Bank 2018). In general, temperature projections are higher for winter compared to summer, which coincide with monsoon in Nepal (Table 3.1). Temperature projections also vary spatially, with the highest projections for Western Nepal, and the lowest for Eastern Nepal (NCVST 2009; Agrawala et al. 2003). Similarly, in the Koshi river basin, the rate of temperature increase will be higher in the trans-Himalayan region during summer and the southern plains during winter (Rajbhandari et al. 2018).

The GCM projections for precipitation by the Climate Research Unit of University of East Anglia shows an overall increase in mean annual precipitation in Nepal (Table 3.1). Rainfall is predicted to increase throughout the year with the highest increase in monsoon. Increase rate will decline in post-monsoon and bounce back to the level of 2040–2059 in 2080–2099 after falling sharply in 2060–2079 in pre-monsoon (Table 3.1). This indicates that monsoon rain is going to be more intense, while the post-monsoon will be even drier. Heavy rainfall events with maximum downpour within a short period of time are 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). This is expected to increase further. The rainfall projections shown in Table 3.1 are substantially higher that those made by Agrawala et al. (2003). The number of days with rainfall above 50 mm is expected to increase by 2.4 days by the end of this century (Table 3.1). A separate GCM and RCM estimates by NCVST (2009) proj-

Table 3.1 Projection of weather variables in Nepal under RCP8.5 scenario

Variable	Period	Pre-monsoon	Monsoon	Post-monsoon	Winter	Annual
Temperature	2040–2059	2.1	1.3	1.8	1.8	1.7
	2060–2079	3.0	2.3	3.0	3.3	2.9
	2080–2099	4.7	3.2	4.5	5.0	4.2
Precipitation	2040–2059	14.1	156.4	24.1	27.5	222.0
	2060–2079	0.5	162.7	4.0	46.4	213.6
	2080–2099	15.0	248.9	2.7	58.5	325.1
Number of days with rainfall >50 mm	2040–2059	0.0	0.8	0.0	0.0	0.8
	2060–2079	0.0	1.3	0.0	0.0	1.3
	2080–2099	0.1	2.3	0.0	0.0	2.4

Source of data: The World Bank (2018)

Table 3.2 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 of data: NCVST (2009)

ects an overall increase in the annual mean precipitation in both the medium and long term time frame. However, the range of projections also depicts the possibility of decrease in annual rainfall in Nepal (Table 3.2).

3.5 Climate Change Impacts in Nepal

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 Terai 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 °C will reduce the rice and wheat yields in the Terai 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 GLOFs, which causes destructions of settlements, agricultural lands, infrastructure, human lives, and properties. According to the 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) report that 1 °C increase in temperature can result in the disappearance of 20% snow and glacier in the mountains above 5,000 m and the estimations of reductions in snow for 2 °C, 3 °C, and 4 °C 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, b; 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 Terai 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 8 out of 16 mountain districts of Nepal were classified as the malaria prone districts in 2010 (WHO 2011). In addition, incidence of previously unseen vector-borne diseases like *kala-azar* and dengue has been frequently reported in the Terai districts. Alternate heat and cold waves during summer and winter seasons have also emerged as livelihood threats in the Terai settlements in the recent years. In the year 2002, 60 cases of fatalities were recorded in the Terai 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 be 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).

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Chapter 4
Conceptual and Analytical Framework

Abstract This book adopts the sustainable rural livelihoods framework proposed by Department for International Development (DFID) as the conceptual framework. The asset pentagon forms the center of the framework. Vulnerability context constitutes the backdrop against which livelihoods are created. Another component is the structures and processes that refer to the institutions, organizations, policies, and legislation that shape livelihoods. Given the vulnerability context, a unit utilizes its assets, structures, and processes to devise livelihood strategies so as to achieve the desired livelihood outcomes. There are various forward linkages and backward loops in the framework that show the interactions among the components. The analytical framework of the book is based on the sustainable rural livelihoods framework, whereby the components are modified to the suit the objectives of the study.

Keywords Vulnerability context · Asset pentagon · Structures and processes · Livelihood strategies · Livelihood outcomes

4.1 Conceptual Framework

The analyses presented in this book adopt the rural livelihood 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 it puts households/communities at the core, and that it 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).

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4.1.1 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. The terms 'asset' and 'capital' are used interchangeably implying the same meaning. 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 the 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 capitals/ assets possession will have higher adaptive capacity as it will facilitate diversification of livelihood strategies (Ellis 2000, 1999) so that households can switch between these assets and strategies at the times of stress (Nelson et al. 2010).

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 brothers or other male members in the family, thereby making them more vulnerable to floods (Demetriades and Esplen 2010).

Structures 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, CBOs, and 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 the 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 toward 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 livelihood strategies will have greater ability to cope and adapt to shock and stresses. In rural areas of low-income countries, a single livelihood strategy is not sufficient to eke out a living; therefore most rural households tend to diversify their livelihood strategies combining both natural resource-based and non-natural resource-based livelihood options (Ellis 1998, 1999). As a result, besides farming, most of the 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.

4.1.2 Relationships Among the Framework Components

Different components in the conceptual framework interact with each other in different ways. The direction of arrows in Fig. 4.1 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 the 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 assets) 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 (physical capital) 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 livelihood outcomes and assets.

Livelihood assets are linked by 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 to 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, structures 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.

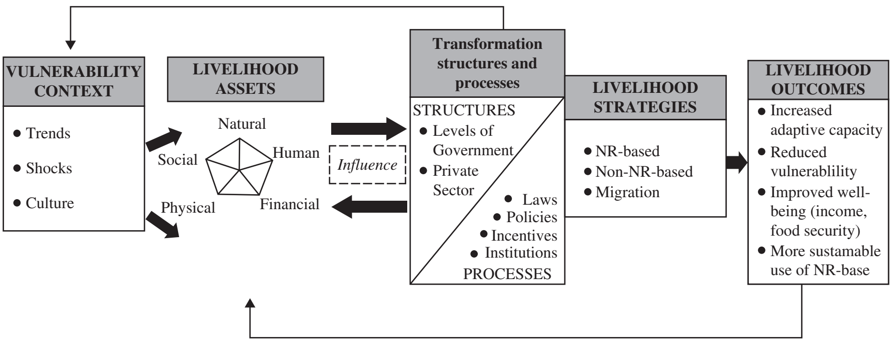

Fig. 4.1 Conceptual framework of the study (Source: DFID 1999; Carney 1998)

Structures and processes also directly influence the choice of livelihood strategies. Policies to build roads or irrigation canals in a village may create opportunities for more remunerative livelihood 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. Structures and processes also have 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 terms 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 (human assets), 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.

4.2 Analytical Framework

The analytical framework for this study (Fig. 4.2) is based on the DFID sustainable livelihoods framework described in the previous section. 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 already been given in the previous section of this chapter. This section will describe the modifications made in the components and the directions of influences, along with

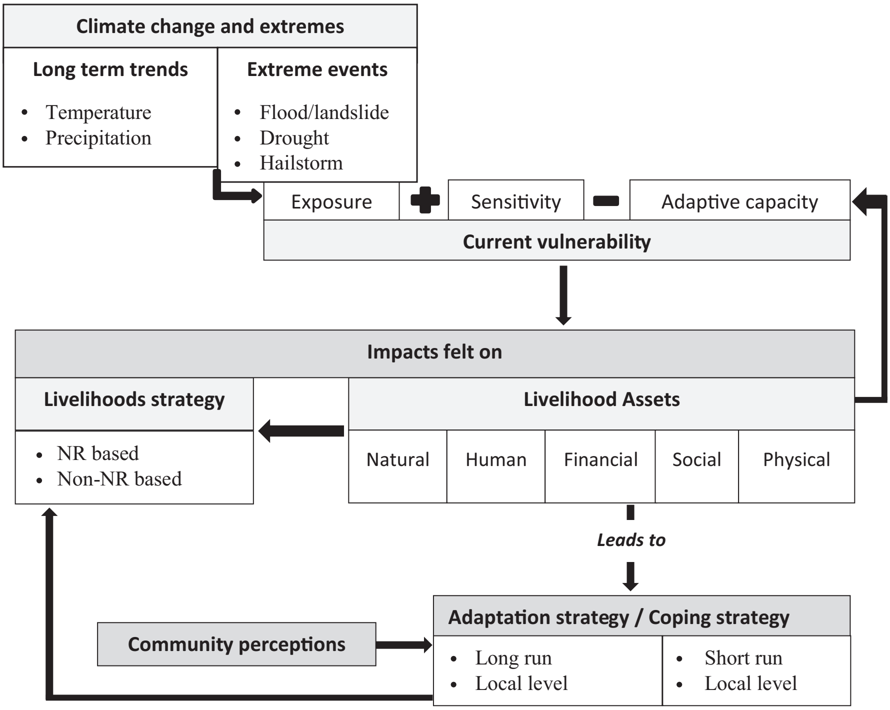

Fig. 4.2 Analytical framework of the study

the sequence according to which the components of the analytical framework will be covered in various chapters.

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 to 2008; similarly, trend for a shorter period of last 10 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 10 years have been considered. Descriptions of the trends and extreme events have been done in Chaps. 9, 10, and 11 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. (2010), 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 Chap. 10. 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 Chap. 8.

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 Chap. 10.

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 Chap. 9. 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 Chap. 12.

Finally, policy decisions at macro, meso, or micro level will be crosscutting across many of the components in the framework. Policies will have a 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.

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Chapter 5
Chepangs: The Community in Focus

Abstract The Chepangs are one of the indigenous nationalities of Nepal, categorized as a highly marginalized group. Majority of the Chepangs live in remote hilly settlements of Chitwan, Makwanpur, Dhading, and Gorkha districts. Although their native area is not very far from the capital city Kathmandu and is surrounded by major highways of the country, the area is poorly served by rudimentary infrastructures, if any at all. This community is also marginalized in terms of socio-economic and political indicators. The livelihoods of the Chepangs have undergone significant transition over the last one-and-a-half century from a nomadic group to shifting cultivation and further to sedentary subsistence agriculture. However, because farming is barely sufficient, the community adopts a multipronged livelihood strategy combining farming with forestry and wage laboring, among others.

Keywords Chepangs · Indigenous nationalities · Highly marginalized · Hunter-gatherer · Shifting cultivation

5.1 Territory of the Chepangs and Vulnerability

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 Makwanpur district, Northeast of Chitwan district, and South of Dhading district. There is also quite significant population of the Chepangs to the North of Trishuli River in the Southeast of Gorkha District, believed to have migrated from their traditional region (Rai 1985). The government of Nepal has categorized the Chepangs as one of the highly

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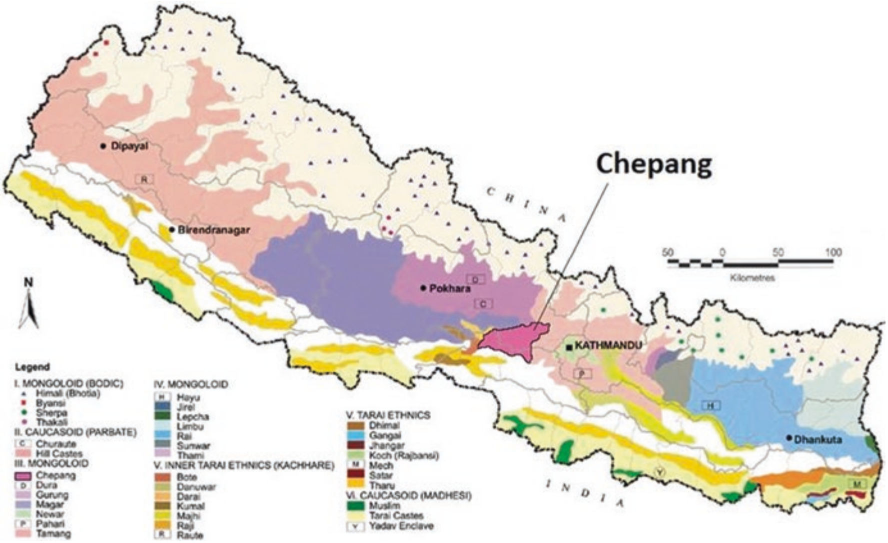

Fig. 5.1 Ethnographic map of Nepal (Source: Gurung et al. 2006; cited by Turin 2007)

marginalized[1] indigenous nationalities living in the hills. According to the population census 2011, the total Chepang population is 68,399 constituting 0.3% of the total population of Nepal (CBS 2014a). Of the total Chepang population, 42.38% lives in Chitwan district, 28.12% in Makwanpur district, 21.19% lives in Dhading district, and 5.05% lives in Gorkha district; the four districts thus form the home to more than 96% of the total Chepang population (CBS 2014b). Majority of the Chepangs live in the steep hilly settlements of these districts that are poorly served, if any, by rudimentary infrastructure such as dirt roads and off-grid power sources. Although their native area is surrounded by major highways of the country, 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 (Fig. 5.1), they are still marginalized from the mainstream of development of the country. They live in the areas most in risk to floods and landslides and are more reliant on local natural resources such as forests

[1] The 59 indigenous nationalities in Nepal are classified into five groups comprising of endangered, highly marginalized, marginalized, disadvantaged, and advanced group (see Appendix 5.1). This classification is based on a composite index comprising of variables like literacy rate, housing, land holdings, occupation, language, graduates, residence, and population size. The indigenous nationalities are further classified into mountains, hills, and terai based on the geographical location where they form a majority.

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. They 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. 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.

5.2 State of Research on the Chepangs: Livelihood Transformation

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 (Rai et al. 2011; Riboli 2000; Gurung 1994a, b, 1995; Neis 1989; Rai 1985). Few quantitative studies have been done on the socio-economic aspects of the Chepangs (Piya 2009; FORWARD 2001a, b; Gribnau et al. 1997).

Often described as guardians of the forest, the Chepangs are believed to be until the last 100–150 years ago a seminomadic 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 1848, p. 650). 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 the Chepangs by Rai (1985) reported that though they 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 7 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. The 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 the early 1970s only registered lands that were permanently cultivated as private properties, thereby failing to recognize *khoriya* patches as the land suitable for registration. Enactment of

Forest Act 1993 further strengthened the government ownership of forests, and the 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*[2]; they also cultivate rice, wheat, and vegetables if they own lowland or irrigated upland. Farming is often practiced in marginal land and is not enough to provide for them for the whole year. Only a small percentage of the Chepang households are fully food self-sufficient. Though agriculture forms the mainstay of their livelihoods, the Chepangs still depend upon forest resources to a large extent, and the contribution of wild and uncultivated edible plants plays an important role in their subsistence economy. During the lean period, the Chepangs depend on forests to gather wild edibles like tubers, yams, and fruits (Rai et al. 2011; Aryal et al. 2009; Piya 2009; Bastakoti and Kattel 2008; Gribnau et al. 1997; Gurung 1995). However, control over and access to forest resources have been severely restricted due to unfavorable state policies, which in turn threaten their traditional livelihoods (Upreti and Adhikari 2006). Beside gathering, the Chepangs also depend upon livestock rearing, wage laboring, collection and sale of non-timber forest products (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, the 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).

[2] Traditionally, *khoriya* is the local term for the practice of shifting cultivation in which a patch of forest is cleared, burnt, and cultivated until the soil is exhausted. The patch is then left fallow for few years, allowing vegetation to regenerate, while other patches are cleared. Although this formed the major cultivation practice of the Chepangs in the past, this practice is almost nonexistent presently, mainly due to government restrictions on clearing forests. Consequently, the term *khoriya* nowadays only refers to un-terraced sloping agricultural land plots usually cultivated annually.

Appendix 5.1: 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)

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Chapter 6
The Study Settings

Abstract This study covers all of the four districts that form the native area of the Chepangs. One village development committee (VDC) from each district was purposively chosen based on the dominance of the Chepang population. Few adjoining hamlets were further chosen based on accessibility. Sixty households were randomly selected from each VDC. Primary data was collected through household survey in two phases. The first phase in 2010 was focused on demographic- and livelihoods-related information. A follow-up survey was conducted among the same households in 2011 focusing on climate change. Only 221 households out of the total 240 households that could be retraced in the second phase form the final sample. This book also utilizes the secondary weather data obtained from the department of hydrology and meteorology. This study incorporates both qualitative and quantitative approach in data analysis.

Keywords Study sites · Sampling · Household survey · Weather data

6.1 Study Sites

This study covers all four districts that form the native area of the Chepangs, i.e., Chitwan, Makwanpur, Dhading, and Gorkha districts (Fig. 6.1). As per the 2011 population census, more than 96% of the Chepang population resides in these four districts. 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 Mahabharata 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 1000 masl, ranging up to 1920 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

L. Piya et al., *Socio-Economic Issues of Climate Change*,
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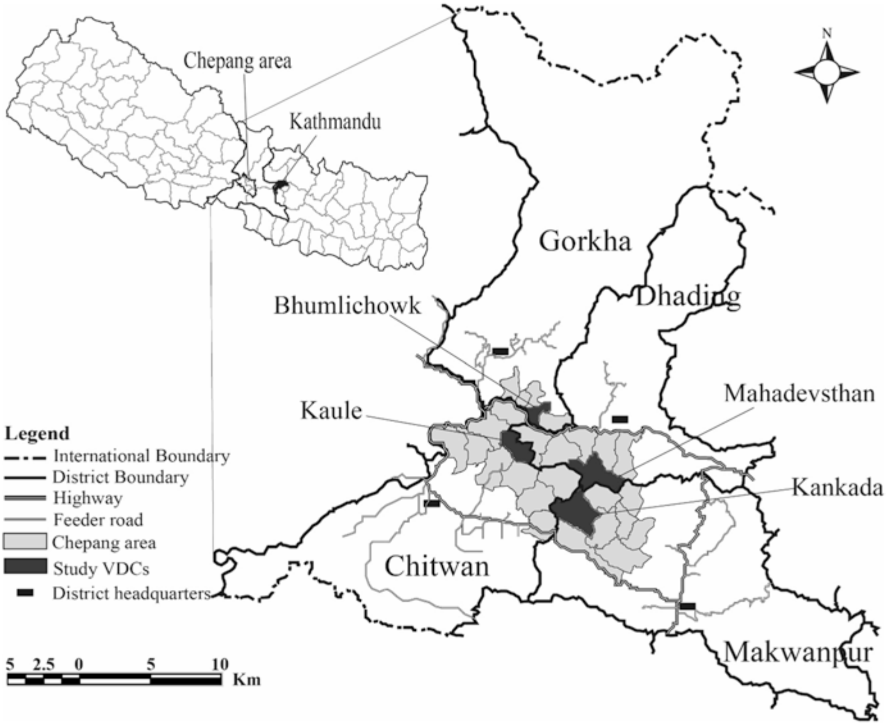

Fig. 6.1 Research area

purpose of this study, one Village Development Committee (VDC[1]) from each district was selected based on the dominance of the Chepang population.

Kaule VDC[2] was selected from Chitwan district. The Chepang is the most dominant ethnic group in Kaule, with a population of 4195 forming 74.7% of the total population of the VDC (CBS 2014a). Kaule VDC has been connected to the Prithvi Highway by an earthen road only in 2011. Around 2 h 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 Chandi Bhanjyang, Shaktikhor, and Siddhi VDCs in Chitwan District, and Jogimara VDC in Dhading District. Altitude of Kaule varies from 810 to 1920 masl (NGIIP 2006a). The highest point in the Mahabharata range, the Siraichuli peak, at an altitude of around 1920 masl, is situated in this VDC.

[1]VDC was the second-lowest administrative unit above wards until the recent administrative reform in Nepal conducted in 2017. After the reform, VDCs are replaced by rural municipalities, and the administrative boundaries have undergone significant changes. Since the surveys for this research was conducted before the reform, the older administrative division has been used for convenience.

[2]As per the administrative reform done in 2017, Kaule VDC is merged into newly formed Ichhyakamana Rural Municipality (Wards 1 and 2).

Kankada VDC[3] from Makwanpur District is the VDC with the highest population of Chepangs in the district. The Chepangs are the most dominant ethnic group in Kankada, with a population of 4614 forming 58.9% of the total population in the VDC (CBS 2014b). Kankada is a very remote VDC in Makwanpur, still untouched by transportation facilities. It shares its borders with Manahari, Raksirang, and 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 385–1710 masl (NGIIP 2006a).

Mahadevsthan VDC[4] in Dhading district has a Chepang population of 2510, accounting for 36.8% of the total population in the VDC (CBS 2014c). The 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, and Pida VDCs in Dhading district; Kankada, Khairang, and Dandakharka VDCs in Makwanpur district; and Lothar VDC in Chitwan district. Altitudinal variation in the VDC ranges from 550 to 1930 masl (NGIIP 2006a).

Bhumlichowk VDC[5] was selected as the study site in Gorkha district. There are no VDCs in Gorkha where the Chepangs are a majority; Bhumlichowk VDC has the largest Chepang population within Gorkha district. Chepangs are the second-largest ethnic group in Bhumlichowk with a population of 1112 forming 31.4% of the total population in the VDC (CBS 2014d). It shares its border with Tanglichowk, Darbhung, and Ghyalchok 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 Darechok 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 1730 masl (NGIIP 2006b). The study VDCs are shown in Fig. 6.1.

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 the 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] As per the administrative reform done in 2017, Kankada VDC is merged into Raksirang Rural Municipality (Wards 6, 7 and 8).

[4] As per the administrative reform done in 2017, Mahadevsthan VDC is merged into Benighat Rorang Rural Municipality (Wards 1 and 2).

[5] As per the administrative reform done in 2017, Bhumlichowk VDC is merged into Gandaki Rural Municipality (Ward 6).

6.2 Sources of Data

6.2.1 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 as well as quantitative 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. 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 4–6 h from the Prithvi Highway. Settlements covered in Kankada VDC include Maaisiraang, Bousiraang, Gajraang, Tekaaraang, Saakhaaraa, Panyuraang, Nyamsiti, Kundule, Bhaamsaati, Chaamanti, Gyangraang, Hattikhola, and Devitaar, located at a walking distance of 3–6 h from Manahari in the 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 2–4 h from a place called Talti in the VDC. In Bhumlichowk VDC, settlements of Hiklung, Thumka, Kyantung, Bhanjyang, and Lupraang (Nupraang/Numpraang) were covered lying at a walking distance of 2.5–4 h 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 in 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 households 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

Table 6.1 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	810–1,920	4,195 (74.7)	60	58
Makwanpur – Kankada	385–1,710	4,614 (58.9)	60	56
Dhading – Mahadevsthan	550–1,930	2,510 (36.8)	60	54
Gorkha – Bhumlichowk	410–1,730	1,112 (31.4)	60	53

Source: [a]NGIIP (2006a, b)
[b]CBS (2014a, b, c, d)
Note: Figures in parenthesis indicate percentage of the VDC total

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 6.1.

Household survey was conducted using semi-structured interview schedule prepared in Nepali language. Masters and bachelors 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 the 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 households' 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 h.

6.2.2 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 Chap. 9. Temperature from 49 temperature stations and precipitation from 218 precipitation stations for the time period 1977–2008 is used to interpolate the temperature and rainfall for the sample households in Chap. 10. The methodology is discussed in detail in the respective chapters.

6.3 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 Chap. 9; principal component analysis is adopted in Chap. 10; and multivariate probit is applied in Chap. 12. 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.

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Chapter 7
Annual Subsistence Cycle: Integration of Farming and Gathering

Abstract Although farming is the mainstay of the Chepang livelihoods, wild and uncultivated plants are still highly important for them as farming alone is rarely sufficient. Majority of the households own unirrigated uplands where they cultivate maize and millet as the major staples. Vegetables are less cultivated by the Chepangs. Wild and uncultivated plants are thus important not only as staple food but also as the source of food diversity and nutritional security in the form of green vegetables, fruits, and spices. A comparison of annual cropping calendar and gathering calendar clearly shows that wild tubers are consumed as staples during the months when the earlier harvest is depleted, and the new harvest is not yet ready. It is important to understand this complementary relationship between farming and gathering to improve the food security of the Chepang community.

Keywords Landholding · Cropping calendar · Livestock · Gathering calendar

7.1 Farming

7.1.1 Landholding and Crops Grown

Landholding among the Chepangs can be classified into three categories: *khet* (irrigated land suitable for paddy transplantation), *bari* (terraced upland, usually unirrigated), and *khoriya* (sloppy unirrigated upland without terraces). *Khet* is the most fertile category of land, usually situated in the foothills nearby the streams. *Bari* and *khoriya* are very stony, sloppy, and lacks irrigation facilities due to which they are less productive. *Khet* is considered an important asset for the households as it has the highest productivity, and three consecutive crops of paddy (*Oryza sativa*), wheat (*Triticum aestivum*), and maize (*Zea mays*) can be cultivated, thereby having higher contributions to the food self-sufficiency of the household. However, owing to the topography of the settlements, very few households own *khet*, which is usually situated at lower elevations far from the houses. It can be seen from Table 7.1 that *khet* is owned by relatively fewer households and the acreage per household is also

L. Piya et al., *Socio-Economic Issues of Climate Change*,
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Table 7.1 Average landholding of the sample households by land category (in *kattha*[a])

Land category	Kaule (n = 58)		Kankada (n = 56)		Mahadevsthan (n = 54)		Bhumlichowk (n = 53)	
	% of HHs	Area/HH	% of HHs	Area/HH	% of HHs	Area/HH	% of HHs	Area/HH
Khet	48.3	2.3	5.4	0.2	68.5	2.6	81.1	3.2
Bari	93.1	7.1	85.7	7.9	98.1	6.2	100	6.1
Khoriya	77.6	3.6	76.8	4.4	46.3	4.1	88.7	3.4

Source of data: Field survey 2010

[a]1 *kattha* = 0.033 hectare

smaller compared to *bari*. The figures are especially very low in Kankada because the VDC faced massive and multiple landslides in July 2001 claiming more than 60 lives and property loss. In the aftermath of this disaster, the fertile *khets* lying in the foothills were all covered with debris from the upstream. These stony land plots can no longer be referred to as *khets*. Most of the households own *bari* in all the four study sites. *Khoriya* is owned by second majority of the households, except in Mahadevsthan. The findings are similar to the study by Gribnau et al. (1997) who reported that 21% of the Chepang households in four VDCs of Chitwan district, namely Shaktikhor, Siddhi, Kaule, and Korak, owned *khet*, 98% owned *bari*, and 95% owned *khoriya*.

Those households which have no *khet* rely mostly on *bari* and *khoriya* for grain production. Maize and millet (*Eleusine coracana*), the two most important staple crops for the Chepangs, are grown in *bari* and *khoriya*. Besides these, the Chepangs also cultivate buckwheat (*Fagopyrum esculentum*) and mustard (*Brassica campestris* var. *toria*) in *bari*, but in lesser quantities. Legumes like soybean (*Glycine max*) and black gram (*Vigna mungo*) are planted along with paddy on the bunds of *khet*, while cowpea (*makai bodi*) (*Vigna* spp.) is mixed cropped with maize. Other legumes like a different variety of cowpea (*kattike bodi*) (*Vigna* spp.), rice bean or *masyang* (*Phaseolus aconitifolius*), and horse gram (*Dolichos biflorus*) are usually cultivated in *khoriya*. Cereals like *sama*, *kaguno* (*Setaria italica*), and *junelo* (*Sorghum vulgare*) which the Chepangs used to cultivate till some 35 years ago (see Rai 1985) are no more cultivated. The Chepang households maintain a small kitchen garden in their courtyard or in the field nearby their houses, where they plant limited varieties of vegetables and spice crops. The Chepangs commonly plant broad leaf mustard (*Brassica juncea*), pumpkin (*Cucurbita maxima*), radish (*Raphanus sativus*), gourds [sponge gourd (*Luffa cylindrica*), snake gourd (*Trichosanthes anguina*), bottle gourd (*Lagenaria siceraria*), and bitter gourd (*Momordica charantia*)], cucumber (*Cucumis sativus*), chayote (*Sechium edule*), and colocasia (*Colocasia antiquorum*). Other less commonly planted vegetables include *barela* (*Momordica balsamina*), brinjal (*Solanum melongena*), beans [snap bean (*Phaseolus lunatus*), four season bean, winter bean (*Dolichos lablab*)], okra (*Abelmoschus esculentus*), tomato (*Lycopersicon esculentum*), onion (*Allium cepa*), potato (*Solanum tuberosum*), cauliflower (*Brassica oleracea* var. *botrytis*), and cabbage (*Brassica* *oleracea* var. *capitata*); these vegetables are still very new to the Chepangs mostly introduced by the development agencies working in the area and are grown only by few households owning *khet* or irrigated *bari*. The most commonly planted spice crop is chilly (*Capsicum annum*) besides which they also plant garlic (*Allium sativum*), ginger (*Zingiber officinale*), and turmeric (*Curcuma domestica*). The Chepangs cultivate very limited quantities of vegetables and spice crops due to the lack of irrigation facilities. Also, openly reared chicken and pigs are a problem as they run around the homestead in search of food and destroy young vegetable seedlings in the kitchen garden.

7.1.2 The Annual Cropping Cycle

Maize and millet, the two important staple crops for the Chepangs, are cultivated by all the households. After the harvest of winter crops, field is plowed and manured for the cultivation of maize. During Faagun–Chait (for conversion of Nepali months into English calendar, see Appendix 7.1), after the intermittent spring rains, maize seed is broadcasted. If the onset of spring rain is late, broadcasting of maize seeds may be delayed until Baisaakh. Immature cobs are consumed from Asaar; the mature cobs are harvested from late Saaun till Bhadau depending on the sowing time. Cowpea (*makai bodi*) is sown together with maize seeds. Green cowpea pods are eaten as vegetables during Jeth–Asaar, while mature seeds are harvested together with maize in Saaun–Bhadau and used as daal.

After maize, millet is transplanted in *bari* and *khoriya*. Millet is sown in seedbeds on dry land in Asaar and transplanted about a month later. If the previous crop of maize is sown late, then this disturbs the transplantation of millet seedling. Under such circumstances, seedling transplantation of millet is delayed until Bhadau. Some households transplant the seedling while the maize is still standing in the field. Many Chepang households simply broadcast the millet seedlings on plowed fields. Millet is harvested from late Kartik till early Poosh. Besides millet, the Chepangs also sow legumes like cowpea (*kattike bodi*), rice bean, and horse gram after maize harvest. These legumes are usually sown in *khoriya*. Green pods of cowpea are sometimes consumed as fresh vegetables; however, these legumes are mostly grown for the purpose of pulses. Mature legume seeds are harvested in Mangsir–Poosh. After the harvest of millet/legumes, the land remains fallow for 2–3 months. In Faagun, before the onset of spring rains, the crops stubbles are burned, and the land is plowed to prepare for sowing maize. In Asoj–Kartik, buckwheat is sown in *bari* in higher altitudes, where millet is not sown. The Chepangs in Kaule barter buckwheat for unprocessed salt (*dheeka noon*[1]) with tradesmen who visit the villages from plain areas. Another winter crop less commonly cultivated is

[1] *Dheeka* means lumps and *noon* means salt in Nepali, referring to the unprocessed salt in crystal form.

mustard, which is also sown in *bari* where millet is not cultivated. Buckwheat is harvested during Poosh–Maagh, and mustard is harvested during Maagh–Faagun.

The few households who own *khet* plant paddy after harvesting maize. As irrigation is available in *khet*, maize is usually planted early in Faagun and is thus harvested earlier in the late Asaar till early Saaun. Paddy seedling sown in seedbeds in Jeth is ready to be transplanted by the time maize is harvested in Asaar–Saaun. Land is thoroughly plowed, puddled, and leveled before paddy seedlings are transplanted. Paddy is ready for harvesting in Kartik–Mangsir. Soybean and black gram are planted in the bunds of *khet* during rice transplantation, and mature seeds are harvested in Mangsir–Poosh. Soybean and black gram are usually sold in the roadhead markets for cash income or to pay back the loans taken from roadhead moneylenders. After paddy harvest in Kartik–Mangsir, wheat seeds are sown in *khet*. Some households may also sow wheat in *bari* after millet is harvested. However, wheat is not commonly sown in *bari* as it needs heavy manuring, whereas *bari*s are manured only once prior to maize seed broadcasting. Wheat can be harvested from late Faagun till Chait. The annual cropping cycles followed by the Chepangs can be summarized as follows:

Bari	*Khoriya*	*Khet*
Maize – millet/buckwheat/ mustard	Maize – millet/legumes (cowpea/rice bean/ horse gram)	Maize – paddy – wheat

Note: Maize is mixed cropped with cowpea (*makai bodi*)
Paddy is intercropped with soybean and black gram

The Chepangs don't give much emphasis on the cultivation of vegetables and spice crops. Of the few plants sown in the kitchen garden, fewer survive due to destruction by chickens, pigs, drought, disease, and pest infestation. Among the spice crops, chilly is an indispensable part of the Chepang diet. They plant chilly seedlings during summer months, which can be harvested from Jeth till Poosh depending on the planting date. They dry the surplus for future use and buy the insufficient amount when they visit the roadside markets. Most of the vegetables grown by the Chepangs are summer vegetables, pumpkin being the most important one, as the young shoot can be used as green vegetables, the fruits can also be eaten as vegetables, and surplus mature ones can be stored for future use. The seeds of pumpkin are sown from Faagun to Baisaakh along the bunds of the fields when maize is sown. Young shoots can be consumed from Chait till Bhadau. Young pumpkin fruits can be consumed from Asaar till Bhadau, while mature fruits are harvested in Asoj and stored for future use. Gourds (sponge gourd, snake gourd, bottle gourd, and bitter gourd) are planted from Faagun till Baisaakh and are consumed throughout summer from Jeth till Asoj. The Chepangs also plant cucumber during Faagun–Chait which can be eaten from Asaar to Bhadau. Indigenous varieties of cucumber can be left to mature in the plant and can be stored for few months. However, these days, indigenous varieties of cucumber are becoming rare, mostly replaced by hybrid seeds. Increasing disease and pest infestation has been reported in the cucurbitaceous vegetables (pumpkin, gourds, and cucumber) after the introduction of hybrid seeds.

Colocasia is planted during Faagun–Chait, and leaves are used as green vegetables during Saaun–Bhadau, while the tubers are dug from Mangsir to Maagh. During the winter, the only green vegetables planted by the Chepangs are broad-leaved mustard and radish. Broad leaf mustard is planted during Bhadau–Asoj and consumed from Asoj throughout the winter till Maagh. Surplus leaves are fermented to make *gundruk* and stored to be used as vegetables for dry months. Radish is planted from Saaun to Kartik and is consumed from Asoj to Poosh. Chayote, a perennial climber, is another common vegetable among the Chepangs. Fruits of Chayote can be harvested from Asoj till Poosh. Chayote can also be bartered with unhusked paddy. The cropping calendar for the major crops grown by the Chepangs is given in Table 7.2.

7.1.3 Livestock

Owing to the difficult topography, goat is the most important livestock for the Chepangs as the goats can graze in any difficult topography. Trade of goat is an important source of cash income for the Chepangs. Gribnau et al. (1997) also reported that 33% of the cash income is from goats for the Chepangs in Chitwan district. Market for goat in the Chepang settlements is very well developed, and buyers from many adjoining districts and major market centers like Narayanghat, Hetauda, and Mugling come to the villages to buy goats. Income from goats is used to buy insufficient grains and other domestic consumables like kerosene, salt, and clothes. It is also used to repay the loans taken from moneylenders during food shortages and emergencies.

Cattles cannot graze on steep slopes, thus have to be fed by carrying loads of fodder from the forest. After goat, bullock is considered important for plowing the fields. Bullocks are usually hired on the basis of labor exchange by other households who do not own bullocks. The cows reared in the Chepang area are usually small-sized local breed and are not very productive. Cows are thus reared for manure, rather than for milk. Buffalo is owned by very few households, as raising buffalo in such steep hills is very difficult. Buffaloes are harder to take care of and are too heavy to be allowed out to pasture or to get water in the rugged terrain. He-buffaloes and she-buffaloes are often slaughtered during festivals; the meat and the cost are shared equally by all the households; an extra share is given to the one who slaughters the animal. Chicken and pig are reared openly and can be found running around the homesteads and even inside the house all the time. Chicken and pigs are mostly reared for own consumption, mostly slaughtered during festivals, and marriages, and are also sold sometimes. Many Chepangs rent-in livestock from Bahuns, Chhetris, and Newars from the nearest roadhead markets on *adhiya* basis. In this system, the Chepangs take all the responsibilities of rearing the livestock, in return of which they get half the share on the offspring. So, if the goat gives birth to two

Table 7.2 Annual crop calendar

Crop	*Baisaakh*	*Jeth*	*Asaar*	*Saaun*	*Bhadau*	*Asoj*	*Kaartik*	*Mangsir*	*Poosh*	*Maagh*	*Faagun*	*Chait*
Cereals, Legumes, and Oilseed												
Maize	**P**		**H**	**H**	**H**						**P**	**P**
Millet				**P**	**P**		**H**	**H**	**H**			
Buckwheat						**P**	**P**		**H**	**H**		
Wheat							**P**	**P**			**H**	**H**
Paddy			**P**	**P**			**H**	**H**				
Soybean			**P**	**P**				**H**	**H**			
Blackgram			**P**	**P**				**H**	**H**			
Cowpea (*Makai*)	**P**	**H**	**H**	**H**	**H**						**P**	**P**
Cowpea (*Kattike*)				**P**	**P**	**H**	**H**	**H**				
Ricebean				**P**	**P**			**H**	**H**			
Horsegram				**P**	**P**			**H**	**H**			
Mustard					**P**	**P**				**H**	**H**	
Spice and Vegetables												
Chilly	**P**	**P**	**P**	**P**								**P**
		H	**H**	**H**	**H**	**H**	**H**	**H**	**H**			
Broad leaf mustard				**P**	**P**	**P**						
						H	**H**	**H**	**H**	**H**		
Radish				**P**	**P**	**P**	**P**					
						H	**H**	**H**	**H**			
Pumpkin fruit	**P**	**P**	**H**	**H**	**H**	**H**					**P**	**P**
Pumpkin shoot	**P**	**P**									**P**	**P**
	H	**H**	**H**	**H**	**H**							**H**
Gourds	**P**	**H**	**H**	**H**	**H**	**H**					**P**	**P**
Cucumber			**H**	**H**	**H**						**P**	**P**
Chayote						**H**	**H**	**H**	**H**		**P**	**P**
Colocasia leaf				**H**	**H**						**P**	**P**
Colocasia tuber								**H**	**H**	**H**	**P**	**P**

Source of data: Field Survey 2010
Note: P = planting, H = harvesting

Table 7.3 Average number of livestock holding by different livestock categories

Livestock	Kaule (n = 58)		Kankada (n = 56)		Mahadevsthan (n = 54)		Bhumlichowk (n = 53)	
	% of HHs	Mean Number owned	% of HHs	Mean Number owned	% of HHs	Mean Number owned	% of HHs	Mean Number owned
Goat	77.6	4.0	85.7	6.2	81.5	5.2	81.1	6.2
Cow/ bullock	96.6	3.8	73.2	2.0	88.9	2.8	98.1	3.3
Buffalo	44.8	0.9	1.8	0.01	55.6	1.1	54.7	1.3
Pig	38.0	0.6	58.9	0.7	42.6	0.5	45.3	0.6
Chicken	89.7	6.3	87.5	7.7	87.0	6.8	90.1	6.2

Source of data: Field Survey 2010

kids, one of them will belong to the Chepang households, while another kid and the mother goat still belong to the non-Chepang owner. In the case of cows, the owners usually pay half the amount of the calf's worth to the Chepang household. Goat is the major livestock reared under the *adhiya* system. Besides goat, few households also rear cows and pigs under this system (Table 7.3).

7.2 Gathering Wild and Uncultivated Food Plants

Wild and uncultivated plants collected from the forests, field bunds, and bushes nearby *bari* and *khoriya* are important source of food for the Chepangs. All the Chepang households covered by the study are involved in collection of such wild edibles. It was found that the wild plants were mostly used as vegetables, followed by fruit, staple food, spice, pickle, oil, and liquor. The most frequently used plant part was fruit, followed by young shoot, tuber, whole plant, aerial yam, flower, leaf, seed, bark, stem, and rhizome.

Wild tubers form the major staple diet for the Chepangs during the lean periods after their agricultural harvest is depleted. The most commonly consumed tubers are *gittha* (*Dioscorea bulbifera*), *bhyakur* (*Dioscorea pentaphylla*), and *tarul* (*Dioscorea alata*). These tubers form the staple diet for most of the Chepang households from Faagun to Asaar (see Table 7.4). *Gittha-bhyakur* taste bitter when uncooked, and the tubers are boiled in ash water to remove the bitterness. *Ban tarul* is regarded as the most delicious of all tubers; however its tubers are thin and long that extend deep into the soil because of which digging of *ban tarul* is more difficult. *Bharlang* (*Dioscorea hispida*), the most poisonous tuber, is a spiny shrub. *Bharlang* is consumed only when the household faces extreme food shortage. Uncooked *bharlang* has a bitter smell and causes headache, nausea, and vomiting if exposed for too long. *Bharlang* needs very careful precautions while preparing. The skin is first peeled, sliced, and boiled in ash water for about an hour. The boiled slices are then soaked in running water in the river for about 24 h. The next day, the slices are boiled seven times, changing the water each time, after which the tubers are ren-

Table 7.4 Annual gathering calendar of major wild food plants

Product	*Baisaakh*	*Jeth*	*Asaar*	*Saaun*	*Bhadau*	*Asoj*	*Kartik*	*Mangsir*	*Poosh*	*Maagh*	*Faagun*	*Chait*
Vegetables												
Sisnoo	▨				▨	▨	▨	▨	▨	▨	▨	▨
Jaluko	▨	▨	▨	▨	▨						▨	▨
Tanki	▨	▨	▨	▨	▨	▨					▨	▨
Niuro	▨	▨	▨	▨							▨	▨
Latte	▨	▨	▨	▨	▨	▨	▨					▨
Bamboo		▨	▨	▨	▨							
Mushroom			▨	▨	▨							
Tubers/Staple food												
Gittha	▨	▨									▨	▨
Bhyakur	▨	▨									▨	▨
Tarul	▨	▨								▨	▨	▨
Chiuri												
Chiuri fruit		▨	▨	▨	▨							
Chiuri seed			▨	▨	▨	▨						
Chiuri butter					▨	▨	▨					

Source of data: Field Survey 2010

dered edible. If the poison remains, it causes nausea-vomiting, sometimes causing death by vomiting blood.

Besides these tubers, forest is the main source of green vegetables for this community. *Sisnoo* (*Urtica dioica*) is the most commonly consumed wild green vegetables, which can be consumed almost all the year round from Bhadau till Baisaakh. It was found that the Chepangs consume the young shoot of *tanki* (*Bauhinia purpurea*) as green vegetables for 8 months in a year from Faagun till Asoj (Table 7.4). Other green vegetables commonly consumed include edible fiddlehead ferns (*niuro*), *jaluko* (*Remusatia vivipara*), and *latte* (*Amaranthus* spp.). These green vegetables can also be collected from Faagun throughout the summer, sometimes till Asoj–Kartik. Wild green vegetables, especially *sisnoo*, *tanki*, and *latte*, are very prolific in nature and can be found abundantly in the bushes nearby forests and on the bunds of *bari* and *khoriya*. Young bamboo shoots are also commonly used as vegetables. These are collected during the summer months from Jeth till Bhadau and are sometimes stored by pickling to be used during the dry season as well. The Chepangs also collect many wild varieties of mushrooms, which sprout in the forest after the monsoon rains (from Asaar till Bhadau). The Chepangs claim to know the differences between poisonous and nonpoisonous mushrooms, as well as methods to cure illness if a mistake is made. The annual gathering calendar for the major wild vegetables is given in Table 7.4.

Chiuri (*Bassia butyracea*), commonly known as butter tree for its rich oily seeds, is another important plant for the Chepangs. The pulp of *chiuri* fruit often forms the major supplementary diet for the Chepangs from Jeth to Bhadau. The seeds are collected from the forests from Asaar till Asoj, and these are used to expel butter. *Chiuri* butter is an important source of cooking oil for the Chepangs. It is also used as hair oil and as medicines for dry skin. Besides domestic uses, *chiuri* butter also has commercial importance. It makes excellent raw materials for quality soaps and is bought by cosmetic companies. It is also used to light lamps in temples and monasteries in Kathmandu. The Chepangs usually sell the *chiuri* butter or seeds to the roadhead traders during Asoj to make cash income for celebrating Dashain.

Many plants have multiple edible uses as well. For instance, young shoots and seeds of *tanki* and *koiralo* (*Bauhinia variegata*) are used as vegetables, and their flowers are used as pickles. The aerial yam of *gittha*, *tarul*, and *kukkur tarul* (*Dioscorea deltoidea*) is powdered and used as pickle. Wild varieties of *timur* (*Zanthoxylum* spp.) and *tejpaat* (*Cinnamomum tamala*) are used as spices. Also, the Chepangs consume fruits of many types of wild figs like *dumri* (*Ficus racemosa*), *badahar* (*Artocarpus lakoocha*), *khanayo* (*Ficus semichordata*), and *pipal* (*Ficus religiosa*). Wild fruits are often gathered and consumed when they visit the forest for grazing goats, and collecting fodders and firewood. However, these wild fruits are rarely brought home.

The amount of knowledge accumulated by the Chepangs about food gathering is astounding. They collect, prepare, and eat deadly poisonous roots. The Chepangs can distinguish the edible mushrooms from the poisonous ones. The Chepangs can remove poison from poisonous tuber, *bharlang*, and from the seed of poisonous legume *pangra* (*Entada phaseoloides*) to render them edible.

7.3 Complementarity Between Farming and Gathering

Although farming forms the mainstay of the Chepang livelihood, the rugged topography, steep slopes, stony lands, inadequate manure, and limited irrigation facilities lead to a productive capacity too small to support the population. The average food self-sufficiency of the Chepang households covered by the study is around 7 months, and only 7.5% of the total households covered by the study are food self-sufficient. Similar findings were also reported by Aryal et al. (2009) and Bhattarai et al. (2003). Gurung (2006) and FORWARD (2001) report even lower average food self-sufficiency of 5 months and that only 1% of the total Chepang households is food self-sufficient. Gribnau et al. (1997) reports that only 4% of the Chepang households were found to be self-sufficient. Gurung (2006) reports even lower figure of only 1% of the total Chepang households being food self-sufficient. They face grain deficit from Faagun to Asaar, the most chronic deficit being Chait to Jeth. The reason for food deficit during this period is because this is the dry season; the land basically remains fallow during the dry months due to lack of irrigation facilities. Also, due to infertile and stony nature of the land, crop productivity is low, and whatever is harvested earlier gets depleted by this time of the year while the new crops are not yet ready to be harvested.

The Chepangs gather wild tubers as staple food during these grain-deficit months. As shown in Table 7.4, the most commonly used tubers are *gittha*, *bhyakur*, and *tarul*, and these are collected during the months of Faagun to Jeth, the period exactly coinciding with the months reported to be the most grain-deficit. During these months, the little millet and other winter cereals harvested in Mangsir–Poosh are already depleted, while the new crop of maize is not yet ready to be consumed. Thus, the Chepangs are compelled to depend on wild tubers during these months. *Chiuri* fruits that mature in Jeth–Asaar also form a major supplementary diet during these months.

Gathering complements not only the staple diet of the Chepangs but also complements the green vegetables. As already stated, since the Chepangs grow very few vegetables, they mostly depend on various kinds of wild and uncultivated green vegetables such as *sisnoo*, *tanki*, *jaluko*, *niuro*, and *latte*. During the dry months of Faagun to Jeth, there is shortage not only of grains but also of green vegetables in the field of the Chepangs (see Table 7.2). Thus, during these months, the shortage of green vegetables is complemented from the wild sources. Wild green vegetables like *sisnoo*, *tanki*, *jaluko*, *niuro*, and *latte* can be gathered even during these dry months when there are no vegetables in the field. The vegetable deficit during winter months (Poosh–Maagh) is fulfilled by *sisnoo*, which can be gathered almost all the year round. Thus, gathering complements not only the grain shortage but also the vegetable shortage in the Chepang community. Thanks to these wild sources, green vegetables form a component of the Chepang diet all the year round (see also Bhattarai 2004; Gribnau et al. 1997). This complementary function of wild sources can be easily understood by comparing the cropping calendar in Table 7.2 and gathering calendar in Table 7.4.

Chiuri seed is another important component of wild edibles collected by the Chepangs. Butter is extracted from these seeds during Bhadau–Kartik, and is used as cooking oil, which is barely sufficient until the little amount of mustard that is grown by very few households is harvested in Maagh–Faagun. Once the stock of *chiuri* butter and mustard oil is over, vegetables are simply boiled in saltwater and eaten. The Chepangs usually buy oil from the market only during festivals when they have to cook meat.

Wild and uncultivated foods are important not only from the aspect of food security but also from the aspects of food diversity, and they undoubtedly contribute to the nutritional requirements for the Chepang community. A study shows that *gittha* and *bhyakur*, the major wild tuber consumed by the Chepangs, contain more crude fiber, crude protein, and crude fat compared to other cultivated yam species (Bhandari et al. 2003). The study further showed that these wild tubers are also important source of dietary minerals. Many wild foods consumed by the Chepangs also perform dual role of food as well as medicine. For instance, *chiuri* butter also has medicinal values for treating rheumatism, wounds, and dry skin.

7.4 Conclusion and Recommendations

The Chepang subsistence agriculture economy lies between scarcity and bare sufficiency. Rugged topography, stony lands, limited manures, and lack of irrigation facilities lead to lower productivity of the crops cultivated. Maize and millet are the two most important staple crops cultivated by the Chepangs. However, millet has received very little attention in the mainstream researches. Varietal improvement of millet to increase the yield even under limited fertilizer and water input would contribute to the food self-sufficiency of the Chepangs. The wild and uncultivated plant species strongly contribute to the subsistence livelihoods of the Chepangs. Wild tubers complement the grain-deficit during the dry periods when the stored food supply is dwindling, and the new harvests are not yet obtained. Beside staple foods, wild sources also contribute to the supply of green vegetables for the Chepang community. The Chepangs cultivate very limited green vegetables, and rather rely on wild sources such as *sisnoo*, *tanki*, *latte*, *jaluko*, and *niuro* which are hardier, and regenerate easily throughout the year, even during the dry seasons. Conservation and sustainable use of uncultivated foods have, however, received relatively little attention in development activities. Development agencies working with this community have put their effort only in promoting hybrid varieties of vegetables, which are more prone to pest and disease infestation, and do not give optimum yield in the absence of adequate inputs like chemical fertilizers, pesticides, and water. The Chepangs on the other hand are not in a position to supply all the necessary inputs, as a result of which the hybrid vegetables are on one hand giving lesser production while, on the other hand, displacing the more resistant local varieties, especially in the case of gourds and cucumber. Little emphasis has been made for the promotion of uncultivated species that are of importance to the Chepangs. Uncultivated plants remain important resources; therefore, updated inventories and information of these resources in terms of availability and use are essential. Some of these wild plants might have the potential to become valuable staple crops and important alternatives to the usual food crops cultivated by the Chepangs. There is a need to undertake action research-based projects in order to exploit the potential of these wild foods and examine the possibilities of domestication. Without the understanding of the importance of both staple food crops and wild uncultivated food crops, agricultural planning will continue to focus on a few major crops and exclude the diverse and important uncultivated food resources. For the Chepang people, who are subsisting their livelihoods by the combination of farming and gathering wild foods, losing one of the key components of their food, i.e., wild edible plants, would mean a major threat to their food security. It is thus important to understand how staple food crops and wild uncultivated food crops complement each other so as to maximize the food security of the Chepang community. This paper has its limitations in that it does not explore the dependence of the Chepang community on hunting and fishing. Future studies focusing on the contribution of wild fauna to the subsistence livelihoods of these people are highly recommended.

Appendix 7.1: Conversion Table for Nepali Months to English Months

Nepali months	English months	Nepali months	English months
1. Baisaakh	Mid-April to mid-May	7. Kartik	Mid-October to mid-November
2. Jeth	Mid-May to mid-June	8. Mangsir	Mid-November to mid-December
3. Asaar	Mid-June to mid-July	9. Poosh	Mid-December to mid-January
4. Shaun	Mid-July to mid-August	10. Maagh	Mid-January to mid-February
5. Bhadau	Mid-August to mid-September	11. Faagun	Mid-February to mid-March
6. Asoj	Mid-September to mid-October	12. Chait	Mid-March to mid-April

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Chapter 8
Sources of Livelihoods: A Portfolio

Abstract This chapter presents a detailed livelihood portfolio of the Chepang community. Eleven major sources of livelihood are identified. Agriculture is the mainstay of livelihoods for the majority of the households. Salaried job, skilled non-farm job, and remittances are more remunerative livelihood sources; however only a few households adopt these activities due to lack of education, assets, investment capital, and skills. Diversification is adopted as the livelihood strategy by almost all the households. The combination of farming, wage laboring, and forestry is the most dominant strategy despite its lower income. This implies that the households are constrained from adopting other remunerative options. Policies and development efforts should be aimed at improving farming, access to forest resources, and non-farm opportunities for sustainable livelihoods of the Chepangs.

Keywords Livelihood sources · Gross annual income · Remunerative sources · Diversification · Activity portfolio

8.1 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; Chambers 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 livelihood strategies that the marginalized rural households undertake (DFID 2003). Therefore, a thorough understanding of the diversified

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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 six sections. Concepts of livelihood strategy from various literatures will be highlighted in the sub-section following this paragraph. The second section focuses on the methodology. Review of related literatures has been done in the third section; findings of the study is presented in the fourth section, discussion is made in the fifth section and the sixth section concludes the chapter.

8.1.1 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 1998, 1999). 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 resource-based strategies include activities like non-skilled wage laboring like working as porters, in stone quarries, in road constructions, etc. and skilled non-farm jobs like tailoring, cooking in restaurants, carpet weaving, welding, 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 livelihood 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 the 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.

8.2 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 livelihood sources. All the questions in the household interviews were directed to receive information for the last one year. Information regarding the commonly adopted livelihood strategies by the community was also collected through participatory methods like key informants' interview and focus 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 1998, 1999). 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.

8.3 Literature Review

Agriculture forms the major livelihood sources for most of the rural population in Nepal (CBS 2003). 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 livelihood security compared to the other two types of livelihoods.

There are few studies that analyze the livelihood strategies of the Chepang community. FORWARD (2001a) reports that the Chepangs have adopted "multi-pronged livelihood strategies" encompassing permanent agriculture and animal husbandry, slash-and-burn cultivation (*khoriya*), wage labor, hunting and gathering practices, cottage industries, and barter system. This study emphasizes that the 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 (Piya 2009; FORWARD 2001a, b; 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 (2001a) 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 the 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 Shaktikhor VDC of Chitwan district, it was found that the 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. The same study reports that field crops provide 24% of annual cash income for the Chepang households, while livestock, forest, and wage laboring, respectively, generate about 38%, 15%, and 14% of their annual cash income. This chapter will contribute to dearth of existing literatures on livelihood studies of the Chepang community by conducting an in-depth livelihood study reporting the households involved in each livelihood sources. Similarly, this chapter assesses the contribution of each source to annual income of the households and analyzes the combination of the livelihood sources undertaken by the Chepang households.

8.4 Findings

8.4.1 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 1 year, plus cash income earned from fruits, and medicinal and aromatic plants 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 in the village. Common wage laboring works include working in stone quarries, limestone mines, and road construction, carrying loads, 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, wild fruits, fodder, firewood, 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 and domesticated leafy vegetables like broad-leaved mustard for wild leafy vegetables.

Salaried job comprises of monthly paid jobs like 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, shoemaking, 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 homemade 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 and self-consumed amount were included in the calculations. Final source is the income from bamboo and wooden handicrafts like baskets and plow 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 8.1 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. The 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

Table 8.1 Gross annual income per household (NRs.[a]) from different sources

	Gross annual income/HH (NRs.) (*n* = 221)		
Source	Number of HHs	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 of data: Field survey 2010
Note: Figures in parenthesis indicate percentage
[a]NRs. = Nepali rupees; 73 NRs. = US$ 1 (at the time of field survey)

Table 8.2 Gross annual income per household (NRs.) according to the primary source

Primary source of income	Number of HHs	Gross annual income/HH (NRs.) ($n = 221$)	
		Mean	SD
Agriculture	96 (43.44)	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 of data: Field survey 2010
Note: Figures in parenthesis indicate percentage

salaried job and skilled non-farm job. The remaining income sources, i.e., business, government transfers, honey, and handicraft, are also pursued 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 8.2, 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 as shown in Table 8.1, it forms the primary source for very few households (4.52% and 2.71%) (see Table 8.2). 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.

8.4.2 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 8.3, 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 (see Table 10.6 in Chap. 10), which is why they can easily dispose their products to the nearby markets in Hugdi,

Table 8.3 Spatial variations in gross annual income per household (NRs.) from various sources

Source	Gross annual income/HH (NRs.)								P-value
	Kaule ($n = 58$)		Kankada ($n = 56$)		Mahadevsthan ($n = 54$)		Bhumlichowk ($n = 53$)		
	Number of HHs	Mean	Number of HHs	Mean	Number of HHs	Mean	Number of HHs	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	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)	67,744.0	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 of data: Field survey 2010
Note: Figures in parenthesis indicate percentage
***, **, * denote significant at 1%, 5%, and 10% level of significance, respectively

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 (see details in Appendix 8.1). Besides, other VDCs lie far away from the roadhead; 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 8.2), 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. The 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.

8.4.3 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 the eleven 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 were kept under one category as "remunerative sources" as they gave higher returns; honey, handicrafts, and allowances were grouped together as "others" because they are less significant as adopted by fewer households and earn lesser income.

Table 8.4 Gross annual income per household (NRs.) according to livelihood strategies

Livelihoods activity portfolio	Number of HHs	Gross annual income/HH (NRs.) ($n = 221$)	
		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	18,700.0
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 of data: Field survey 2010
Note: Figures in parenthesis indicate percentage

Thus, altogether six different categories of 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 8.4. 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 subsequently increases with the combination of more number of livelihood sources. Overall, the lowest income is NRs. 32,790.5 for the combination farming alone, and the highest is NRs. 168,905.3 for the combination of all six livelihood sources. From Table 8.4, 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 adopted by 29.4% 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 the Chepang community. During the dry seasons, when there are few agricultural activities in the village, the Chepangs undertake wage laboring to fulfill the consumption needs, for which the male members temporarily migrate outside the village for jobs like carrying loads, working in stone quarries, and road constructions. The Chepangs depend on forest for collection of fodder, litter, fuel, and commercial products. Apart from that, as discussed in the previous chapter, 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 the Chepang households are 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 schooling 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 (see Appendix 8.2). 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 8.1). 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 (see Table 10.6 in Chap. 10). 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 the Chepangs. However, most of the households belong to small-holders' category owning less than five livestock units, so that they rarely make extra income that can be saved or used for further investments. The livelihoods of the 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, and 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.

8.5 Discussion

Agriculture is the mainstay of the livelihood of the Chepangs. Livestock, wage laboring, forestry, salaried jobs, skilled non-farm jobs, remittance, petty business, honey and handicrafts are the other livelihood sources for this community beside agriculture. 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 involves temporary outmigration 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 (2001a); 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 contributes 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 (see Appendix 8.3).

In terms of primary sources of income, agriculture forms the 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 have 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 29.4% of the households; however, income from this combination is lower than other combinations having remunerative sources as a component. Thus, the majority of the Chepang households are 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.

8.6 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 the 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 livelihoods of the Chepang community.

Appendices

Appendix 8.1: Average Landholding of the Sample Households by Land Category (in **Kattha**[a]*)*

Land category	Aggregate (*n* = 221)		Kaule (*n* = 58)		Kankada (*n* = 56)		Mahadevsthan (*n* = 54)		Bhumlichowk (*n* = 53)	
	Number of HHs	Area/HH	Number of HHs	Area/HH	Number of HHs	Area/HH	Number of HHs	Area/HH	Number of HHs	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 of data: Field survey 2010
Note: Figures in parenthesis indicate percentage [a]1 *kattha* = 0.033 hectare

Appendix 8.2: 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[a]	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[b])	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 of data: Field Survey 2010
Note: Figures in parenthesis indicate percentage
[a]Household Head [b]Livestock Standard Unit (LSU) is the aggregate of different types of livestock 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 (CBS 2003; Baral 2005)

Appendix 8.3: 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 of data: Field survey 2010

Note: Figures in parenthesis indicate standard deviation

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

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Chapter 9
Climate Change: Perceptions and the Determinants

Abstract The community perceptions are compared with the actual trends of temperature and rainfall recorded in the nearest meteorological stations. Spatial clustering of those perceptions is tested using Global Moran's I test. A probit model is used to analyze the characteristics that differentiate the respondents who correctly perceive the changes from those who do not. Access to information and extension services facilitate perceptions of temperature and rainfall changes. Cultivation of cash crops also facilitates perceptions of rainfall. On the other hand, formal education and engagement in non-farm income sources reduce the ability to perceive the changes. In the case of temperature, farming experience alone is not sufficient to perceive the ongoing changes. Priority must be placed on the dissemination of relevant information to the community and updating the educational curriculum.

Keywords Perception · Temperature and rainfall trend · Global Moran's I test · Probit

9.1 Introduction

Changes in climate are 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 2007). No doubt, these studies have contributed immensely to understand the biophysical 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

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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 the perceptions of changing temperature and rainfall patterns in the study area and triangulates the perceptions with the 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.

9.2 Sources of Data

This study is based on the primary data collected from group discussions in the first phase of field visits and from the household surveys conducted in both the phases. The first phase of the 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), livelihood activities, and income sources 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 information on general perceptions of climate change and locally observed indicators. Based on the information from these group discussions, interview schedule was designed and follow-up field visit was again made in May–June 2011. Questions focused on the individual perceptions of climate change included in the follow-up survey are used for analysis in this chapter. While assessing the perceptions of the households regarding the changes in climatic variables and the occurrence of extreme climatic events, the time frame of past 10 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

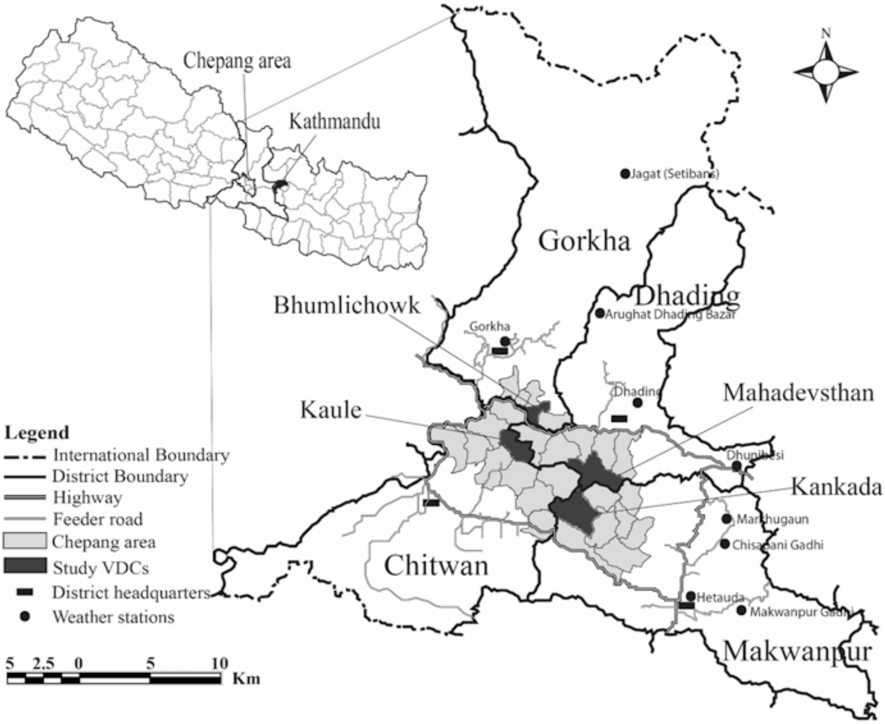

Fig. 9.1 Map of study districts showing Chepang area, study VDCs, and weather stations considered for this chapter

temperature, and precipitation (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-setibas, Gorkha). The locations of these weather stations within the respective districts are shown in Fig. 9.1.

The altitude, latitude, and longitude of these weather stations are given in Table 9.1. 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 9.1 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	Chisapanigadhi	1,707	27.55	85.13	Precipitation (rainfall) (1970–2008)
	Hetauda	474	27.42	85.05	Precipitation (rainfall) (1966–2008)
					Temperature (1966–2008)
	Markhugaun	1,530	27.62	85.15	Precipitation (rainfall) (1972–2008)
	Makwanpurgadhi	1,030	27.42	85.17	Precipitation (rainfall) (1975–2008)
Dhading	Arughat Dhading Bazar	518	28.05	84.82	Precipitation (rainfall) (1971–2008)
	Dhading	1,420	27.87	84.93	Precipitation (rainfall) (1970–2008)
	Dhunibeshi	1,085	27.72	85.18	Precipitation (rainfall) (1971–2008)
					Temperature (1975–2008)
Gorkha	Jagat (Setibas)	1,334	28.37	84.90	Precipitation (rainfall) (1971–2008)
	Gorkha	1,097	28.00	84.62	Precipitation (rainfall) (1971–2008)
					Temperature (1971–2008)

Source of data: [a]Raw data from DHM

9.3 Triangulation of Perceptions with the 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 9.2). 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.

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 commu-

Table 9.2 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 of data: Field survey 2011
Note: Figures in parenthesis indicate percentage

nity 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 10 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.

9.3.1 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 9.3.

Table 9.3 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 of data: 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.

The recorded summer temperature trend is shown in Fig. 9.2. 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.

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

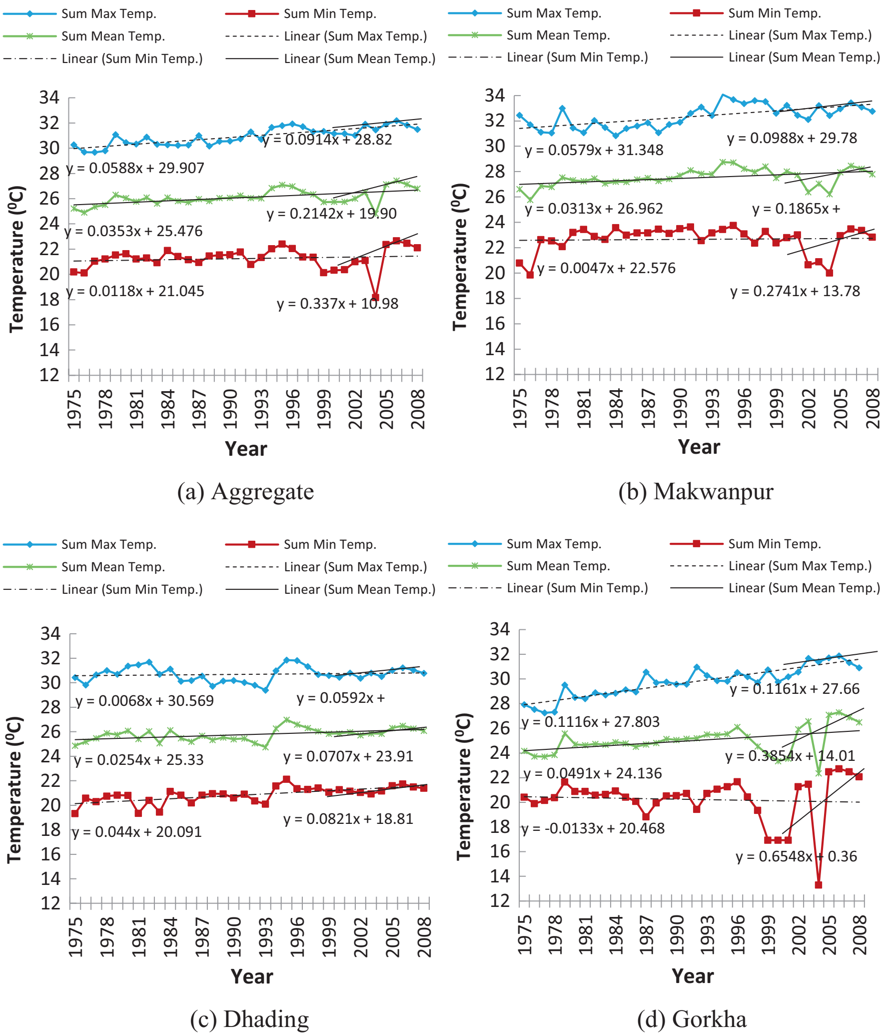

Fig. 9.2 Average summer temperature trend (May–August) for the selected stations. (**a**) Aggregate, (**b**) Makwanpur, (**c**) Dhading, and (**d**) Gorkha
Source of data: Raw data from DHM

minimum winter temperature falling for Gorkha district (Fig. 9.3). 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

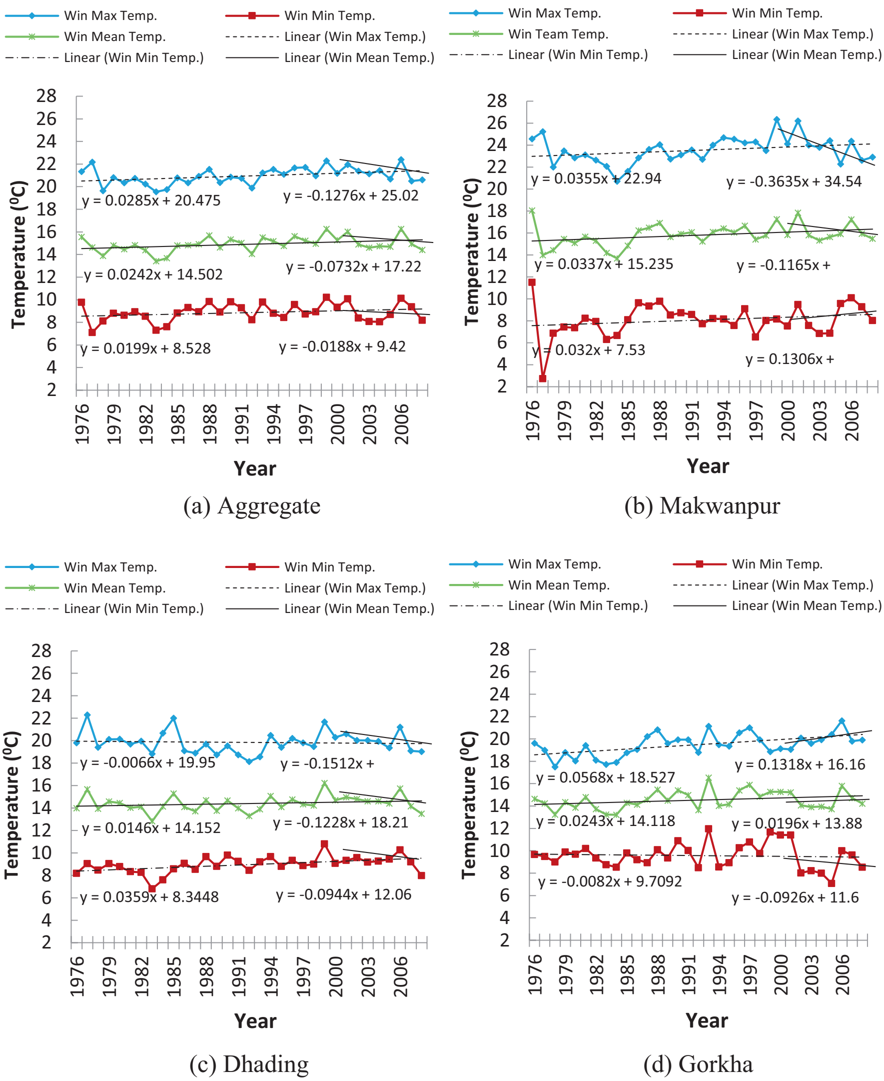

Fig. 9.3 Average winter temperature trend (December–February) for the selected stations. (**a**) Aggregate, (**b**) Makwanpur, (**c**) Dhading, and (**d**) Gorkha
Source of data: Raw data from DHM

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 10 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.

9.3.2 Changes in Rainfall: Perceptions and Actual Trends

9.3.2.1 Perceptions of Changes in Annual Rainfall

Perception of rainfall was asked to the respondents in terms of rainfall quantity as well as timings (Table 9.4). 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 have 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.

Table 9.4 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 of data: Field survey 2011
Note: Figures in parenthesis indicate percentage
Percentage may not add up to 100 due to multiple answers

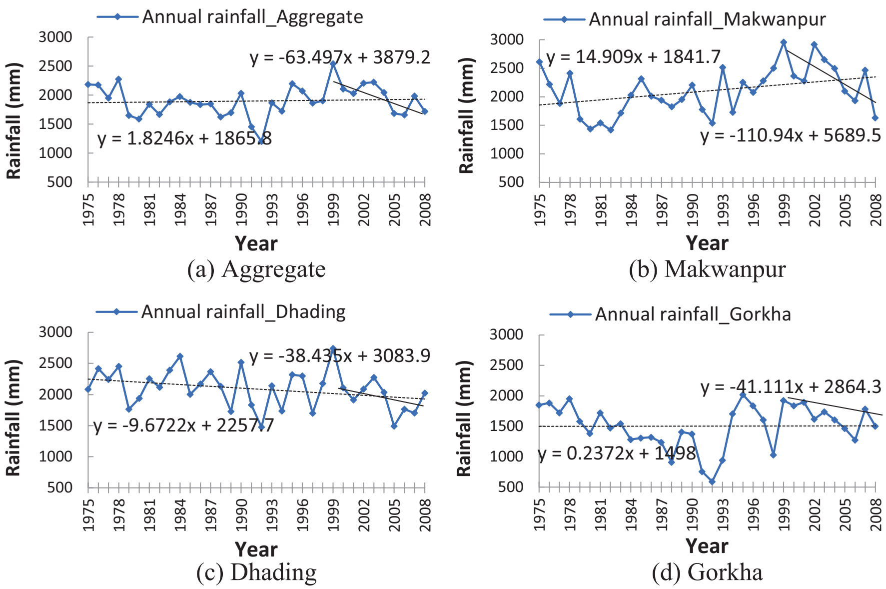

Fig. 9.4 Total annual rainfall averaged for the selected stations. (**a**) Aggregate, (**b**) Makwanpur, (**c**) Dhading, and (**d**) Gorkha
Source of data: Raw data from DHM

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%–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.

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 Fig. 9.4. Rainfall patterns show that the interannual variations are very large for all the districts, thereby making the rainfall pattern quite unpredictable. The rainfall trend for overall Nepal also shows large interannual 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 different 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.

9.3.2.2 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 have important implications for the 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 9.5).

Trend analysis done in Fig. 9.5 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 the fastest in Gorkha district. The results show that, keeping aside those respondents who did

Table 9.5 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 of data: Field survey 2011
Note: Figures in parenthesis indicate percentage

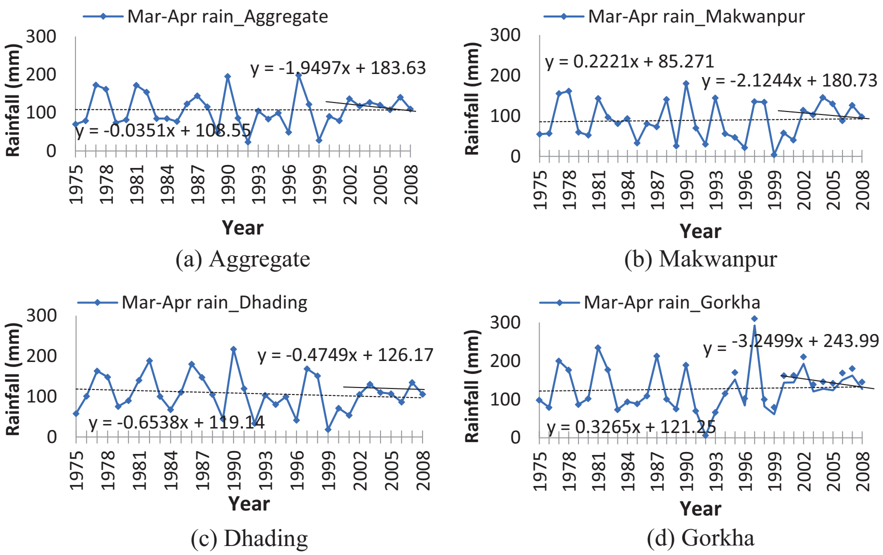

Fig. 9.5 Total post-winter rainfall (March–April) averaged for the selected stations. (**a**) Aggregate, (**b**) Makwanpur, (**c**) Dhading, (**d**) Gorkha
Source of data: Raw data from DHM

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.

The annual rainfall pattern in Nepal is dominated by monsoon, with nearly 80% of the total rainfall 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 phases in terms of water demand. Similarly, monsoon rain also coincides with transplantation of millet and paddy. Table 9.6 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

Table 9.6 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 of data: Field survey 2011
Note: Figures in parenthesis indicate percentage
Percentage may not add up to 100 due to multiple answers

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.

Trend analysis of monsoon rainfall is given in Fig. 9.6. 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 shows decreasing trend for all the districts, the rate being the fastest for Makwanpur.

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 9.7.

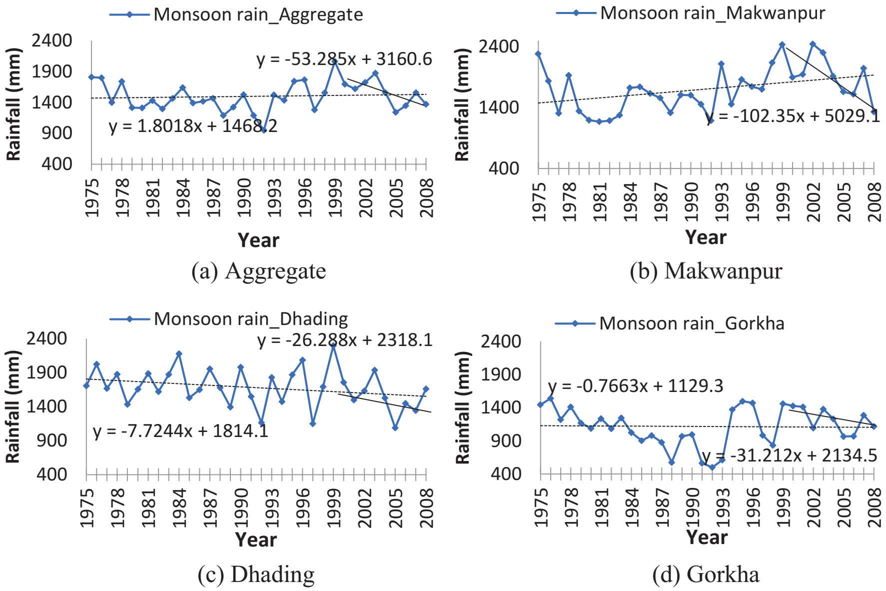

Fig. 9.6 Total monsoon rainfall trend (June–September) averaged for the selected stations. (**a**) Aggregate, (**b**) Makwanpur, (**c**) Dhading, and (**d**) Gorkha
Source of data: Raw data from DHM

Table 9.7 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 of data: 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 (Fig. 9.7). 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.

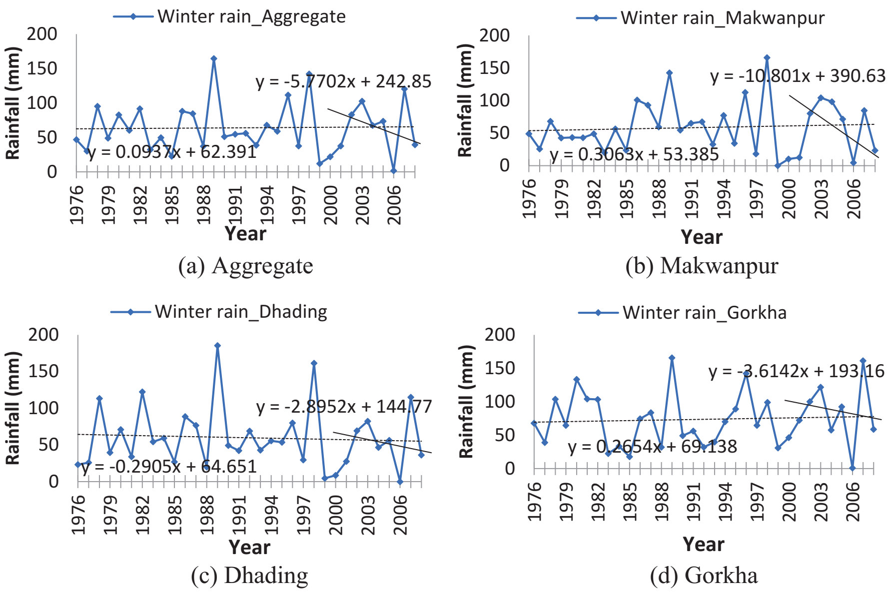

Fig. 9.7 Total winter rainfall trend (December–February) averaged for the selected stations. (**a**) Aggregate, (**b**) Makwanpur, (**c**) Dhading, and (**d**) Gorkha
Source of data: Raw data from DHM

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.

9.4 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 are 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 Global 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 are 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 9.8. 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.

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 show that response of early monsoon, less rainfall in monsoon, damaging rainfall in monsoon, and unpredictable timing of monsoon each shows a significantly clustering pattern. At the same time, 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 the Chepangs, winter is an off-season for agriculture, thus they do not follow the patterns of winter rainfall that closely.

Table 9.8 Global Moran's I test for spatial autocorrelation of perceptions of temperature and rainfall

Perceptions	Global 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

9.5 Analysis of the Factors that Facilitate Perceptions Using Binomial Probit Model

9.5.1 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 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.

$$z_i = x_i\beta + u_i, i = 1,\ldots,n \tag{9.1}$$

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

$$y_i = \begin{cases} 1 \, if \; z_i > 0 \\ 0 \, if \; z_i \leq 0 \end{cases} \tag{9.2}$$

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

$$P\left(y_i = 1 \mid x_i\right) = \Phi\left(x_i\beta\right) \tag{9.3}$$

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

$$\Phi\left(z\right) \equiv \int_{-\infty}^{z} \varnothing\left(v\right) dv \tag{9.4}$$

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

$$\varnothing\left(v\right) = \left(2\pi\right)^{-1/2} \exp\left(\frac{-v^2}{2}\right) \tag{9.5}$$

The choice of standard normal cumulative distribution function, Φ(.), ensures that Eq. (9.3) 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

$$ME = \frac{\partial P\left(y_i = 1\right)}{\partial x_i} = \frac{\partial \Phi\left(x_i\beta\right)}{\partial x_i} = \Phi'\left(x_i\beta\right)\beta_j \tag{9.6}$$

Because $\Phi(.)$ 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.

9.5.2 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 9.9. 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 10 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 9.9 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**[b]	**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 group(s)	Dummy; 1 = yes, 0 = no	0.65 (0.48)	+
Participate in training(s)	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)	−

Sources of data: [a]Field survey 2011; [b]Field survey 2010
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 NGOs[1] 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 providing 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 training(s) 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.

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 9.9 shows that farming (comprising of both

[1]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).

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 farmers 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, black gram, horse gram) 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 comprise of only 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 the total income.

9.5.3 *Results of the Binomial Probit Model for the Determinants of Perceptions*

The results of the probit model are presented in Table 9.10. 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%.

Table 9.10 Estimates from the probit models to analyze perceptions

	Perceive hotter summer and/or colder winter		Perceive decreasing rainfall	
Independent variables	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 group(s)	0.1627	0.013**	0.1178	0.095*
Participation in training(s)	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

The estimates are presented in terms of marginal effects. The positive sign of the estimates denotes that the factor enables perceptions in the right direction, while negative sign denotes that the particular factor does not enable perceptions in the right direction. The coefficient estimates of the models are given in Appendix 9.1.

For the temperature model, interestingly, only four variables, viz., gender, ownership of radio, membership in group(s), and participation in training(s), 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 group(s) 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, this information is 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.

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 are very important for such households. This shows that those households who are dominantly dependent on agriculture and livestock for their livelihoods follow the rainfall 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 than 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, farmers who cultivate cash crops are those who have received related training(s) from the NGOs, thus they are better informed about these phenomena. Results in Table 9.10 show that if the households depend more on non-farm sources like salaried jobs (teaching), skilled jobs (carpenter, cook, carpet weaving), and wage laboring (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) whereby 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 broadcasts, while females are more involved in household chores and thus rarely find time to listen. 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 rainfall and is significant for temperature. The implications here are twofold: firstly, with higher education, the probability of pursuing non-farm jobs increases, thereby paying lesser attention to climate; secondly the curriculum in the schools does 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.

9.6 Conclusion and Policy Implications

The trend analysis of temperature and rainfall for both long term and short term provide 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 demonstrate 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 meteorological 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 CBOs to obtain readings from rain gauge and thermometers would not only make it possible to generate data sets 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.

Appendix 9.1 Coefficients from the Probit Models of Perception Analysis

	Perceive hotter summer and/or colder winter		Perceive decreasing rainfall	
Independent variables	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 group(s)	0.4835	0.019**	0.3231	0.105*
Participation in training(s)	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

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Chapter 10
Community Vulnerability to Climate Change

Abstract The vulnerability analysis in this chapter is based on indices constructed from selected indicators measuring exposure, sensitivity, and adaptive capacity. The indicators were weighted using principal component analysis. Inter-village analysis of the vulnerability index indicated that exposure in a locality is modified by the inherent adaptive capacity of the households, and this determines overall vulnerability. Inter-household analysis of vulnerability indicated that poor households with low adaptive capacity were vulnerable irrespective of their location. The availability of non-farm livelihood opportunities and community access to formal/vocational education and skill development training will reduce household vulnerability to climate change. Policy interventions should focus on improving the adaptive capacity of households, prioritizing financial and human assets.

Keywords Exposure · Sensitivity · Adaptive capacity · Principal component analysis · Quartiles

10.1 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 2007). 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). It is ranked the 14th most vulnerable country in the climate risk index (Kreft and Eckstein 2013). Nepal is already a country vulnerable to natural disasters particularly floods and landslides. With an increased intensity in monsoon rain, the risk of flash flooding, erosion, and landslides will be increased. The adverse impacts of climate change and extreme events

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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. There are very few studies into vulnerability analysis in Nepal at the national/regional level (MoE 2010) or at the household level (Ghimire et al. 2010). 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 subsection hereunder deals with the conceptualization of vulnerability based on literatures. 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.

10.1.1 Conceptualizing Vulnerability to Climate Change

The concept of vulnerability has undergone several transformations over the past decade. The IPCC Second Assessment Report (SAR) 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). The TAR refined the 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" (McCarthy et al. 2001, p 6). The AR4 contained this same definition. In the AR5, the IPCC defined vulnerability as "the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (Oppenheimer et al. 2014, p 1048).

The SAR views vulnerability as the "endpoint" of a sequence of analyses. It starts with projections of future climate trends, development of possible climate scenarios, study of the biophysical impacts of such climate changes, and identification of adaptive options. Any residual consequences that remain after the implementation of adaptation measures define the vulnerability (Kelly and Adger 2000). Such analysis centers around hazards, focusing on biophysical drivers such as temperature and precipitation. It relies on projections from biophysical models, which contain many uncertainties (Nelson et al. 2010a). In the recent years, studies on climate change emphasize that vulnerability is not only defined by hazards but also by the emergent property of human-environmental systems that enable people to cope with changes, thereby linking vulnerability to adaptive capacity (Vincent 2004; Adger 1999; Adger and Kelly 1999). This approach puts vulnerability at the "starting point" of analysis – a state that exists within a system before it encounters a hazard. Such differences in approach have led to the terms "biophysical" versus "social" vulnerability (Brooks 2003). The IPCC definitions over the years reflect the shift of emphasis from biophysical to social dimensions of vulnerability. This chapter integrates both dimensions to provide a holistic vulnerability analysis.

The AR5 also makes a distinction between "contextual" (starting point) and "outcome" (endpoint) vulnerability. Contextual vulnerability is defined as a present inability to cope with external pressures or changes, such as changing climate conditions. It is a characteristic of social and ecological systems generated by multiple factors and processes (O'Brien et al. 2007 cited in IPCC 2014). The definition of outcome vulnerability given by AR5 is the same as that stated earlier in the paper.

The endpoint approach is often criticized for assuming humans as passive receivers of hazards and failing to account for the human-environmental interactions to cope with such hazards (Vincent 2004). The starting point approach recognizes that physical phenomena are mediated by a particular human context in which they occur. While biophysical studies are important to understand the biophysics of climate change, they have less influence on the policy-making process since variables such as temperature and precipitation are not under the control of policy-makers. Studies on social vulnerability are more relevant as they focus on the drivers of current adaptive capacity such as poverty and access to resources.

Theoretically, social and biophysical approaches represent two divergent schools of thought. However, social vulnerability assessments need to take hazards into consideration since vulnerability is always hazard-specific. Accordingly, some studies have used an integrated approach for vulnerability assessments, combining social vulnerability (adaptive capacity) with biophysical vulnerability (exposure and sensitivity) (Nelson et al. 2010b; Gbetibouo and Ringler 2009). This study takes an integrated approach and uses a combination of biophysical and socio-economic indicators to formulate the vulnerability index.

10.2 Methodology

10.2.1 Sources of Data

The 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 the 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 toward 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 monthly minimum and maximum temperature and rainfall data obtained from DHM in Kathmandu, Nepal, for the time period of 32 years, from 1977 to 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 were interpolated for each year from the weather stations using the latitude-longitude information of each household by ordinary kriging method in ArcGIS 10 (ESRI, www.esri.com/).

10.2.2 Choosing the Vulnerability Indicators

Vulnerability to climate change is multidimensional and is determined by a complex interrelationship 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. The choice of indicators is crucial because inappropriate indicators lead to the construction of an invalid index. The chosen indicators represent the locational specificity of the study sites. The representativeness of the selected indicators was verified through insights from focus group discussion. Following the definition of vulnerability given by the IPCC in the SAR, vulnerability is considered a function of exposure, sensitivity, and adaptive capacity.

10.2.2.1 Exposure

Following O'Brien et al. (2004, p 305), exposure is represented as "either long-term changes in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events." This definition includes climate change and extreme events, which forms the central focus of our study. Historical changes in climate variables and the frequency[1] of extreme climatic events are considered indicators of exposure (Table 10.1). The coefficient of the trends of climate variables (minimum-maximum temperature and precipitation) for the period

Table 10.1 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	+

[1] The magnitude of extreme climate events can be measured by the losses caused by those events. Because the magnitude of losses is accounted for by the indicators of sensitivity, only frequency has been considered under exposure to avoid duplication in the calculation of overall vulnerability.

1977–2008 was calculated separately for each sample household through interpolation as described earlier. Floods/landslides, droughts, and hailstorms were the most commonly occurring natural disasters in the study area. The frequency of occurrences of these disasters for the last 10 years was obtained for each household from the survey (Appendix 10.1). These indicators identify exposure of the community as a whole and can be applicable across multiples sectors. Historical data was used to account for exposure. While future projections of climate give important information on future exposure, such modeling demands rich data sets on climate variables, which are very limited in Nepal. Thus, the results obtained from model-based future projections would be questionable. Therefore, using available historical data sets was a more reliable option. It was hypothesized that the higher the rate of change of the climate variables and the higher the frequency of natural disasters, the higher was the exposure of the households to climate change and extremes.

10.2.2.2 Sensitivity

Sensitivity is measured by the "degree to which a system is modified or affected by an internal or external disturbance or set of disturbances" (Gallopin 2003, p 4). This approach to sensitivity considers the cumulative impacts of past climate hazards on livelihoods as a proxy for future sensitivity as the households facing higher impacts are the ones which will be more sensitive in the future. Death of family members and loss of property (viz., land measured in *kattha*,[2] livestock in livestock standard units (LSU),[3] and crops valued in Nepali rupees (NRs.)[4]) due to climate-related disasters over the last 10 years represent sensitivity for the purpose of this study (Table 10.2).

It is hypothesized that higher impacts of past climatic disasters increase the sensitivity of households. Income structure also determines a household's sensitivity. A higher share of natural resource-based income will increase a household's sensitivity as these sources are more dependent on climate, while a higher share of non-natural resource-based remunerative income sources will reduce sensitivity. Salaried jobs, remittances, and skilled non-farm jobs are categorized as remunerative sources because the return from these sources is comparatively high and consistent compared with other sources. A detailed breakdown of the share of various income sources is given in Appendix 8.3 (in Chap. 8).

[2] 1 *kattha* = 0.033 hectare.

[3] LSU is the aggregate of different types of livestock 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 (CBS 2003; Baral 2005).

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

Table 10.2 Indicators for sensitivity

Component indicators	Description of the indicators	Unit	Hypothesized relation
Fatalities	Death of family members due to climate-related disasters (floods, landslides) over the last 10 years	Number	+
Loss of properties	Total land damaged by flood/landslides over the last 10 years	Area in *kattha*	+
	Total livestock death due to flood/landslides/drought/hail over the last 10 years	LSU	+
	Total crop damage due to flood/landslides/drought/hail over the last 10 years	Value in NRs.	+
Income structure	The share of natural resource-based income (agriculture, livestock, forest, honey, and handicraft) to total income	%	+
	Share of non-natural resource-based remunerative income (salaried job, remittance, skilled non-farm job) to total income	%	−

10.2.2.3 Adaptive Capacity

The selection of indicators for adaptive capacity is based on the Department for International Development sustainable livelihoods framework (DFID 1999). DFID views livelihood outcomes as a function of the ownership or access to livelihood assets, whereby households with a sufficient range of assets have more adaptation strategies for coping with adversity. Diversified assets allow for substitution among the assets to switch from one livelihood activity to another at times. In the framework, adaptive capacity is considered a function of the household's possession of five types of asset: physical, human, natural, financial, and social. The indicators for physical assets were type of house, ownership of mobile phone/radio, walking distance to the nearest motor road, and irrigated land (Table 10.3). The ownership of a mobile phone/radio increases adaptive capacity through access to weather-related information. Walking distance to the nearest motor road is assumed to be inversely related to adaptive capacity as households located far from roads will be at a disadvantage for reasons such as lack of opportunity for income generation due to lack of markets or inability to access service centers such as hospitals at a time of emergency.

Human assets are represented by the highest qualification in the family, dependency ratio, and training(s) or vocational course(s) attended by the family members. Formal education and skill development training enable family members to undertake skilled non-farm activities, which are more remunerative and less climate-sensitive.

The quality of the land possessed by households is taken as an indicator of natural assets. The Chepangs possess three categories of land. Low-lying paddy land (*khet*) is the most productive category of their land and usually has an irrigation source. *Bari* is terraced upland, which may or may not be irrigated and is less productive than *khet*. *Khoriya*, which are unterraced sloping land plots in the hills, are

Table 10.3 Indicators for adaptive capacity

Component indicators	Description of the indicators	Unit	Hypothesized relation
Physical assets	House type (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 device to access information (mobile, radio) (0 = no, 1 = yes)	Ordinal value	+
	Walking distance to the nearest motor road	Hours	−
	Irrigated land	% of total	+
Human assets	Highest qualification in the family	Number of schooling years	+
	Dependency ratio	–	−
	Training(s) or vocational course(s) attended by family members	Number	+
Natural assets	Share of 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 per capita	NRs.	+
	Livelihood diversification index (LDI)	–	+
	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	+

the least productive category. A higher share of more productive land (*khet* and *bari*) means a higher adaptive capacity, while a higher share of *khoriya* indicates the opposite. The possession of bullocks, which are the only means of plowing fields in the hills, is another indicator of natural assets.

Under financial assets, the gross household annual income per capita, livelihood diversification index (LDI), household savings, and ownership of small livestock are taken as indicators. For the Chepangs, small livestock are an important source of cash income and are kept as buffer for times of financial stress or to pay back loans borrowed from moneylenders. A higher value of LDI indicates better risk management due to the ability of the household to switch among livelihood activities as required. The Herfindahl index of diversification was used (Kimenju and Tschirley 2009), calculated as:

$$D_k = 1 - \sum_{i=1}^{N} \left(S_{i,k}\right)^2, \tag{10.1}$$

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 contribution of i^{th} activity to the total household income for the k^{th} household. For this study, 11 different livelihood activities were identified (described earlier in Chap. 8).

Finally, social assets are represented by memberships of formal CBOs and access to credit. Membership in CBOs helps households to improve their social networks and also gives them access to new information during the meetings and through contact with outsiders. Access to credit is also taken as a social asset because, for the Chepangs, taking loans from social contacts is one of the most important strategies to cope with seasonal food shortages.

10.2.3 Calculation of the Vulnerability Index

Having chosen suitable indicators, the normalized value was calculated to bring the values of the indicators within the range of 0–1 so that they were directly comparable.

$$Normalized\ value = \frac{Observed\ Value - Mean}{Standard\ Deviation}. \tag{10.2}$$

Next, weights were assigned to the indicators. Some research follows equal weighting (Nelson et al. 2005; Vincent 2004). However, this is somewhat arbitrary and may lead to overweighting of less important indicators and underweighting of more important ones. Weighting can also be based on expert judgment (Vincent 2007; Adger and Vincent 2005). However, this approach is often criticized for being too subjective and for being constrained by limited availability of or lack of consensus among subject matter specialists (Gbetibouo and Ringler 2009). A preferable method is assigning weights to indicators through principal component analysis (PCA[5]), which is based on statistical procedures as opposed to subjective

[5] PCA is a method of deriving a smaller number of orthogonal linear combinations of variables from a larger set of variables such that the information in the original set is retained as much as possible. The first principal component refers to the linear index of all variables retaining the largest amount of information common to the variables. For a mathematical explanation of PCA, see Filmer and Pritchett (2001).

judgments. The empirical validity of using the first principal components as weights for indicators is demonstrated by Filmer and Pritchett (2001) using multiple data sets and shows the internal and external coherence of an index created by PCA weightage. This method has been adopted by various studies (Nelson et al. 2010b; Gbetibouo and Ringler 2009; Cutter et al. 2003) to assign weights to different types of variables (binary, discrete, or continuous). PCA was run for the selected indicators of exposure, sensitivity, and adaptive capacity separately in STATA10 (StataCorp, www.stata.com) to calculate weights. The weights varied between −1 and +1; the sign denoting the direction of relationship of that indicator with other indicators used to construct the respective index. The magnitude of the weights describes the contribution of each indicator to the index value.

Stepwise PCA was run for the indicators of adaptive capacity. The first-step PCA was run for the indicators of each asset category separately to observe their relative importance within each category. The weights obtained from first-step PCA were used to calculate subindices for each asset type. The second-step PCA was run using the subindex values for the five asset types to analyze which asset group contributed the most to adaptive capacity. The overall adaptive capacity index was calculated using the weights obtained from second-step PCA.

The normalized variables were then multiplied by the assigned weights to construct separate indices for exposure, sensitivity, and adaptive capacity, as follows:

$$I_j = \sum_{i=1}^{k} b_i \left[\frac{a_{ji} - x_i}{s_i} \right], \tag{10.3}$$

where I_j is the index value for j^{th} household, b_i is the loading from first component of PCA (PCA1) taken as the weight for indicator *i*, a_{ji} is the value of indicator *i* for j^{th} household, x_i is the mean value of indicator *i*, and s_i is the standard deviation of the indicator *i*.

Finally, a vulnerability index (V) for each household was calculated as:

$$V = Exposure + Sensitivity - Adaptive\,capacity. \tag{10.4}$$

The overall vulnerability index facilitated inter-VDC comparison as well as inter-household comparison. A high value of the vulnerability index indicates higher vulnerability. However, a negative value of the index does not imply that the household is not at all vulnerable. This index does not give an absolute measurement of vulnerability but a comparative ranking among the sampled households or study VDCs. Analysis of variance (ANOVA) was conducted to compare the means among the four study sites as well as the four vulnerability quartiles.

10.3 Results and Discussion

The weights obtained from the PCA analysis are given in Table 10.4, 10.5, and 10.6 for the indicators of exposure, sensitivity, and adaptive capacity, respectively, along with the mean values of indicators across the four study sites.

The weights for the indicators of exposure are all positive as hypothesized except for the maximum temperature trends. The absolute values of the weights reveal that minimum and maximum temperature trends contribute more to the exposure index than precipitation trends and natural disasters. Both minimum and maximum temperature coefficients show a slowly increasing trend for all the study VDCs. Precipitation also show an increasing trend, with the rate for Kaule being significantly higher compared with the other three VDCs. The number of natural disasters over the last 10 years is the highest for Mahadevsthan followed by Bhumlichowk.

The indicators of sensitivity contribute to the sensitivity index in the direction hypothesized (Table 10.5). The impacts of natural disasters on livelihood are seen to have more influence on the overall sensitivity index than income structure. A negative weight indicates that a higher share of remunerative income assists in decreasing the overall household sensitivity. A higher share of natural resource-based income makes the household more sensitive to climate change and extremes. The number of natural disasters is the lowest, but the damage caused is the highest in Kankada, for all the sensitivity indicators (Compare Tables 10.4 and 10.5). This is related to higher incidences of intensive rainfall over the last decade, which caused more landslides in the area. The 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 10.1). The higher share of natural resource-based income in all the study VDCs shows that the Chepang livelihoods are predominantly based on natural resources, notably agriculture, livestock, and forestry (Appendix 8.3 in Chap. 8).

The weights from the first- and second-step PCAs, for indicators and subindices of adaptive capacity, are given in Tables 10.6 and 10.7, respectively, along with the

Table 10.4 Weights and VDC-wide 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[a]	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[a]	−0.59	0.03 (0.00)	0.03 (0.00)	0.04 (0.00)	0.04 (0.00)	0.03 (0.00)	0.00***
Precipitation[a]	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[b]	0.09	2.65 (1.18)	2.66 (1.43)	2.05 (0.92)	3.00 (1.05)	2.92 (1.00)	0.00***

Sources of data: [a]Raw data from DHM; [b]Field Survey 2011
Note: Figures in parenthesis indicate standard deviation
*** indicates significant at 1% level of significance

Table 10.5 Weights and VDC-wide 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[a]	0.52	0.09 (0.91)	0.00 (0)	0.36 (1.79)	0.00 (0)	0.00 (0)	0.09*
Land affected[a]	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[a]	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[a]	0.53	17,958.5 (32,521.7)	6,628.8 (7549.5)	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[b]	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[b]	−0.06	11.21 (21.20)	9.56 (18.50)	14.60 (23.91)	10.67 (23.16)	9.99 (18.93)	0.57

Sources of data: [a]Field Survey 2011; [b]Field Survey 2010
Note: Figures in parenthesis indicate standard deviation
***, **, *indicates significant at 1%, 5%, and 10% level of significance, respectively

mean values. In general, the mean value of the assets reveals that Bhumlichowk has comparatively higher asset possession, while Kaule has the least. For physical assets, house type has the highest influence. Walking distance to the nearest motor road negatively impacts adaptive capacity as hypothesized. For the human assets, qualifications and training/vocational courses receive higher positive weights. Negative weight implies that a higher dependency ratio decreases adaptive capacity. Under natural assets, land ownership influences adaptive capacity more than bullock ownership. A higher share of *khoriya* results in lower adaptive capacity as implied by the negative weight. Among the financial assets, gross annual income per capita is the most important determinant of adaptive capacity. For social assets, both indicators have equal weights.

The mean subindex values for individual asset types (Table 10.7) again show that Bhumlichowk ranks the first, while Kaule ranks the last in most cases, and the P values suggested statistically significant differences. Weights from the second-step PCA show that financial and human assets are the two most important determinants of overall adaptive capacity. Natural assets are the least important, which is relevant given that natural assets are impacted more by climate change and related disasters.

As described earlier, indices for exposure, sensitivity, and adaptive capacity are separately calculated, and from these the overall vulnerability index was derived. The average index values for the four study VDCs is presented in Fig. 10.1.

According to the value of the vulnerability index, Kaule is the most vulnerable VDC, while Mahadevsthan is the least. The differences among the VDCs are statis-

Table 10.6 Weights and VDC-wide mean values for indicators of adaptive capacity

	Indicators	Weight	Aggregate (n = 221)	Kaule (n = 58)	Kankada (n = 56)	Mahadevsthan (n = 54)	Bhumlichowk (n = 53)	P value
Physical asset	House type	0.61	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 phone/radio)	0.52	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 the nearest motor road	−0.43	2.12 (2.62)	3.09 (0.82)	3.15 (0.69)	1.39 (4.76)	0.72 (0.33)	0.00^{***}
	Irrigated land	0.42	13.1 (21.9)	7.7 (19.8)	2.9 (13.34)	22.5 (24.85)	20.03 (22.32)	0.00^{***}
Human asset	Highest qualification	0.71	4.62 (2.90)	4.36 (2.76)	4.88 (2.94)	3.74 (3.08)	5.51 (2.58)	0.01^{**}
	Dependency ratio	−0.04	1.21 (0.76)	0.93 (0.65)	1.42 (0.84)	1.11 (0.68)	1.40 (0.75)	0.00^{***}
	Trainings/vocational courses	0.71	0.52 (0.78)	0.41 (0.62)	0.48 (0.74)	0.56 (0.88)	0.62 (0.86)	0.52
Natural asset	Share of productive land possessed	0.70	74.5 (25.5)	77.1 (21.0)	61.6 (33.3)	84.4 (23.24)	75.07 (15.66)	0.00^{***}
	Share of less productive land possessed	−0.70	25.02 (25.03)	22.88 (20.98)	36.58 (32.65)	15.46 (23.27)	24.88 (15.64)	0.00^{***}
	Have bullock	0.13	0.66 (0.47)	0.64 (0.48)	0.71 (0.46)	0.59 (0.50)	0.70 (0.46)	0.51
Financial asset	Gross annual income per capita	0.62	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^{***}
	LDI	0.30	0.53 (0.14)	0.54 (0.17)	0.54 (0.14)	0.54 (0.13)	0.52 (0.13)	0.82
	Total savings	0.46	2,136.9 (9469.9)	1,119.9 (4554.1)	1,822.3 (10,660.1)	1,481.7 (4678.5)	4,249.6 (14,419.4)	0.30
	Ownership of goat, poultry, and pig	0.55	1.93 (1.35)	1.61 (1.07)	2.22 (1.47)	1.87 (1.22)	2.03 (1.56)	0.09^{*}
Social asset	Memberships in CBOs	0.71	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	0.71	2.65 (0.95)	2.31 (0.86)	2.77 (1.06)	2.74 (0.85)	2.79 (0.95)	0.01^{**}

Source of data: Field Survey 2010

Note: Figures in parenthesis indicate standard deviation

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

Table 10.7 Weights and VDC-wide mean values for subindices of adaptive capacity

Subindices	Weight	Kaule (*n* = 58)	Kankada (*n* = 56)	Mahadevsthan (*n* = 54)	Bhumlichowk (*n* = 53)	P value
Physical assets	0.42	−0.62 (0.7)	−0.32 (0.9)	0.35 (1.3)	0.67 (0.9)	0.00***
Human assets	0.54	−0.14 (0.9)	0.02 (1.2)	−0.17 (1.2)	0.30 (1.1)	0.10*
Natural assets	0.19	0.13 (1.2)	−0.66 (1.8)	0.52 (1.3)	0.03 (0.9)	0.00***
Financial assets	0.55	−0.46 (0.8)	0.14 (1.1)	−0.17 (0.9)	0.52 (1.4)	0.00***
Social assets	0.44	−0.39 (0.9)	0.06 (1.0)	0.25 (1.0)	0.11 (0.9)	0.00***

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

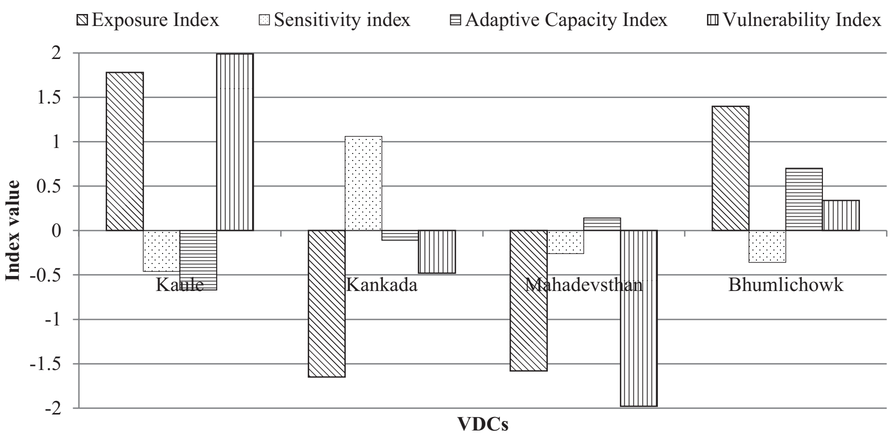

Fig. 10.1 The average index values for the study VDCs

tically significant (Appendix 10.2). Kaule has the highest exposure coupled with the lowest adaptive capacity. Bhumlichowk, despite having the highest adaptive capacity, ranks as the second most vulnerable because of high exposure. Despite having a comparatively lower adaptive capacity than Bhumlichowk, Kankada and Mahadevsthan fared better in overall vulnerability as these VDCs faces less exposure. Comparing these two less vulnerable VDCs, both were similar in terms of exposure; however, higher sensitivity and lower adaptive capacity in Kankada results in higher vulnerability. Kankada and Mahadevsthan have lower adaptive capacity, and as a result the livelihood impacts of extreme climatic events are higher in these VDCs. This is demonstrated in Table 10.5, where the livelihood impacts of extreme climatic events are the highest in Kankada, due mainly to the number of reported landslides (Appendix 10.1). The second highest livelihood impact of extreme climate events was reported in Mahadevsthan (Table 10.5), which has suffered from a series of droughts in recent years (Appendix 10.1). Despite a higher number of reported landslides and a similar number of reported droughts in Bhumlichowk (Appendix 10.1), it has less reported damage than Mahadevsthan, which is attributed to its higher adaptive capacity. This implies that it is very impor-

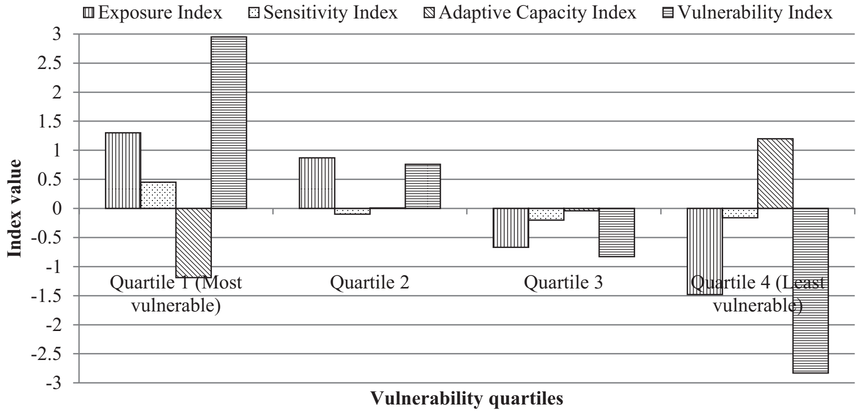

Fig. 10.2 The average index values by vulnerability quartiles

tant to build the adaptive capacity of the community to enable the residents to face hazards imposed by climate disasters.

For inter-household analysis, the sample households from all four VDCs are brought together and categorized into four vulnerability quartiles, the first representing the most vulnerable and fourth representing the least vulnerable households. Indices for exposure and sensitivity are the highest for the first quartile and the least for the fourth quartile as expected (Fig. 10.2) and are significantly different among the quartiles (Appendix 10.3). Similarly, adaptive capacity follows the expected order, with the value being the lowest for the first quartile and consecutively higher for subsequent quartiles. This showed that irrespective of the locations, households with lower adaptive capacity were faced with higher exposure and higher sensitivity to climate change and extreme events. Poorer households everywhere are thus vulnerable.

10.4 Conclusion and Policy Implications

The results of the inter-VDC comparison imply that the exposure of a locality to long-term changes in climate variables and natural disasters is mediated by the inherent adaptive capacity of the community to determine the overall vulnerability. Inter-VDC comparison also shows that lower adaptive capacity resulted in higher sensitivity to climate disasters (e.g., Kankada). This is because households with lower adaptive capacity are hindered from formulating efficient response measures, either before or after a disaster. When an event struck, those least prepared households are the most impacted, thereby exhibiting highest sensitivity. Interquartile analysis of vulnerability shows that the most vulnerable households are those with the lowest adaptive capacity, highest exposure, and highest sensitivity irrespective of the locality. Of the three components of vulnerability, adaptive capacity is the one with direct policy implications. Improving adaptive capacity also has implications for decreasing 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 (financial assets) reduces the dependence of the community on natural resource-based livelihoods, thereby reducing their sensitivity toward climate change and extremes. With improved access to assets, the community can devise measures to reduce their sensitivity to the risks and hazards imposed by exposure to climate-related disasters.

Among various components of adaptive capacity, PCA weightage suggested that the foremost policy focus in the Chepang community should be to improve financial and human assets. Household income is the most important component of financial assets thereby suggesting the need for interventions to provide income-generation opportunities for the community. Among the various income sources available, non-farm sources that are not based on natural resources reduce the household's sensitivity to climate. This implies that the policy should emphasize the creation of non-farm livelihood opportunities, which will not only improve the cash income of the community but also reduce their dependence on natural resources. This is also relevant as natural assets received the least weights among the asset categories. Non-farm remunerative income sources refer to salaried jobs (e.g., agriculture/veterinary technician) and skilled non-farm jobs (e.g., sewing, carpentry) for which education and vocational training are essential. This in turn relates to the need to strengthen human assets. This necessitates policy and development interventions at the national level to improve the access of community members to formal/vocational education and skill development training to develop the human capacity needed to use existing opportunities and assets.

The next priority must be given to improving social and physical assets. Strengthening local institutions and social networks means better services such as training, credit, and market access for the Chepangs. Among the physical assets, improving access to sources of information such as mobile phones/radios, along with better quality housing, will help the community to lessen their vulnerability. Similarly, agriculture still constitutes the mainstay of the community: thus, the development of basic infrastructure such as irrigation facilities is a must. Finally, the construction of all-weather roads linking settlements to the nearest population centers will help to create markets for farm products and also improve access to inputs, information, and off-farm employment opportunities.

Appendices

Appendix 10.1 Frequency 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
Flood/ 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 of data: Field survey 2011
Note: Figures in parenthesis indicate standard deviation
*** indicates significant at 1% level of significance

Appendix 10.2 VDC-Wide 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 10.3 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

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Chapter 11
Livelihood Impacts of Climate Change and Extreme Events

Abstract This chapter assesses the locally observed impacts of changing trends of temperature, precipitation, and the occurrence of extreme climatic events on the livelihoods activities and outcomes of the Chepangs. The impacts are documented for three aspects of climate change, viz., changing temperature patterns, rainfall patterns, and occurrence of extreme climatic events. The most reported impact of changing temperature is drying of crops followed by illnesses in human due to higher temperatures. The more frequently reported impact of lesser rainfall is declining agricultural production. Also, shifts in rainfall patterns have been reported to impact the time of sowing or transplanting of crops. Floods/landslides, droughts, and hailstorms are the most frequently reported extreme events. The impacts reported are the highest for floods/landslides.

Keywords Changing temperature and precipitation · Extreme events · Fatalities · Livelihood impacts

11.1 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 2007). 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).

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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.

11.2 Data Source and Analysis

This chapter uses the information obtained from group discussions and key informants' interview in the first phase of the field visit 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 Chap. 9, the impacts assessment was also based on the perceptions of the respondents for the last 10 years. The analysis in this chapter is basically descriptive in nature.

11.3 Impacts of Climate Change and Extreme Climatic Events on People's Lives

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

11.3.1 Impacts of Temperature Changes

The impacts of changes in temperature are summarized in Table 11.1. 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 rain-fed 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.

Table 11.1 Impacts of changes in temperature

Impacts of	Types of impacts
Higher temperature on crops	Drying of crops (43), more flower drop in fruit trees (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 of data: Field Survey 2011
Note: Figures in parenthesis indicate the number of responses received

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 February). 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.

11.3.2 Impacts of Rainfall Changes

The impacts of changes in rainfall quantity and patterns are summarized in Table 11.2. As the 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 stages of maize. In reference to Chap. 9, 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. The Chepangs wait for post-winter rain to prepare the 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

Table 11.2 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 of data: Field Survey 2011
Note: Figures in parenthesis indicate the number of responses received

the records show). Monsoon rain is also important for maize as the period coincides with silking and tasseling stages of maize, the most critical growth phases 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 the 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 of 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.

11.3.3 Impacts of Extreme Climatic Events

The most commonly reported climatic hazards in the study area are floods/landslides, droughts, and hailstorms; and these are the 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 the greatest number of high intensity rains, that is to say the number of occurrences of highest amount of rainfall within 24 h (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 5 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 resowing of maize after the losses from hailstorms. Pears and oranges are the major cash crops for the Chepangs, especially in Kaule VDC. Due to hailstorms, they have been unable to sell the produce for the last 3–5 years.

Table 11.3 shows the number of occurrences of the climatic disasters that happened over the last 10 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 the highest in Mahadevsthan (1.35), the 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

Table 11.3 Extreme climatic events reported for the last 10 years

VDC	Parameters	Flood/ landslide	Drought	Hailstorm
Aggregate (*n* = 221)	Number 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 (*n* = 58)	Number 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 (*n* = 56)	Number 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 (*n* = *54*)	Number 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 (*n*= 53)	Number 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 of data: Field survey 2011
Note: Figures in parenthesis indicate percentage

households reported 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 are comparatively less reported in Kankada than in other VDCs. In Mahadevsthan, both drought and hailstorm are 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 4 years, showing that these climate extremes are getting more frequent recently.

The livelihood impacts of these extreme climatic events over the last 10 years, as shown in Table 11.4, have been already discussed in Chap. 10. The impacts were quantified in terms of fatalities of family members, land washed away by flood/

Table 11.4 Livelihood impacts of flood/landslide, drought, and hailstorms over the last 10 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 (*kattha*[a])	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[b])	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.[c])	17,958.5 (32,521.7)	6,628.8 (7549.5)	35,329.6 (51,563.6)	17,202.3 (31,026.1)	12,773.1 (11,081.1)	0.00***

Source of data: Field Survey 2011
Note: ***,* denote significant at 1% and 10% level of significance, respectively; [a]1 *kattha* = 0.033 hectare; [b]LSU is the aggregate of different types of livestock 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 (CBS 2003; Baral 2005); [c]73 NRs. = 1 US$ (at the time of field survey)

landslides in, and death of livestock due to these events measured in LSU, and loss of standing crops due to these events was measured in terms of monetary values. Fatalities were reported only in Kankada VDC, which is caused by the massive flood/landslide that occurred in the VDC in July of 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. This implies that floods/landslides are the most devastating climatic hazards among those reported.

11.4 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 the Chepangs. For the Chepangs whose livelihoods are always on the brink of food scarcity, a 2-month 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 rain-fed 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 of 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.

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Chapter 12
Adaptation Strategies and Factors Influencing the Adaptation Choices

Abstract This chapter documents the ongoing community-based adaptation practices, which are categorized according to the fivefold classification based on risk pooling across space, time, assets, household, and market. It is measured in terms of adoption rate by the households. A comparison of this adoption rate with adaptive capacity across the four study sites shows that balanced possession of all asset categories is necessary to translate adaptive capacity into adaptation actions. A multivariate probit model is used to analyze the factors influencing the adoption of various adaptation practices. Five categories of adaptation choices are analyzed against a set of socio-economic, institutional, infrastructural, and perception variables. Perception, landholding, land tenure, distance to road, credit, information, extension services, and training are influential to enable the households to adapt.

Keywords Adaptive capacity · Adaptation choices · Risk pooling · Multivariate probit

12.1 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

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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 the 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 rainfed 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 microscale but may involve multiple scales and multiple actors. For instance, decisions to implement crop insurance schemes by the national level policymakers can be a suitable adaptation option for the subsistence farmers at the microlevel. 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 the 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 toward 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.

12.2 Theoretical Framework for Classifying Adaptation Practices

As summarized in the literature review in Chap. 2, past studies highlight 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 the 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 fivefold 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 and 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 livelihood studies as the classification is based on how the climate risks affect the household assets and community capabilities across space and time.

12.3 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 Chap. 10) to analyze if the adoption of particular practice by a household is determined by the inherent adaptive capacity. The determinants of the households' adaptation choices are analyzed using a multivariate probit model. The empirical model and the variables are discussed later in the chapter.

12.4 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 ten different adaptation practices were identified (Table 12.1).

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 Chap. 10.

Table 12.1 Existing adaptation practices across the four study sites

Adaptation practices	Number of households adopting the practice					
	Aggregate (n = 221)	Kaule (n = 58)	Kankada (n = 56)	Mahadevsthan (n = 54)	Bhumlichowk (n = 53)	P-value
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
Agroforestry	176 (79.6)	44 (75.9)	39 (69.6)	42 (77.8)	51 (96.2)	0.00***
Planting hedgerow	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 nonfarm jobs	36 (16.3)	5 (8.6)	13 (23.2)	5 (9.3)	13 (24.5)	0.02**

(continued)

Table 12.1 (continued)

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

12.4.1 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).

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 Fig. 10.1 (also refer to Table 10.7 and Appendix 10.2) in Chap. 10 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 Table 10.7 (in Chap. 10) 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.

12.4.1.1 Increased Dependence on Wild Foods

As already discussed in Chap. 7, the annual subsistence cycle of the Chepang community 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 Table 10.7 (in Chap. 10). 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 has 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 the second highest among the four sites. The difference among the study sites is statistically significant.

12.4.1.2 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 mid 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 3 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 1 to 2 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 2 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 the highest human assets development in terms of qualification as well as vocational trainings (Table 10.6 in Chap. 10), it can be expected that farmers in Bhumlichowk are significantly more innovative compared to the other VDCs.

12.4.1.3 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, and digging drainage sluices during monsoon are quite common practices in hill agriculture and hold 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 the highest number of destructive landslides over the past 10 years. Practices like legumes integration with cereals for improving the soil fertility and agroforestry 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 hedgerow 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 hedgerow construction in unterraced *khoriyas*. Hedgerow 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 the 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 with the general expectations that VDC with highest adaptive capacity also has highest adoption rates.

12.4.2 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, the Chepangs buy grains on credit from the shops at the nearest roadhead market. As described under social assets, the Chepangs depend upon informal sources of credit for fulfilling their cash needs. Many Chepang households have established a network with the roadhead shopkeepers and money lenders for the purpose of credits and loans. The Chepangs repay by selling goat, poultry, commercial forest products, fruits, agriproducts, honey, etc. Most literatures discredit this relationship between the Chepangs and shopkeepers/moneylenders due to the lower prices offered by the shopkeepers 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 Chap. 8, even if formal lending institutions exist, the 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.

12.4.3 Combination of Mobility and Diversification: Temporary Labor Migration

Temporary migration of male members during the dry season to nearby cities in search of nonfarm 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 nonfarm 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. The 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. As discussed in detail in Chap. 8, 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 nonfarm 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 (see Chap. 8). Thus, assistance by the development agencies to diversify the households' livelihoods to nonfarm remunerative jobs will help them reduce the risks posed by extreme climatic events. As can be seen from Table 12.1, 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 the highest in human assets (Table 10.7 in Chap. 10) with the highest average qualification and vocational trainings (Table 10.6 in Chap. 10). The adoption rate of remunerative nonfarm 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 nonfarm 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 nonfarm jobs. Also financial resource is needed for investing in education, vocational trainings, and related expenditures to go abroad.

12.4.4 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 10.6 in Chap. 10), due to which recurrently occurring droughts are major threats to the 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 nongovernmental 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 (Table 12.1). 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 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 10.6 in Chap. 10). Otherwise, the adoption rate of the 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 10.6 in Chap. 10). Leaving Mahadevsthan VDC aside, both the adoption rate and membership in CBOs are higher in Bhumlichowk, followed by Kankada and Kaule.

12.4.5 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 10.6 in Chap. 10). 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 h, followed by Mahadevsthan (1.4 h), while the distance is above 3 h 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 (Table 12.1). 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. 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. This is because, different from Bhumlichowk, the cash crops grown in Kankada are black gram 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.

12.4.6 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 (Table 12.1). The practice of raising 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 12.1, 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 (Table 10.7 in Chap. 10). 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 ten adaptation practices, while the figures are seven 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 is necessary to utilize the existing resources to the fullest. Secondly, the 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 are recommendable to arrive at a better explanation of the process by which adaptive capacity is translated into adaptation practices.

12.5 Determinants of Households' Choices of Adaptation Practices

As outlined in Chap. 2, there are many 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 subsection 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.

12.5.1 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 independent discrete choice models or univariate models. A better alternative to independent discrete choice models or 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) focus on the crop choices as an adaptation strategy in Africa and South America, respectively; Seo et al. (2009) 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. (2009) 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

$$Z_{ij} = X_i \beta + \epsilon_i, i = 1,\ldots,n \tag{12.1}$$

where $\beta = \left(\overrightarrow{\beta_1}',\ldots,\overrightarrow{\beta_J}'\right)$ is a matrix of unknown regression coefficient and 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}, represent the unobserved correlation between the stochastic components 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

$$Y_{ij} = \begin{Bmatrix} 1 \text{if} \, Z_{ij} > 0; \\ 0 \text{otherwise.} \end{Bmatrix} i = 1,\ldots,n \, \text{and} \, j = 1,\ldots,J \tag{12.2}$$

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

$$P\left(Y_{ij}=1 \mid X_i,\beta,\Sigma\right)=\int A_{iJ},\ldots,\int A_{i1}\Phi_T\left(Z_{ij} \mid X_i,\beta,\Sigma\right)dZ_{ij} \qquad (12.3)$$

where A_{ij} is the interval $(0,\infty)$ if Y_{ij} = 1 and the interval $(-\infty,0]$ if otherwise; and $\Phi_T(Z_{ij}| X_i, \beta, \rho_{ij})$ 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).

12.5.2 Variables for the MVP Model to Analyze the Determinants of Adaptation

The choices of adaptation practices listed in Table 12.1 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 nonfarm jobs were merged into a single variable as livelihood portfolio diversification; and wage laboring and collecting wild edibles were 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 12.2).

The 13 independent variables selected for this paper are listed in Table 12.3. 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 (see Chap. 9). The changes in climatic variables were considered for the last 10 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 that 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.

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. 2009; Seo and Mendelsohn 2008a) and some reporting both positive and negative

Table 12.2 Adaptation practices adopted by the 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
Nonfarm 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 of data: Field survey 2011

Table 12.3 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]Sources of data: Field survey 2010 and 2011
[b]TCS Traditional Coping Strategies, [c]LPD Livelihood Portfolio Diversification

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, 2009) 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) report 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. 2009; Gbetibouo 2009). For this study, the 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 lands 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) report that larger farms are less likely to adopt nonfarm 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 the Chepangs, due to certain government policies, difficult administrative procedures, and ignorance on the part of the Chepangs, many land plots that they 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 to 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, 2009; 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 has been found to facilitate adaptation to climate change (Deressa et al. 2011, 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 CBO(s), and participation in training(s) 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, Kaule variable has been considered as the dummy variable. Among the four study sites, Kaule VDC is reported to have the least adaptive capacity in terms of indicators based on the possession of various livelihood assets (Chap. 10). Thus it is hypothesized that households in Kaule are less likely to adapt to climate vagaries.

12.5.3 MVP Model of Households' Adaptation Choices: Results and Discussion

The results of the MVP model presented in Table 12.4 show that the direction of influence for most of the explanatory variables is as expected with 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 that "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 the 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

Table 12.4 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 in CBO(s)	−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 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.

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 group(s)/CBO(s) 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 report 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.

The 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 CBO(s) are more likely to construct water collection tanks as stated before, the water collection tanks are constructed with technical and partial financial support from these organizations.

Only the site variable is significant in adjusting sowing time, the households in Kaule having higher propensity to adopt this practice. As discussed before, perception of rainfall facilitates the time adjustment while the perception of temperature 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 traditional coping strategies is also negatively significant implying that households rely on subsistence credit only when they are constrained to adopt other alternative coping measures. The Chepangs often borrow small amount of money from relatives, neighbors, or the local moneylenders in order to fulfill their immediate needs.

The results in Table 12.4 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 (EAM) 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 12.3, 94% of the sample households report that they have access to some credit sources. However, the direction of influence is surprisingly negative for households with access to credit. This is because the Chepangs borrow credit to fulfill their subsistence needs rather than for productive investment. Their access to productive credit is limited because there are no formal lending institutions in the remote areas. In addition, the Chepangs often lack fixed assets needed as collateral in order to obtain loan from formal lending institutions. This necessitates the need of provision of collateral-free 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 highlight that while membership in organization(s) 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 needs 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.

12.6 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 adaptation 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 implication 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 to utilize 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 nonfarm 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 the 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 nonexistent 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 microcredits 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 land ownership by the indigenous people and facilitate registration of land plots cultivated by the Chepangs. The 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 training(s) complemented with provision of microcredits 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.

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Chapter 13
Conclusion

Abstract The foremost policy to address climate change must be to improve the adaptive capacity, which is the only component of vulnerability that is under the direct influence of policy-makers. Mainstreaming climate change into development investments is a must; and a no-regrets approach must be adopted while doing so. Climate change is intricately related to sustainable development as it crosscuts across all the four pillars of sustainable development, viz., environmental conservation, economic development, human capacity development, and social networks and institutional factors like policies, good governance, and equity. Human skill and financial capital are indispensable to utilize the remaining resources for higher adaptive capacity. Paradoxically, these two are the most limited assets in rural areas. Efforts must be geared toward this direction to facilitate adaptation.

Keywords Mainstreaming climate change · No-regrets approach · Sustainable development

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 livelihood 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 vulnerability 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

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also has positive implications in helping the households to build resilience in the face of climatic hazards thereby reduce vulnerability.

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 has 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 livelihood 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 the case of Nepal would be the construction of hydropower dams which need to consider the possible changes in runoff due to glacial melts upstream. Similarly, development of drought-resistant crop varieties will help farmers adapt to increasing frequency of drought and at the same time contribute to the overall goal of reducing hunger. Promotion of agroforestry, 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, and 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, and 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 livelihood 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 populations 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, sociocultural 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 sociocultural hierarchies limit the access of communities to institutions and policy formulations, which in turn limit the households' livelihood options and consequently the adaptation choices. For instance, inability of socioculturally marginalized people to be a part of forest user groups will limit their options to use the forest resources, thereby limiting their livelihood options. Similarly, lack of access to extension and input 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 are 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 beneficiaries of the revenues earned from carbon finance. The discussion finally brings us back to the asset pentagon in rural sustainable livelihood 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 livelihood outcome. Paradoxically, the most limited assets in the rural areas are in fact the financial and human assets. Therefore, in order to improve the adaptive capacity and facilitate adaptation in rural areas, the primary focus must be to increase the cash income through livelihood diversification and human asset development by providing education and vocational training. This corresponds to economic and social factors in the sustainable development framework. Kaule VDC ranks the lowest in the majority of asset categories; thus out of the four study VDCs, Kaule VDC needs integrated development assistance that subsequently addresses 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 developments 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 the economic and institutional pillars of sustainable development.

13.1 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 get 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. A handful of researches that use perception as a determinant of adaptation do 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 giving 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 have been changing over time.

Index

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