Climate, Agriculture and Migration: A Critical Review of Dynamic Livelihood Changes in the Nepali Tarai

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Abstract

Climate change is altering human relationships with their places in complex ways in Nepal. This research examines the responses to challenges brought about by environmental change at two municipalities, Damak and Dhangadhi—in the southern plains of Nepal known as the Tarai. The dissertation presents narratives on the social and ecological history of the Tarai, portraying the current environment as a product that has been shaped in part by in-migrants, and the associated entrenched social inequalities. The understanding of the complex dynamic relationships between climate change, agriculture and migration leads to a critical discussion of opportunities for planned adaptation measures to increase resilience of the dynamic socio-ecological system.

This research utilizes both quantitative and qualitative primary data, collected through a questionnaire survey of 298 households and 23 in-depth interviews to analyse trends in livelihoods strategies in the Tarai. The questionnaire sought details on basic household assets, livelihood practices, reliance on natural resources, perception of changing climatic patterns and remittances for migrant households. The socio-economic backgrounds of individuals, households, their motivations for migration and the impacts on households are analysed within a socio-ecological analytical framework, using the primary data. Meteorological data from the past three decades was used to generate climate indices to quantify climate variability and change. The insights from the climate data analysis were compared with the primary data generated both from the questionnaire survey and narratives gathered from interviews, to develop an understanding of the local socio-ecological interface.

The study highlights the importance of the process by which households minimize risks by investing in multiple off-farm livelihood options, including supporting family members to become migrant workers in the hope of receiving stable remittances. The increased chances of extreme precipitation pose additional challenges to the sensitive agricultural practices. Examination of households' demographic details suggests a prevailing low level of human capital with limited prospects for in-situ off-farm employment, pressuring families to exploit livelihood opportunities from migration. Migrants from higher socio-economic backgrounds are opting for new international destinations, particularly in the Gulf Countries and Malaysia, while those less fortunate rely on long established destinations in India and Nepal. This change signifies that Tarai migrants have become essential transnational actors in a globalised world, and highlights the connectedness of the Tarai rural communities to the rest of the world. The results suggest that the dynamics of recent in-migration into the Tarai has led to innovative responses to new risks, but those responses are highly complex, involving multiple movements of people and capital to exploit a new international labour environment.

The thesis contributes to existing knowledge on interactions between agricultural systems, environmental change and human mobility; and especially on contemporary policy discussions on the inclusion of circular migration as an adaptation policy to mitigate the impact on future climate change on primary resource dependent communities. While enabling Tarai residents to better adapt to change and avoid poverty traps in the short-term, ex-situ measures disrupt the complex local socio-ecosystems at the household level.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree. I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968. I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

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Signed: _____

Date: _____

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Abbreviations

AUD	Australian Dollars
BS	Bikram Sambat
CBS	Central Bureau of Statistics
CCl	Commission for Climatology
CDO	Chief District Officer
CLIVAR	Climate Variability and Predictability
CVFS	Chitwan Valley Family Study
DHM	Department of Hydrology and Meteorology
DoS	Department of Survey
EPS	Employment Permit System
ETCCDI	Expert Team on Climate Change Detection and Indices
FDI	Foreign Direct Investment
FM	Frequency Modulation
GDP	Gross Domestic Product
GFC	Global Financial Crisis
GIS	Geographic Information System
GoN	Government of Nepal
HDI	Human Development Index
IB	Insurance Board
IOM	Institute of Migration
IPCC	Intergovernmental Panel on Climate Change
LPG	Liquefied petroleum gas
masl	meters above sea level
MK	Mann-Kendall
NAPA	National Adaptation Plan of Actions
NELM	new economics of labour migration
NGO	Non-Government Organization
NLSS	Nepal Living Standard Survey
NPR	Nepalese Rupees
NRB	Nepal Rastra Bank
NVivo	NVivo qualitative data analysis Software developed by QSR International Pty Ltd.
ppb	parts per billion
PPP	Purchasing Power Parity
SI units	International System of units
SLC	School Leaving Certificate
UAE	United Arab Emirates
UN	United Nations
UNDP	United Nations Development Project
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UofA	The University of Adelaide
USA	United States of America
USD	United States Dollars
VDC	Village Development Committee
WECD	World Commission on Environment and Development
WMO	World Meteorological Organization

Description of local units used in the text

For currencies mentioned in the text, the United States Dollar (USD) equivalent of the amounts in Nepali Rupee (NPR) is given in parentheses with the conversion rate of USD1 equivalent to NPR100. The conversion rate is based on the prevailing rate during the fieldwork period (September 2013 to March 2014) as set by Nepal Rastra Bank (NRB) rounded to a whole number figure for simplicity. During the same time, 1 Australian Dollars (AUD) was valued at around NPR93 according to the official rates set by NRB.

In addition to the Gregorian calendar, Nepal follows the Bikram Sambat (BS) calendar system with the new year commencing around mid-April. BS system is the official system and most commonly used. Typically, the BS calendar is ahead from the Gregorian calendar by fifty-seven years but the exact conversion of days from among the BS and Gregorian system requires complex calculations. Year 2016 for instance was year 2072-2073 BS.

Land area is typically measured in local units in Nepal. In the Tarai, land measurements are done in Bigha, Kattha and Dhur units (1 Bigha = Kattha, 1 Kattha = Dhur) and in Hill or Mountain region, in Ropani, Ana, Paisa and Dam units (1 Ropani = 16 Ana, 1 Ana = 16 Paisa, 1 Paisa = 4 Dam). In International System of Units (SI units) terms, 1 Bigha and 1 Ropani are equivalent to 6,772.632 sq. m. and 508.737 sq. m. respectively. In this text, any mention of land area in local terms are also described in SI accepted unit of hectare (ha), which represents an area of 10,000 sq. m.

1. Introduction and problem formulation

1.1 Introduction

There has been a global interest towards understanding how societies navigate complex impacts of environmental and social changes. Human responses to global climate change have been a special matter of concern in the field of human geography. Impacts of climate change are resulting in warmer temperatures, changes in rainfall patterns, melting glaciers and rising sea-levels (Intergovernmental Panel on Climate Change—IPCC 2014). The natural environment of a particular place has always influenced how human societies lived there. Livelihood systems respond to any changes in the local environment and adapt to new and expected conditions. However, shocks from the unprecedented acceleration in rates of warming or increases in extreme events could have a lasting effect on societies if they are unable to adapt.

There are a variety of means that can help human societies cope and adapt to environmental changes. Yet, the accessibility of the tools is mediated by socio-economic factors and it's the poorest groups of the society which often lacks the capacity to reduce the impacts. Furthermore, globalisation has brought about interconnectedness, which extends the labour opportunities beyond national and regional boundaries, but at the same time, can add external risks to livelihoods independent of the locality. This thesis explores the Nepali Tarai[1] socio-ecosystem to enquire how livelihood systems respond to internal and external drivers of change. It examines the livelihood strategies of rural households with attention to the increasing reliance on circular migration in response to agricultural pressures. To make the necessary enquires, this study analyses the external and internal pressures on agriculture; evaluates the impacts from global environmental change; assesses the role circular migration in local livelihoods; examines the trends in circular migration; and evaluates the role of transnational networks in rural livelihood systems. The study is based on case studies of two municipalities, Damak and Dhangadhi from the southern Nepali plains, also known as the Tarai.

This chapter presents the problem statements, the rationale behind the research undertaking and outlines its aims and puts forward the research questions. The problem statements highlight current research and outlines research gaps by reviewing published literature on socio-ecological transformations in the context of environmental and other global changes. First, the conceptual basis of conducting the research is presented by providing some of the background on the Tarai socio-ecological system. Next, gaps in contemporary research are highlighted to justify the need

[1] Although the anglicized term "Terai" is widely used, Shrestha and Bhattarai (2003, p. 417) state that the correct form is "Tarai" and this thesis adopts this spelling.

for the research. This is followed by the section outlining research aims and describing key research questions. Finally, justification for site selection and organisation of the thesis are presented.

1.2 Background

Nepal is a developing country with a little above a quarter of its population living under poverty[2] (Central Bureau of Statistics (CBS) 2011). 8.5 percent of Nepalis earn less than USD1.90 per day[3] (PovcalNet 2013). Agriculture, livestock rearing and poultry provide livelihoods for just above 60 percent of its population aged ten and above (CBS 2012d). Nepal has also been marred by frequent occurrences of disaster incidents like landslides, floods and earthquakes. Despite having made progress in social and political development, the overall economic growth has been very slow. With a Human Development Index (HDI) of 0.548, Nepal was ranked 145th in the world in 2015, signalling sluggish economic growth and a low level of adoption of successful development policies (United Nations Development Project—UNDP 2015). Nepal is also considered as having a high vulnerability to the impacts of global climate change in many sectors including agriculture (Bhatt et al. 2014), hydropower (Sharma & Shakya 2006; Shrestha & Aryal 2011), tourism (Nyaupane & Chhetri 2009) and biodiversity (Bhatta et al. 2015).

To understand the context of the Tarai region, it will be fitting to begin with an explanation of the features of the country. Officially referred to as the Federal Democratic Republic of Nepal, the country spans about 800 kilometres in an east-west direction and around 160 kilometres in the north-south direction. It occupies an area of 147,181 km^2 and encompasses a third of the length of the Himalayan mountain range. On the north lies the Xizang province of China, also known as the Tibet Autonomous Region. On the east, south and west, Nepal borders India with Sikkim and West Bengal states on the east, Bihar and Uttar Pradesh states in the south and Uttarakhand (formally Uttaranchal) state in the west. Nepal is a landlocked nation with the closest ocean ports in Kolkata, India. Two other countries, Bangladesh and Bhutan are close to Nepal, with Banglabandha in Bangladesh being only 43 km via road from Kakarvitta at the eastern border of Nepal.

The terrain of Nepal reveals a wide range of variation starting off with the flat plains with altitude as low as 60 metres above sea-level (masl), to the highest elevation on earth at 8,848 masl in the Himalayas. Based on ecological features, Nepal is broadly divided into three zones, the lowland – Tarai (also referred to as Madhesh), the Mid-Hills, and the Mountains. The variation in the terrain

[2] Poverty measure based on the National Poverty Line.
[3] Value based on 2011 Purchasing Power Parity (PPP).

of these ecological zones result in a highly varied climate and in turn influence the diverse socio-economic activities between the regions within the confines of a relatively small country. Box 1.1 presents a comparison of the three ecological regions based on key attributes.

Box 1.1 Brief comparison between Mountains, Hills and the Tarai

- Mountains or the Himalayan region which occupy 15 percent of the country
  - Altitude: >3,000 to 8,848 masl
  - Physical features: snow-capped mountains; rough terrain; limited potential for vegetation
  - Climate: arctic and alpine
  - Population density: 34 persons per km^2
- Hills or Mid-Hills region occupies 68 percent of land
  - Altitude: > 300 to 3,000 masl
  - Physical features: suitable for terraced farming
  - Climate: temperate in the south and subalpine in the north
  - Population density: 186 persons per km^2
- Tarai or the plains which occupy 17 percent of the country
  - Altitude: 60 to 300 masl
  - Physical features: plain land; sub-tropical forest and marshlands; suitable for agriculture
  - Climate: tropical and sub-tropical
  - Population density: 392 persons per km^2

Due to large variations in topography, climate and livelihoods between the three regions, impacts of climate change on local environments and communities are expected to differ substantially. Even with the same ecological belt, variations will occur due to local factors such as distance from the coastline and proximity to rivers. For that reason, the sites are chosen from the same ecological belt to provide as close as possible to a baseline for comparing climatic trends and responses to them. However, since the socio-ecological systems are distinct, each case can only speak for itself.

Global environmental change impacts add additional burdens to the Tarai, which is already grappling with numerous socio-economic and ecological problems. It is widely understood that the vulnerabilities of the socio-ecological systems are not exclusively based on physical stressors, but are mediated by a range of socio-economic components (Adger 2006; Kelly & Adger 2000). Using an inter-disciplinary approach, this research explores the underlying human-

nature interactions and examines how responses to social and environmental change are being carried out and planned for in two study sides. Using primary and secondary data, the complex interactions between social and environmental systems of the Tarai are explored. Of particular interest is the expansion of the spatial extent that rural livelihood systems can tap into with the increasing reliance on circular migration to distant destinations.

1.3 Conceptual basis for the thesis

The natural environment and the human communities of a place interact with each other in complex ways with human systems changing environmental systems and vice versa. Human-environment interactions in the Tarai occur in multiple ways: agricultural practices use natural resources; floods shape land available for use; forests provide firewood and materials for construction; demand for irrigation leads to extraction of underground water and so on. Knowledge and personal experience impacts the cultural understanding of the natural environment and can impact environment-related decisions (Craik 1972). Most decisions related to natural resources or the environment in the Tarai can be expected to be occur at the household level as most agricultural decisions are undertaken at that level. The community's major activities are also determined by the collective decisions of the household members.

In the Tarai, agriculture is mostly a household managed activity with little or no mechanisation. Irrigation infrastructure are minimal and in many case have not been maintained, and most farmers work independently or in groups to arrange inputs such as seeds, fertilisers, insecticides and water for irrigation. Despite increasing yields, the agricultural practices in the Tarai face numerous problems. With more than 53 percent of land holdings in the country being less than 0.5 ha (CBS 2013b), advantages of scale cannot be realised. To supplement for meagre localised development opportunities, farming households have also exploited ex-situ livelihood opportunities involving circular migration as an additional form of income as, in the case of farming communities elsewhere (Ellis 2000). The relative contribution to national Gross Domestic Product (GDP) from the agriculture sector has declined significantly in Nepal from 68 percent in 1971 to 37 percent in 2011 (Gyanwaly 2014), with income from services sectors replacing the farm-based economy. The increasing shift from an agricultural to service based economy was to be expected as Nepal opened up to international trade and adopted various economic reforms.

The study of impacts from climate change cannot be discussed in isolation to other risks, especially in the case of the Tarai. The region itself has undergone a rapid ecological and social transition in the past decades which has shaped the current socio-ecosystem. With the slow rate of modernisation, agricultural practices have not undergone much change. At the same time, the access to natural resources like water, grazing lands and forest have dwindled and are often

inaccessible for poorer farmers. This difficulty in providing adequate conditions for agriculture, however, should not be understood as a singular impact of climate change, but should be analysed in the context of other ecological, social and economic predicaments facing the Tarai. This research links the cases from the Tarai to global processes that are part of broader shifts in how societies are beginning to function. Particularly, the analysis of circular migration as a process of transnationalism which offers a means to adapt to local environmental changes and the Tarai provides a unique example of the spatial extent of livelihood diversification.

The idea of a global society can be said to have started in the 17th century after the signing of the Peace of Westphalia in 1648 which paved way for the modern international systems and interactions. In a post-westphalian context, societies are not simply bounded by national borders but are increasingly connected internationally; the structure of the modern society is hence a "world society" (Luhmann 1998 as cited in Matten 2004). While Nepal was a relative late-comer in this global society, efforts of liberalisation and privatisation have been embraced fully by the government, especially after the reinstatement of democracy in 1990. Nepal's embracement of globalisation has indeed fuelled the economy by expanding the service sector and opening up new markets for exports. However, the export income and the contribution of foreign direct investments (FDIs) to national GDP stood at only 0.24 percent in 2015 (The World Bank 2016a). Globalisation has introduced a new set of opportunities to the Tarai. Although the region has been less able to take advantage from exports and foreign investments, the business of supplying a cheap labour force to global destinations has boomed. Nepali migrants can choose from a total of 108 countries to sell their labour (DoFE 2014, p. 202). To indicate the scale of this mobility, around 43 percent of the Tarai households had a migrant abroad, based on the NLSS 2010-11 data (Sharma et al. 2014, p. 14).

1.4 Research direction

It must also be noted that this research was originally conceived to explore particular complexities in addressing community adaptation issues to water induced hazards. In the early stages, after reviewing contemporary issues at the study sites, by force of circumstances, the scope expanded to encompass wide ranging topics including the broader implications of livelihood and environmental change, the effect of globalization, trends in international labour demand, and transnational human mobility. The concept of "the environment" after all (as discussed in Chapter 2), relates by definition to the interface between the physical environment and the humans that are influencing it, and are being influenced by it at the same time (Berkes et al. 2003), and hence the direction towards understanding social aspects of the environment was expected. What came as a surprise to the researcher during initial scoping studies, was the extent of human mobility to

new international destinations among poor farming households to secure their livelihoods. Considering the information from the field, a shift in the focus of the research was decided. This directed the research towards exploring the fundamental factors determining mobility decision-making and possible linkages to changes in the physical environment.

1.5 Research gap

Studies regarding climate change in Nepal have been more focused on ecological and physical aspects of climate change impacts, and are generally missing analyses that encompass human systems in association with ecological systems. While the modelling of future trends and scenarios provides useful information for planning, it could also be argued that there should be more research addressing current vulnerabilities to society from climate change (Jacka 2009). That change in research focus is starting to occur with recent studies in Nepal. Researchers in Nepal have begun to look at the barriers for climate change adaptation from broader socio-ecological perspectives with emphasis on processes that mediate impacts from the environment e.g. Dulal et al. (2010) and Gentle and Maraseni (2012).

There has been an increased interest in the study of climate impacts and adaptation in the Himalayan region as indicated by the number of academic publications in recent years; see for example Shrestha et al. (1999a); Qi et al. (2013); Shrestha et al. (2012); National Research Council (2012); Baidya et al. (2008) and Shrestha and Aryal (2011) on climatic trends. A number of academic papers researching environmental change from sociological perspectives have also been published; for example, see Dulal et al. (2010), Gentle and Maraseni (2012), McDowell et al. (2012), Manandhar et al. (2011), Sherpa (2014), Devkota et al. (2011), Chaudhari et al. (2011) and Aryal et al. (2014). Most research has focused on the Himalayan context and very few are focused on the Tarai region. The focus on the Himalayan region is rationalised due to the fact that the warming trends over Mountain areas, especially in the high latitude and mid-latitude Asian regions have seen average temperature increase at a rate faster than the global averages (Nogués-Bravo et al. 2007). Despite the recent surge in academic scholarship on environmental change and adaptation in the region, there is a clear lack of focus on the implications of environmental change on the local socio-ecological systems of the Tarai. Especially, there is a lack of research on the impact to local livelihoods in relation to ecological and socio-economic pressures and informed adaptation decision-making. Moreover, the historic context of socio-ecological resilience and the role of ex-situ livelihood development to compensate for local pressures have been largely overlooked in the context of adaptation to environmental change (Bardsley & Hugo 2010). Studies have mostly focused on impacts and subsequent adaptation measures with little attention to the existing pressures, historical resilience and analysing the

issues as a complex socio-ecological system. This study analyses historical resilience and also encompasses the role of transnational networks in the functioning of the local socio-ecological systems thus linking the interactions of socio-ecological systems at different temporal and spatial scales.

The lack of proper datasets has been partly blamed for the dearth of research on environment-migration relationship (Bilsborrow & Henry 2012). In this research, primary data on environmental as well as demographic variables, are gathered via household surveys and interviews to provide direct insights into non-linear environment-migration relationships. The integration of secondary data on physical indicators of climate with local perception aids in triangulating findings. The argument is presented that such linking of multi-disciplinary information from both qualitative and quantitative methods are necessary to analyse the dynamic livelihood decisions at the individual and household level.

These cases also highlight how global to local linkages occur as planetary climate change is manifesting in local implications for underdeveloped farming communities. The findings are expected to provide valuable insights into the role of socio-ecological systems to assist communities to adapt to the threats from environmental change. This study adds to the growing body of evidence-backed knowledge on human-society interactions and adds valuable insights into the household livelihood responses of to environmental pressures.

This research, by critically evaluating two interacting themes, namely, circular migration, and global climate change, presents their influences on local livelihood systems. When compounded, they provide a detailed analysis of the underlying complex relationships between global environmental change and socio-ecological resilience and human mobility in two Tarai locations. This study is not intended to generalise findings and inferences for the whole of the Tarai belt. Nevertheless, the findings will help in understanding the direct and indirect influences of the environment in locals' livelihood decision-making in majority agrarian communities. To generate a fuller picture, details on other locations across the Tarai are needed – a task that is hoped to be covered by future research.

To address the prevailing gaps in contemporary scholarship, specific research aims and objects were developed which are listed next.

1.6 Research aims and research questions

1) To investigate the key drivers of change impacting the livelihood of the Tarai communities from a socio-ecological systems' perspective.

2) To assess how Tarai communities handle livelihood pressures through in-situ and ex-situ earning opportunities.

In order to achieve the above aims, this research addresses a number of research questions as outlined below:

1) To what extent has the climate of the Tarai changed in the last three decades?
2) To what extent have the locals perceived changes to the local environment and climatic patterns?
3) To what extent is the Tarai socio-ecological system able to adapt to current and future impacts of climate variability and change?
4) To what extent are the Tarai farming households able to diversify their livelihood to include off-farm opportunities?
5) To what extent is circular migration helping the Tarai farming households adapt to agricultural pressures?
6) To what extent is the circular migration decision driven by environmental pressures?

1.7 Justification of the focus on the Tarai

Most of the earlier research on environmental change in Nepal has focused on the Mountain region. This research takes the case of the Tarai with a unique history of landscape and human settlement compared to the Mountains and the Hills. Upon the analysis and review of literature, the Tarai was selected as the region of interest due to the following reasons:

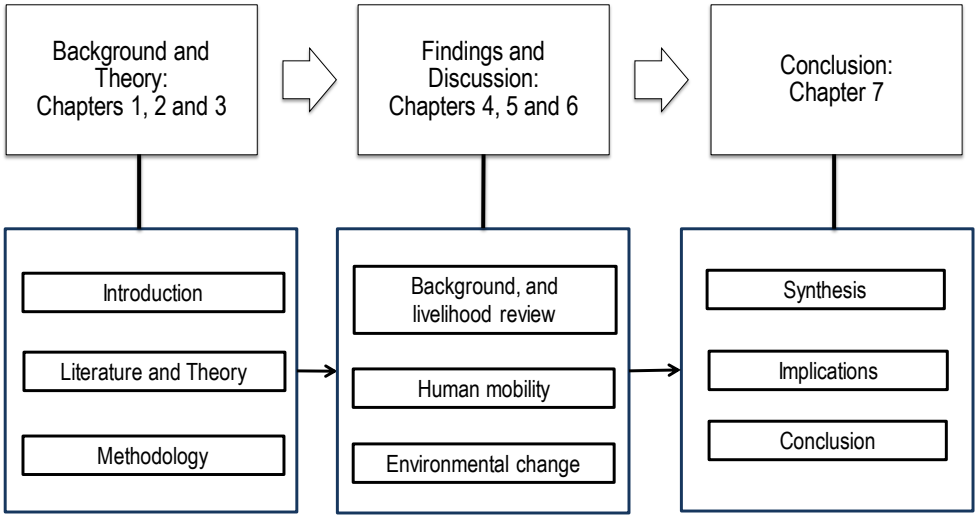
1. The unique history of transformations in the landscape.
2. The significance of the region's share of the national population, particularly the dramatic increase in population in recent decades compared to other regions in the country.
3. The role of Tarai in the agricultural production to Nepal.
4. The significance of the region's potential for agricultural production due to climate, soil condition and access to water.
5. The unique migration history, including its proximity to India, a regional hub with document free access to Nepalis.

The selection of the study sites within the Tarai belt was carried out on the basis of high incidence of floods in recent years. The detail description of the analytical method to select the two study sites are discussed in Chapter 3.

1.8 Organisation of the thesis

This thesis document is organised into seven chapters as illustrated in Figure 1.1. The first three chapters provide the background information and theoretical conceptualisations. This introductory chapter is followed by theoretical discussion and conceptualisations of key processes in the study of agricultural pressures, livelihood systems, environmental change and human mobility. Chapter 2 also outlines a review of literature underlining what is already documented and what is unidentified. Chapter 3 outlines the methodological approach adopted to arrive at the conclusions in this thesis and underscores the role of the researcher in deciding research directions. The findings of the study are discussed in the next three chapters. Chapter 4 provides a review of livelihood systems utilised by the Tarai communities and how such systems have evolved over the years. Chapter 5 presents a critical discussion on the role of human mobility as a means of off-farm livelihood. The final discussion chapter, Chapter 6, assesses the impacts of global environmental change in the Tarai. Together, the discussion chapters present a critical examination of environmental change and human mobility in relation to rural livelihood systems in the Tarai. This approach presents the relationships of livelihood systems to human mobility and environmental change separately in Chapters 5 and 6, and then examines the inter-relationships in the concluding section, Chapter 7. A justification of adopting this approach is presented in the next chapter (Section 2.7).

Figure 1.1 Diagrammatic representation of the organisation of the thesis.



2. Literature review and theoretical conceptualisations

2.1 Introduction

This chapter presents a review of selected theories on human-environment interactions and discusses conceptual descriptions of key terms used in this research. It also explores how adaptation to environmental change has been theorised in the literature, the inclusion of migration as a form of adaptation in recent literature, and how the challenges in the Tarai can be theorised as the inevitable consequences of transitioning into modern times where societies are linked globally. In the course of elaborating the concepts of adaptation, human mobility and development and their inter-relations, the frameworks of socio-ecological systems, environmental migration and reflexive modernisation are discussed.

Firstly, a brief introduction of human-environment research through a socio-ecological systems framework is presented. Secondly, conceptualisations of terms related to environmental issues in relation to human societies are discussed. This section starts off by exploring theories on vulnerability as they evolved to include broader issues. This is followed by discussions on coping and adaptation in the context of environmental change. The final conceptual discussion is on the risk society theory based on Beck's seminal work and how it can be applied in the context of the Tarai, particularly in the context of the impacts of globalisation. Next, the development of the Nepali Tarai is discussed using Beck's theory of reflexive modernisation to explain the multiple issues that the region is facing, arguably, as a result of planned modernisation. A brief discussion on theories on environment-migration nexus follows next. This is followed by the review of climate variability and change literature in the regional context.

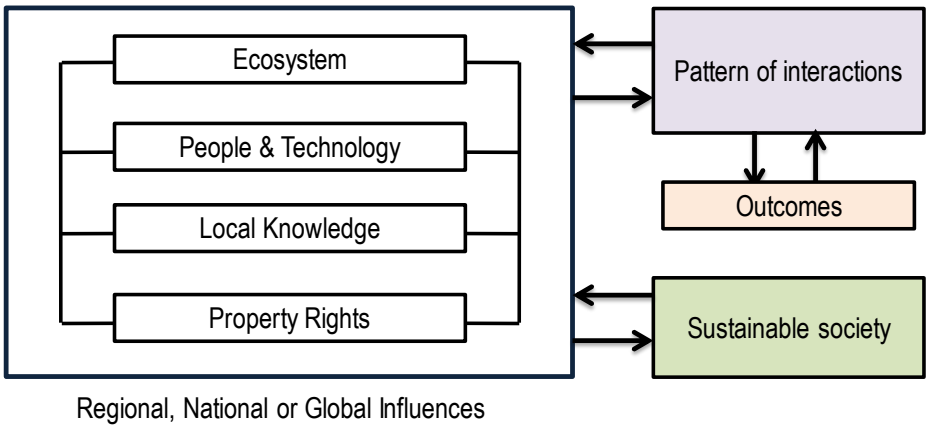
2.2 Studying human-environment interactions

Human societies interact with natural resources and their surrounding physical environment through complex relationships between natural and social systems. Social-ecological or socio-ecological systems are complex, integrated systems in which human societies are conceptualised as an integral part of nature (Berkes et al. 2000). In the context of human-environmental interactions, a socio-ecological system constitutes the discourse of exploring the relationships between human and natural components as a part of complex web with multi-stage feedbacks and inter-dependencies (Berkes et al. 2003). The socio-ecological system framework was proposed to study the complex issues surrounding the sustainability in the face of increased resource extraction by humans by including multi-disciplinary approach including study of biological systems, governance structures and sociological theories (Ostrom 2009).

Many theorists have suggested strategies of resilience and sustained management of the environment to enhance coping capacities to adapt to climate change (Adger 1999; Barnett 2010; Pelling 1999). The topic of human adaptation to climate change itself was once considered an under-studied and under-developed subject (Berkes & Jolly 2001; Burton et al. 2002). Now however, numerous studies have been carried out through different theoretical dimensions such as anthropology by Crate (2008), Jacka (2009); development theory by Adger (1999); feminist ecology by Bee (2013); political ecology by Pelling (1999), Tschakert (2013) and Shearer (2012); and entitlement approaches by Adger (2003), Pelling and High (2005), and Dulal et al. (2010).

The concept of socio-ecological system is based on the premise that environmental problems are impossible to solve with traditional solutions based on resource and environment theories but require the inclusion of societal aspects as well (Berkes et al. 2003). A conceptual diagram of the socio-ecological interactions with the goal of sustainable society is given in Figure 2.1. According to the framework, the interactions within the ecosystem and the people based on the technologies, knowledge and resource sharing mechanisms results in the final outcome of the overall socio-ecological system. Documenting and understanding the patterns of interactions can give insights into how a certain outcome is attained.

Figure 2.1 Conceptualisation of social and ecological systems for resilience and sustainability.



Source: Adapted from Berkes et al. (2000, p. 15).

An ecological system is under constant pressure from multiple stressors and factors. In fact, socio-ecological systems are under constant pressures trying to change the system, but under general circumstances, the system remains within thresholds of tolerance that allows it to continue to function (Gallopín 2006). Even slow rates of change of any one factor can have a miniscule effect on the system until a threshold is crossed, at which time the effects magnify and may cause shifts which are difficult to reverse (Scheffer & Carpenter 2003). Predicting and detecting such thresholds can allow interventions in the system to avoid the system from

overcoming the threshold and thus prevent the system from reaching an undesired state (Bardsley & Hugo 2010; Lebel et al. 2006; Scheffer & Carpenter 2003). Wrathall (2012) has theorised how a specific event of massive coastal inundation sparked exodus of the villagers resulting in major changes to the livelihoods and overall degradation of the social system that existed prior to the event. In such situations, it's the poor and the marginalised who suffer the most due to higher "social vulnerability"—a term which will be discussed later. Analysis of the inter-linkages of socio-ecological system will help in better planning such that not only lives are saved but also the social fabric is preserved should such an event occur.

Since the environment does not exist in independence of society in the Anthropocene, the study of "the environment" inherently always includes the interface between humans and the environment. The study of adapting to environmental change demands an exploration of how the community and the natural systems interact and influence each other. The emphasis then should be on studying the physical environmental system in relation to the human communities influencing and being influenced by it. A study on environmental issues hence compulsorily includes topics on knowledge sharing, political rights, social inequalities, power structures and cross-boundary interactions. In this research, the case of the Tarai is explored with critical analysis of the evolution of interactions and outcomes in response to external influences. Next, a brief review of literature on the two central themes of this research are presented. Firstly, literature on human mobility in relation to climate change, followed by discussion on documenting environmental change in the Tarai.

2.3 Human mobility and climate change

In the context of human geography, the term 'migration' generally refers to the movement of people from one place to another. The movements can be over short distances within a country or international, and the relocation can range from seasonal to permanent or anything in between (Hugo 1996). The drivers of migration vary from economic reasons, to conflicts, natural hazards or lifestyle reasons. The analysis of migration has been tackled from different perspectives in the social sciences. Theories on migration can be crudely lumped into two categories—micro and macro perspective theories based on whether the focus is on the individual/household or broader institutional factors. Micro perspectives look at the migrant's individual traits and household features to analyse why and how they migrate. Therefore, household-level indicators are important determinants in predicting migration decisions (Hugo 1998). Macro perspective theories emphasise the influential characteristics of the influence of community or national and international policies which make migrants seek livelihood opportunities away from home.

Among the theories looking at micro factors, the "new economics" or “new economics of labour migration (NELM)” model frames decisions from a household perspective in contrast to the neo-classical with an emphasis on an individual's decision (Bodvarsson & Van den Berg 2013). New economics, and other related models implicitly assume an important association between mobility and search for off-farm employment as a way to minimise risk. Households or families minimise risk by allocating local and distant work to different members of the household (Stark 1995). The selective nature of migration is also important, since the chosen migrant in the household is most likely the one with superior human capital endowments like health, strength or education (Bodvarsson & Van den Berg 2013). The strong emphasis on family needs and the altruistic nature of individuals to remit income back home is vital for the socio-economic conditions of the Tarai. Modern circular migrants dominate contemporary migration in the Tarai—almost entirely aiming to generate remittances in a short time frame per destination, and there is little desire to permanently migrate, so the NELM model arguably best explains the micro factors of the case studies presented here.

It is not only the individual and household factors, but also the global demand for cheap labour and the national and international fiscal policies that make such movements possible. Among the theories looking at macro perspectives, "institutional theory" captures the macro scenario of migration by recognising the role of recruitment agencies, international employers, and nation states as agents working together that facilitate mobility from certain sources to certain destinations. This theory regards migrants as agents who are “organised, selected and controlled" (Goss & Lindquist 1995b, p. 335). Although the "new economics" model may explain the micro factors at the individual and household level, it is important to include factors, such as the role of the environment in the migration decision-making; the processes by which livelihood opportunities are handled by households in the home community; the management of environmental threats that increases uncertainty in in-situ livelihoods. The role of macro factors still applies in the context of the vast network of institutions which help rural communities expand their livelihood opportunities to an international level.

2.3.1 Environment and migration

The role of migration as a means for managing environmental risks to reduce household’s vulnerability and ensure livelihood security has been studied by many (Black et al. 2011; Hugo 2008; Scheffran et al. ; Tacoli 2009; Warner 2010). In recent years, the scholarship on environment-migration nexus has grown considerably, especially in the context of migration induced by climate change. The concept of environmental migration is said to have started with the identification of "environmental refugees", which was coined by the then United Nations

Environment Programme (UNEP) representative El Hinnawi in 1985 (Millock 2015). Much environmental migration literature relates to cases of natural disasters like hurricanes, floods or slow onset changes like sea-level change, soil erosion and environmental degradation (Bardsley & Hugo 2010). In the case of the Tarai, it is important that both the occurrences of extreme events, such as floods and the slow degradation of the environment, be examined to analyse possible implications for migration decision-making. Common theories and case studies on climate change and migration describe migrations with a wide gamut of impact horizons—some can be rapid onset like an extreme weather event, whereas others can be slow, taking decades to cause real effects like receding shorelines. The resulting migration from such events will also vary widely, ranging from being displaced and having no place to return on one extreme end, and seeking temporary, seasonal work in a neighbouring region at the other.

The relationship between environment and migration includes complex interactions between environmental factors and various socio-economic variables are required to explain why the decision to migrate or not to stay behind is carried out. Castles (2002, p. 5), for example, argues that migration cannot be studied in isolation because the phenomenon itself is influenced by wider social processes. The proponents of this theory points to the problems of drawing direct causal relationships without considering the social and political dynamics under which all human decisions are made. Analysing the environmental impacts and the underlying vulnerabilities of the community provides insights into possible outcomes of the impacts. Migration can be one of the outcomes but the environmental causes and are almost always intertwined with other socio-economic factors. This mediation adds to the complexity of the nexus of causality and relationships to the environment are difficult to detect. Despite the recent overwhelming interest in environment-migration relationships, migration events caused by environmental triggers are nothing new, as human movements have always been affected by environmental events and access to resources (Piguet et al. 2011). The modern history of the Tarai landscape is built around the exploitation of natural resources to sustain increased population and the desire of individuals and households to escape hardships prone regions, and so it provides important examples of that history.

The study of climate change impacts on migration demands multidisciplinary research involving comprehensive data gathering and conceptual formulations (Kniveton et al. 2008). Household or individual vulnerability analyses can inform who are most affected and most likely to migrate. Since migration often involves financial capital and access to social networks, the most vulnerable may be left behind and are unable to tap into the benefits of migration (Black et al. 2011). Factors related to agricultural activities and access to natural resources have been

conceptualised to have impacts on the well-being of individuals, households and communities. Such environmental factors are difficult to detect as there are complex interactions among multiple variables related to socio-economic and institutional issues.

Overall, the consensus among the theories are that 1) migration decision-making involves complex considerations by the individual and the household weighing the available options and costs; 2) migration is rarely a single onset phenomena and involves multiple stressors. It is important to understand that environmental impacts will not (except in the most extreme cases) will not result in huge sections of the population migrating. This approach considers existing patterns of movement and how such flows will evolve in the context of environmental stressors at the source. Although this research does not study the pull factors at destinations in any detail, the shift in destination choices has been documented and analysed. Analysis on who migrated and who stays behind is carried out based on the socio-economic conditions of the household and their perception of environmental impacts.

Due to high reliance on traditional farming techniques, the success of harvests in the Tarai are still strongly influenced by rainfall patterns, especially monsoonal rainfall during the months of June to September. A year of agriculture with an unfavourable rainfall pattern will result in poor harvests and thus be more likely to push the household to seek off-farm income to maintain stability. The relationship is not direct as various factors related to the socio-economic status of the household interact with these decisions. This diversification strategy employed by the household is well documented; in fact, off-farm livelihood development is core to the agrarian transitions in the Tarai and elsewhere [e.g. See Nielsen and Vigh (2012); Mortimore and Adams (1999); Henry et al. (2004); and Ellis (2000)]. Changes to extreme precipitation and consequential flood and landslide incidents are expected to further aggravate the problems of poverty in Nepal and result in increased out-migration (Hugo & Bardsley 2013). A few studies have looked at the impact of environment among other factors on out-migration from the Nepali Tarai. Massey et al. (2010b), using data from the central Nepali Tarai, found that in rural areas, out-migration is reduced when there is increased local economic development in the short-term, but such improvements will increase the social capital and economic capability that encourages out-migration in the long-term. In other words, improved personal and household conditions have a negative impact on the desire to migrate. Access to capital, both economic and social, however enables rural people to look for more migration opportunities. This chain of events is in line with the traditional economic principle that access to capital enables the individual to finance migration so the propensity to migrate is increased (Massey et al. 1999). Massey et al. (2010a), using secondary data from the Chitwan Valley Family Study (CVFS) from late 1990s, revealed that the

effect of environment on migration decision-making was mostly for short-distance mobilities in the central Tarai. Rather than migration being a recent livelihood strategy for the people of the Tarai, there have been inter-generational changes in forms of mobility. Hence, it is difficult to accurately detect the simplistic influences of environmental factors in the migration decision-making. Rather, the environment has played a central role in the development of the Tarai as a populous region. Elements of regional natural resources such as dense forests, fertile soils and ample water sources, coupled with the warm climate made the region a prime candidate for agricultural development, and that has facilitated in-migration as a result. More recent mobility is simply a form of movement more suited to the contemporary globalised era.

2.3.2 Summary review of principles on environment-led migration

The scholarship on environment and migration has shifted from the focus on alarmist displacements scenarios to migration being a tool in the household's arsenal for adaptation (Tacoli & Mabala 2010, p. 394). Migration as a form of adaptation has been recognised by many case studies – e.g. Oliver-smith et al. (2009); Warner (2010). Bardsley and Hugo (2010, p. 243) for example, frame migration both as strategic adaptation and a forced response to failures in-situ adaptation to environmental change. Findlay (2011) has outlined principles on how migration resulting from climate change will behave in terms of destination selection. The focus on destination patterns suggests an important pathway for analysing environmental migration and predict future flows. A focus on destinations gives the government options to facilitate moves through international relations, thus making moves more accessible for people at the local level as a form of adaptation in addition to in-situ adaptation options (Findlay 2011).

Additionally, other migration theories and case studies have made similar predictions for movements resulting from environmental change. A summary of the major principles from the migration scholarship is presented below.

1. The majority of those affected will seek to remain and not migrate (Findlay 2011).
2. International migration is expensive and it's generally the poorest who are left behind (Black et al. 2011; Castles 2002; de Haan 2000).
3. Cause and effect of migration are not straight forward; cases vary by case e.g. drought and migration, rainfall and migration (Boyle et al. 1998; Castles et al. 2013; Wood 2001)
4. Migration patterns are likely to follow existing patterns (Adamo 2009; Hugo 1996)
5. Most migration is internal and short-term (Hugo 1996, 2006; Massey et al. 2010a)
6. Environmental impacts mostly result in short-distance moves (Massey et al. 2010a)

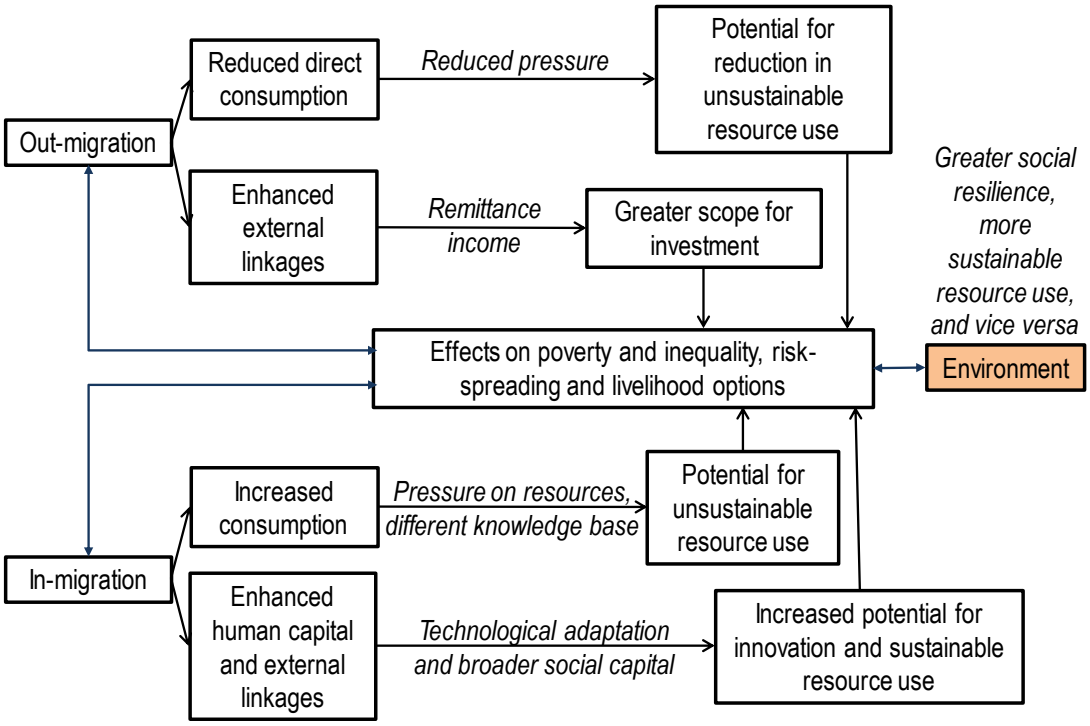
Many prevailing theories on migration do not explicitly link migration with environmental factors, but some theories can explain the role of environmental component in migration decision-making. Social resilience refers to the community's power to survive external disturbances with relative ease (Adger et al. 2002). This concept of resilience can be applied at the household level to mean the ability of the household to come out unscathed after facing a strong shock. External disturbances can come in many forms—environmental hazards, change in government policy, shifts in social structures and so on (Adger et al. 2002). Households deal with stress through livelihood activities, access to natural resources, access to financial capital and access to social networks. For instance, if a household relying on agriculture were to lose a harvest due to a flood, they will cope with a range of mechanisms like alternative employment, selling of livestock or borrowing money. These mechanisms which depend on the resource base available and the socio-economic condition of the household that allows the household to survive and plan for the next round of crops. Households also aspire for certain goals in order to improve resilience. At the most basic level, households want to 1) increase income, and 2) reduce or spread risk. Utilising a range of natural, economic and social resources, households and communities work dynamically towards those targets. As long as the household has ample resilience, external shocks will be absorbed and the household will return to operating normally. However, if external pressures are particularly harsh, or if the resilience is already reduced from earlier shocks, then household will collapse. The overall interactions within the system are determined in part by the political-economic structure of the state.

Adger et al. (2002) argue that, both in-migration and out-migration alter the interactions by which communities access natural resources and ultimately impacts overall resilience. Figure 2.2, adapted from Adger et al. (2002, p. 359) work shows a model of the impacts migration can have on community's overall resilience and the ecology. Migrants moving into a community takes its toll on the natural resources as demand increases. On the positive side, migrants bring human capital, which can lead to efficient use of resources. Together, that was the basic pattern of mobility in the Tarai for three decades from the 1960s. Migrants moving away from the community free up resources for the remaining population aiding in resource conservation. Additionally, remittance income sent by migrants can be channelled into local development efforts, but can also lead to a reduction in human resources locally. Adger et al. (2002, p. 359) state:

> Migration and remittances provide flexibility in livelihood options, and returning migrants enrich the stocks of human, social and cultural capital of origin communities, bringing with them links to trans-national networks.

The interactions in recent times in the Tarai are a lot more complicated and involve more intricate linkages than suggested in Figure 2.2. Nevertheless, this basic conceptual linkage can be used to examine the effect of migration on socio-ecological resilience at a broader level.

Figure 2.2 Conceptualisation of the effect of migration on socio-ecological resilience.



Source: Adapted from Adger et al. (2002, p. 359).

Remittances received from migrant members provide opportunities for the household to invest in land and technology resulting in advancement of agricultural practice. Investment in education and health of household members enable improved management of resources in the future. Remittances input received can boost the receiving economy through positive multiplier effects (Stahl & Arnold 1986). However, remittance income can have negative consequence on the system if invested in unsustainable practices (Adams 1993; Sapkota 2013).

2.3.3 Theorising environment-migration nexus

The out-migration from under-developed regions in search of better livelihood opportunities has sparked a wide range of research for well beyond a century. Such movements of people occur nationally, regionally and across international destinations and have implications on the source regions as well as the destination regions. In deciphering the factors behind these flows, studies have focused on illustrating the roles of social, economic and demographic variables. It is widely recognised that the study of migration cannot be limited to a sole discipline (Castles & Miller 2003; Molho 2013). Earlier theories of migration focused primarily on economic aspects. These theories view the differences between source and destination as a function of economic

opportunities as theorised by Ravenstein (1989), and Hicks (1932) (Molho 2013). A clear weakness of this theory is the full weightage on individual factors while ignoring interactive cultural, social, political and historic factors which can influence the decision-making process. Later theories like the "new economics" model put higher stress on larger units like families and households as decision makers (Stark 1995). Diversification of income by rural households is a necessary means to minimise or avoid unanticipated risks; a migrant member of the household is a common way of ensuring multiple income sources (Ellis 2000). These theories still ignore external factors and regard collective decision-making by the household as the sole motivator of migration. Additionally, many social decisions including migration are carried out as communities and societies rather than families or individuals (Goss & Lindquist 1995a). To overcome this particular shortcoming, "network theory" methods look at the effects of social networks like kinships and strength of communities which individuals utilise to gain livelihood opportunities and household (Massey et al. 1990).

There have also been theories proposed that examine the impacts of wider institutions on migration phenomenon. These "macro-perspective" theories study migration as a combination of the political economy of global market, inter-nation relations and the set of agreed mechanisms to facilitate or hinder the flows of humans across national or international borders (Castles et al. 2013).

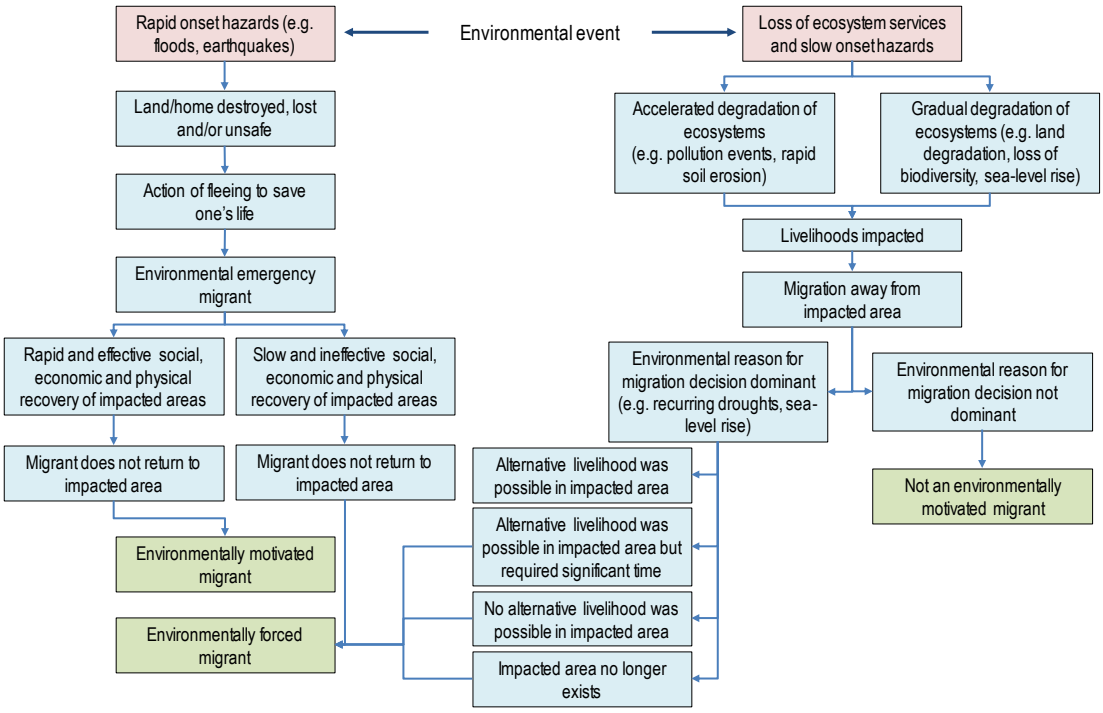
Environmental factors as the source of migration is increasingly being explored. Although environmental factors are generally not the primary drivers of migration, the consensus among the environment-migration researchers is on the complex interactions of environment-related variables which influence social and economic factors. Studies have looked at environmental factors such as access to firewood, and degradation of natural resources [e.g. Massey et al. (2010a)]; extreme events [e.g. Uddin (2013), Runfola et al. (2016), and Wrathall (2012)]; drought incidents and rainfall variability [e.g. Henry et al. (2004), Findley (1994), Gray and Mueller (2012), and McLeman et al. (2007)]; and global environmental change [e.g. Warner (2010), and Scheffran et al. (2012)]. It is that complexity which will, in part, be examined in this thesis.

From an individual or a household perspective, migration can be a tool to diverse income and strengthen resilience against economic risks arising from various factors including environmental factors. In the case of rural societies relying on agriculture, the economic risks can arise from factors such as a decrease in production; a rise in cost of production; a fall in price of output; a lack of rainfall; a loss of land to flood; damaged crops; a lack of markets to sell produce; or an inability to purchase fertilisers etc. Many such factors are directly or indirectly tied to environmental triggers. Farmers, especially in developing regions, rely heavily on rainfall for

irrigating their crops due to resource constraints. They also rely on natural resources like forests, river water and communal land for agricultural and allied activities. Households may opt for migration to reduce uncertainties surrounding their livelihood in the hope of reducing risk at the household level (Massey et al. 1993). In such cases, a member from the household migrates to a far-off location in the hope of sending remittances that are independent of the conditions at home. Farming in an underdeveloped rural setting is a risky venture and there are no socio-economic safety nets in case the harvest goes bad. As widely documented in the prevailing literature, sending off a member as a migrant gives the household a mechanism of insurance against economic shocks. The benefit of regular remittance from a migrant member provides a lifeline to the source household. Often, the high cost of migration pays off, as remittances are usually higher than the income at the source location.

Migration resulting from environment varies immensely from a simple livelihood diversification strategy, to forced evacuation due to loss of homeland. Renaud et al. (2011) have theorised a framework for determining categories of environmental migrants, namely, "environmentally motivated migrant" or "environmentally forced migrant" (Figure 2.3). While the framework is able to explain a wide range of environmental migrants, the process by which environmental factors translate into migration is complex and non-linear, a topic which will be discussed in detail in Chapter 5.

Figure 2.3 Classification of environmental processes and migration outcomes



Source: Adapted from Renaud et al. (2011, p. 16).

The Nepali Tarai has long been characterised by a high level of internal and international migration, especially to India (see Kansakar (1985), Gurung (1989) for more detailed accounts). The modern history of Nepali out-migration to India goes back to early 1800s (Dahal & Chaitanya 1987) but for this research, only the migration patterns from the 1960 onwards are considered in detail. In the 60s and the 70s, there was a government-led planned resettlement program to move people from the Hills to settle in the newly cleared land on the plains (Kansakar 1985; Shrestha 1985). The resettlement was initiated in 1970 in Jhapa district and 1976 in Kailali district (Kansakar 1985).

Nepal also shares a long and open border with India. Generally, Nepali citizens have freedom to move within the country and to India without restriction. As travellers crossing the border from either sides are not required to submit any documents, the movement goes largely unrecorded. Due to the nature of temporary mobility, it is difficult to quantify and is often not captured by most surveys and censuses (Hugo 1982). Regmi (1971, p. 10) claims that one of the reasons behind the extension of the Tarai to include in the new Kingdom which became present Nepal, in the 18th century by the then king, Prithvi Narayan Shah, was the advantage of agricultural lands. The Tarai once supplied produce to places across the border and further, to like Patna and Murshidbad (Regmi 1971, p. 20). In the 18th century, in an attempt to increase revenue for the state, the in migrants were brought in from neighbouring India and settled in frontier lands in the Tarai (Regmi 1971, p. 143). In some regions in the eastern Tarai, citizens who wanted to settle were handed land for free, but despite such efforts, the population in the Tarai remained low, until the Nepali government-led migrations (Regmi 1971, p. 146).

2.3.4 Documenting environmental change in the Tarai

The linkages attempted in this thesis regarding environmental change, farmers' perception, social change and temporary migration are mostly not direct and definite. Yet, the impact of changing rainfall patterns and warming temperature are visible in the daily lives of the Tarai residents. Although remittances have improved resource access and shielded households from hazards in Nepal, the poor and marginalised are still facing barriers with added vulnerability. The access to remittance income significantly enhances the coping or adaptive capacity of the household. Remittances sent from household members have been invaluable for post-flood resettlements in the Koshi Basin in Nepal (Banerjee et al. 2011). Besides the obvious disadvantages in relation to access to resource and facilities, poor and marginalised communities' vulnerability is linked with institutional mechanisms and the political economy which favours the more privileged (Adger 1999). The access to means of off-farm and ex-situ income depends on the household's socio-economic situation. Understanding gendered and cultural divisions can also be important to gain

insights into how they respond to social and environmental stressors (Bee 2013). For these reasons, a purely physical explanation of the parameters causing environmental variability and change will be of limited use in planning a societal response. The understanding of complex socio-ecological interactions can be employed to aid adaptation responses and planning (Wiseman & Bardsley 2013). Studies of the multiple inter-linked drivers that constitute socio-ecological systems is needed to account for vulnerability and once identified, such drivers can be used to forge planning solutions.

2.4 Climate variability and change in the Tarai

Much of the existing literature on climatic trends rely on interpolated values, but such trends should be taken with caution as they are unable to depict variations at local scales. Regionally, a study of climate data from 116 stations in Central and South Asia found an increase of both daily minimum and daily maximum temperatures (Klein Tank et al. 2006). Sheikh et al. (2015) observed increases in warm extremes and decreases in cold extremes over South Asia. The IPCC (2001) reported global increases in minimum temperatures at a rate nearly twice that of maximum temperatures since 1950s. According to Salinger (2005, p. 12), increases of average night-time daily minimum temperatures over land were twice the rate of increase of daytime daily maximum temperatures (i.e. approximately 0.2°C, compared to 0.1°C per decade) from 1950 to 2000. Recent IPCC reporting also suggests faster increases in the minimum temperature extremes in comparison to the maximum temperature extremes across the globe (Hartmann et al. 2013). However, the IPCC's fourth assessment report notes that South Asia (India) has witnessed increases in both cold and warm extremes (Christensen et al. 2007).

The study of extreme temperature dynamics is an important component of climate change research. Hartmann et al. (2013) and Ciais et al. (2005), have reported increases in heat waves and extreme maximum temperature events globally, but with considerable temporal and spatial variability. Choi et al. (2009), Caesar et al. (2011), and Chambers and Griffiths (2008) have also reported increasing trends in frequencies of extremely warm days and nights, extremely cold days and nights, and heat waves in South-East Asia and Oceania. Furthermore, it is believed that the changes in mean temperatures (which are well documented in the Himalaya) will lead to higher temperature extremes and greater rainfall extremes in the region (Mitchell et al. 2006). Agarwal et al. (2015) estimate an increase in the number of summer days and tropical nights during the 2020s, 2050s and 2090s in the Koshi Basin in eastern Nepal.

Both historic and projected precipitation, as well as the analysis of instrumental records from the last three decades, reveal evidence of variable and uncertain monsoonal rainfall in Asia. However, it is reported that various existing global and/or regional climate models fall short at reliably

predicting precipitation levels for South Asia in general (Karmacharya et al. 2015) and Nepal in particular (Gillies et al. 2013).

The South Asian monsoon is critically important for agricultural production in the fertile Ganges basin where the Nepali Tarai is situated. Many studies claim that the summer monsoon has become more erratic in recent decades (Cherchi et al. 2011; Kripalani et al. 2007; Mirza 2011; Shrestha et al. 2000; Turner & Slingo 2009; Wang et al. 2012; Zhang & Zhou 2011). Naidu et al. (2015) described decreased rainfall over most of India in the last three decades resulting in reductions in average soil moisture conditions. However, monsoonal behaviour in Nepal, has been found to be highly variable in the last three decades of the last millennia (Chaulagain 2006; Manandhar et al. 2011; Shrestha et al. 2000). Some studies project moderate increases in the extreme monsoonal rainfall (Bapuji Rao et al. 2014; Rao et al. 2014; Schewe et al. 2011; Sharmila et al. 2015), while others like Sheikh et al. (2015) identify more mixed changes with evidence of spatially coherent changes only available at local scales. These studies project future increases in the severity and frequency of both short and strong monsoons, indicating increases in the intensity of wet days, and long and weak monsoons, together with an increased probability of the occurrence of events conducive for both floods and droughts in the Indian sub-continent. In particular, very heavy rainy days (R95p) are projected to increase by around 40–50 percent, while the precipitation per wet day (SDII) may intensify by 10–40 percent by 2080s in the Indian sub-continent (Bapuji Rao et al. 2014), with likely spatial inconsistencies indicating further variability and uncertainties. Panday et al. (2014) also estimate an increase of both extreme warming and wetter climate over the Hindu-Kush Himalaya region in the 21st century.

Before delving into a specific outline of Tarai research in the following chapters, the conceptualisations of core ideas that have been used to frame the critical discussion are presented.

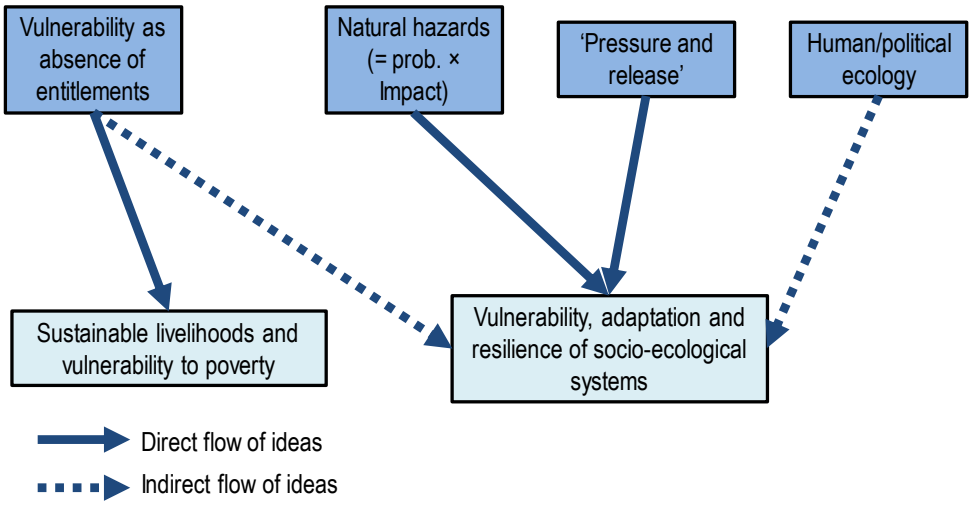
2.5 Conceptual descriptions of climate change risk

2.5.1 Vulnerability

Natural systems comprise bio-physical processes occurring in the surrounding environment, whereas social systems are formed by the rules and institutions that govern how humans can and cannot make use of natural resources. Together, they form a system of understanding or interpreting the natural systems in relation to human societies (Berkes et al. 2000). The vulnerability, or lack thereof, of a household or a group depends on the availability of resources and the access of the household to the resources (Adger & Kelly 1999). A household's livelihood strategy is affected by external factors such as the environment, political and socio-economic

situation and changes in opportunities. Thus, it's not only the lack of the resources that determines vulnerability, but rather the absence of ways in which the resources can be accessed. In the context of environmental hazards, vulnerability is determined by a combination of the hazard magnitude, which influences the exposure and the sensitivity, and the resilience or adaptive capacity of the subject to cope with the hazard (Turner et al. 2003). The vulnerability of a household's livelihood opportunities from environmental impacts such as from floods, droughts or rainfall variability will thus critically depend on how the household can handle the situation, perhaps through utilising savings, selling of assets, borrowing money or seeking alternative livelihoods. In the context of negative impacts from climate change, Adger (1999, p. 252) defines social vulnerability as "the exposure of groups or individuals to stress as a result of the impacts of climate change and related climate extremes, following from the definition outlined by Chambers (1989)". Adger (1999, p. 252) further points out the intricate relation between poverty and vulnerability citing poverty as "an important aspect of vulnerability because of its direct association with access to resources which affects both baseline vulnerability and coping from the impacts of extreme events". Adger (2006) compares the access to resources as entitlements, based on the works of Sen (1981, 1997) and Leach et al. (1997) explain the temporal nature of vulnerability, which depends on changing access to resources over time. The aspects of a Tarai household's ability to safeguard its livelihood opportunities in relation to poverty and social inequalities are described in Chapter 4. Adger (1999) conceptualisations of vulnerability have been based on cases of climate change impacts in Vietnam and is especially applicable in the context of the Tarai due to parallels in incidences of poverty in rural Vietnam and the Tarai although the context themselves are unique in many ways. The concept of vulnerability itself has developed gradually over the years starting off with societal linkages of hazards to the contemporary description, which includes socio-political theories as summarised in Figure 2.4. This inter-disciplinary borrowing of ideas is key in analysing the complexities of socio-ecological systems.

Figure 2.4 Evolution of the concept of vulnerability.



Source: Adapted from Adger (2006, p. 271).

Adger and Kelly (1999) proposed a framework for conceptualising social vulnerability to climate change by using three categories of indicators, namely, poverty, inequality and institutional adaptation, which are in reality, linked through interactions between institutions as determined by the prevailing social norms. Table 2.1 outlines the indicators, their properties and how they shape vulnerabilities. Once again, poverty and inequality, which closely relate to vulnerability, form the basis of two indicators. Both poverty and inequality however are co-produced by social institutions and norms which direct the usage rights for resources. The third indicator relates to the institutional structure, which determines the rules of sharing, directly influences entitlements. Adger and Kelly (1999) point out that the institutions in this case include informal institutions as well as formal institutions. An example of an informal institution in the context of the Tarai could be the practice of males seeking off-farm work, while females are left to take care of the household farm and livestock. Local government efforts for disaster mitigation and relief is an example of a formal institution.

Table 2.1 A framework for conceptualising social vulnerability to climate change

Vulnerability indicator	Proxy for	Mechanism for translation into vulnerability	Measured by
Poverty	Marginalisation.	Narrowing of coping strategies; less diversified and restricted entitlements; lack of empowerment.	Materials or experiential poverty measures.
Inequality	Degree of collective responsibility, informal and formal insurance and underlying social welfare function.	**Direct:** concentration of available resources in smaller population affecting collective entitlements. **Indirect:** inequality to poverty links as a cause of entitlement concentration	Measures of the quantitative distribution of assets and entitlements
Institutional adaptation	Architecture of entitlements determines exposure; institutions as conduits for collective perceptions of vulnerability; endogenous political institutions constrain or enable adaptation.	Responsiveness, evolution and adaptability of all institutional structures.	Study of institutions through decision-making, social learning and inertia.

Source: Adapted from Adger and Kelly (1999, p. 259).

2.5.2 Coping

Many systems can withstand stress over a short-timeframe if the magnitude is within its coping range. The coping capacity of a system can be defined as the ability to respond to an occurrence of harm without facing significant consequences (Kelly & Adger 2000). Adaptive capacity of a system on the other hand, refers to modifications in a system's "structure, functioning or organisation to survive under hazards threatening its existence" (Pelling 2011, p. 35). Essentially here, coping actions utilise the existing structures with minor adjustments on actions, whereas adaptation measures are more calculated and include stronger shifts in actions that changes the organisational structures. Table 2.2 outlines some of the differences between coping and adaptation as complied by Pelling (2011). Yohe and Tol (2002) describe the coping range of a system as the variation of impacts within which the system will survive unscathed. When the impacts are far greater than the coping range, the damage to the system is important and detrimental. The range of actions available for coping however, depends on the overall adaptive capacity of the system and incorporates the role of coping capacity. Coping constitutes the range of actions used by a household to survive unanticipated shocks as and when it occurs. Adaptation by contrast includes some form of "forward planning" of livelihood diversification to ensure shocks will be handled in the future (Ellis 2000). In the case of a Tarai household, the

coping capacity depends on the household's socio-economic status, like the availability of land, human capital, savings, and the ability to borrow money. In cases of an adverse event, say flooding, the household will be unable to gain expected income from harvests, and lead to coping actions such as spending savings, borrowing money, minimising expenses, and selling of assets to compensate. Enhancing coping capacity through increased savings, easier borrowing mechanisms and diversifying livelihoods will benefit the household in handling future occurrences of risks of similar magnitude. Over time, a household can increase its coping capacity by increasing savings, investing in assets or involving one member in off-farm work. In the case of future risks becoming significantly more damaging, or occurring more frequently, the coping capacity will be unable to protect the family from a permanent impact. For example, if a household loses all their agricultural land to flood, their livelihood system is permanently eroded thus fundamentally changing future livelihood options.

Table 2.2 Comparison between coping and adaptation.

Coping	Adaptation	Source
The ability of a unit to respond to an occurrence of harm and to avoid its potential impacts	The ability of a unit to gradually transform its structure, functioning or organisation to survive under hazards threatening its existence	Kelly and Adger (2000)
The means to survive within the prevailing systems of rules	Change to the institutions (cultural norms, laws, routine behaviour) embodied in livelihoods	Gore (1993)
The range of actions available to respond to the perceived climate change risks in any given policy context	Change to the set of available inputs that determine coping capacity	Yohe and Tol (2002)
The process through which established practices and underlying institutions are marshalled when confronted by the impacts of climate change	The process through which an actor is able to reflect upon and enact change in those practices and underlying institutions that generate root and proximate causes of risk, frame capacity to cope and further rounds of adaptation to climate change	Pelling (2010)

Source: From Pelling (2011, p. 36).

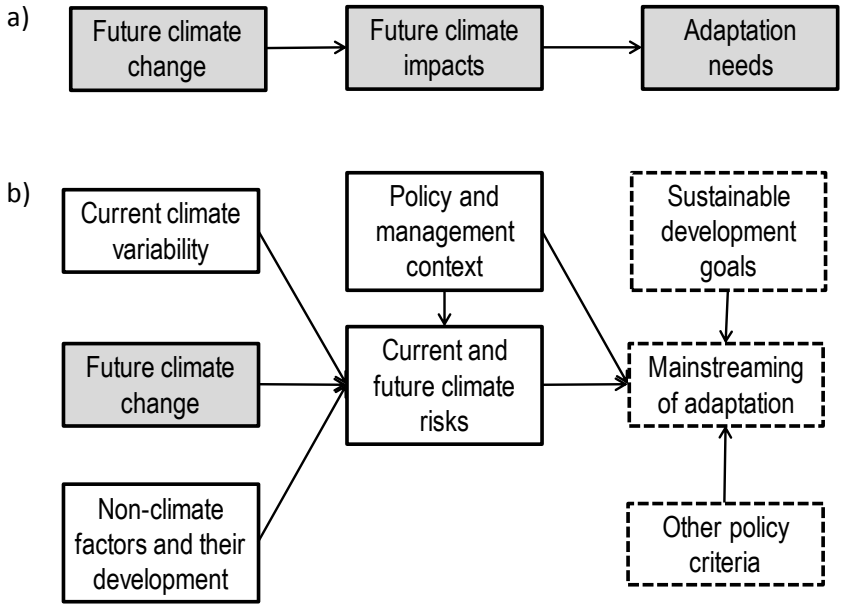
2.5.3 Adaptation

The study of adaptation has received increased attention although the interest in guiding paths to address climate change. Adaptation to environmental change itself is not a recent phenomenon. In fact, human societies and socio-ecological systems have always taken cues from the surrounding environment and made significant adjustments to their way of life. The IPCC defines adaptation as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2013, p. 118). The IPCC also outline three types of adaptations: 1) Anticipatory or proactive adaptation which are carried out before the impacts are even felt; 2) Autonomous or spontaneous adaptation which does not constitute a calculated response to climatic stimuli but is prompted by ecological changes in natural systems or, by market or welfare changes in human systems; and 3) Planned

adaptation, which is the outcome of a deliberate policy decision, formulated from an awareness that conditions have changed or the changes are inevitable and that action is needed to return to, maintain, or achieve a desired state. Adaptation processes are intended to modify systems such that impacts of actual or expected changes cause minimal harm to the system. The modifications occur through behavioural changes that reduce harm or by exploring opportunities and building resilience. Although the concept of adaptation can be defined in simple terms, explaining the process of adaptation, the actors carrying out adaptation and the interaction of adaptation actions with the socio-ecological systems adds layers of complexities (Pelling 2011). In particular, the processes of adaptation are intricate and require a multi-disciplinary approach to understand (Tschakert 2007). A typical case of adaptation, as described by Füssel (2007), consists of extreme events occurring a number of times, forcing the community to decide on an adaptation response, because the alternative of not adapting would incur a greater loss. Post adaptation, the community is able to withstand extreme events of any anticipated magnitude. If in the post adaptation period, extreme events of magnitude larger than planned were to occur, then the community would not be able to function normally but could recover more quickly. This can lead to further adaptation measures, this time, in anticipation of the recent extreme events. Resilient systems are better equipped to adapt to adverse impacts and can also tap into the advantages brought about by the changes (Barnett 2001). Historical experiences of a community with disasters or abrupt environmental changes can aid in building resilience and can be exploited in the advent of further changes.

The literature on climate change adaptation takes into consideration both climate and non-climate factors (Füssel 2007; Füssel & Klein 2006). Initially, adaptation approaches were categorised as a direct causal relationship between climate impacts and effects as shown in Section (b), Figure 2.5. Many initial adaptation planning efforts such as the initial national communications to the United Nations Framework Convention on Climate Change (UNFCCC) were based on this framework. Recent frameworks include a more intricate assessment that involve non-climatic factors in addition to climatic factors and take into account the goals in parallel with other development goals as shown in Section (a), Figure 2.5.

Figure 2.5 Conceptual framework showing the evolution of climate adaptation approaches.



Source: Adapted from Füssel (2007, p. 272).

Pelling (2011) has conceptualised adaptation discourses in three different but related stages, resilience, transition and transformation. Table 2.3 outlines the distinctions between the three stages as per the resilience-transition-transformation framework. Resilience constitutes the ability to adjust within the established norms; transition describes step by step changes undertaken without challenging the existing rights structure; and transformation refers to complete "regime change" (Pelling 2011). Adaptation in the form of resilience constitute the actions carried out to safeguard the system from external impacts within the existing structural framework. Resilience of a socio-ecological system changes over time as the experiences of facing a hazard is transferred through social learning processes. Adger and Kelly (1999, p. 257) conceptualise social learning as "a composite of individual adaptation, such that adaptation comes about through activities which depend on the participation of group members in discourse, imitation or shared collective or individual action". In the case of the Tarai, the practices to protect agricultural fields from floods can be taken as social learning which results in adaptive actions collectively. The measures which have worked in the past will be remembered and practiced in the future raising the overall resilience of the system for similar threats.

Table 2.3 Attributes of adaptation for resilience, transition and transformation.

	Resilience	Transition	Transformation
Goal	Functional persistence in a changing environment	Realise full potential through the exercise of rights within the established regime	Reconfigure the structures of development
Scope	Change in technology, management practice and organisation	Change in practices of governance to secure procedural justice; this can in turn lead to incremental change in the governance system	Change overarching political-economy regime
Policy focus	Resilient building practice Use of new seed varieties	Implementation of legal responsibilities by private and public sector actors and exercise of legal rights by citizens	New political discourses redefine the basis for distributing security and opportunity in society and socio-ecological relationships
Dominant analytical perspectives	Socio-ecological systems and adaptive management	Governance and regime analysis	Discourse, ethics and political-economy

Source: From Pelling (2011, p. 51).

Actions within the system to protect from external impacts are ultimately influenced by external institutions. The slow change of a system to incorporate new practices without attempting structural changes can be described by transition. Transition actions go a step further from resilience phase in the sense that the actions are not only about preserving the functioning of the system but modifying the governance processes (Pelling 2011). Transformation stage constitute of actions that seeks changes of the system by reorganising rules of exchanges (Pelling 2011). The notion of transformation of society in an attempt to minimise risk forms the basis of modernisation. The actions of modernisation however do not free the society from risks, but rather introduces itself to new risks, giving rise to what Beck (1992) theorises as risk society which will be discussed next.

2.6 Risk society and transnationalism

Beck theorised that the consequences of human progress and industrial development are a set of inevitable risks, which were never seen before (Beck 2009). According to the theory of reflexive modernisation, large social changes are not simply a product of intentional preparation but rather a result of the inherent transformation from first to second (or reflexive) modernity (Beck 1999). Reflexive modernisation thus is conceptualised as a process of transformation through the unplanned but compulsory side effects of modernisation. The risks of the past arose from events like famine, drought and illness which to a large extent have been solved and replaced by new “manufactured” risks (Mythen 2004). Beck (2010) links the issue of climate change to the consequences of reflexive modernisation. The risks from climate change are essentially distributed such as the poor and the most vulnerable receive a disproportionate share. According to Beck (2010), the problems arising from climate change are intrinsically related.

> Social inequalities and climate change are two sides of the same coin. One cannot conceptualise inequalities and power any longer without taking the consequences of climate change into account, and one cannot conceptualise climate change without taking its impacts on social inequalities and power into account (Beck 2010, p. 257)

Beck's Risk Society concept is said to have emerged in part to deal with environmental issues in Europe. The consequences of modern environmental problems are difficult to handle and the ultimate culprit is not one particular source but the broader society with its resource hungry mode of implementation (Matten 2004). Classical modernity comes from rationalisation of the traditional structure of societies whereas reflexive modernisation questions the practices and modifies the course of action based on the new available information. Matten (2004) further explains that environmental problems in a reflexive modern world are inevitable results or side-effects of modern lifestyle. The new risks cannot be handled by conventional tools and means. The risks are "not a result of any particular individual's decision" (Matten 2004, p. 380). Moreover, the risks are also not bound by traditional boundaries. In Beck's risk society, the environmental risks have political consequences (Mythen 2004, p. 36). Beck (2010, p. 264) further argues that cosmopolitanism could hold opportunities for a transnational solution to global environmental problems.

> The cosmopolitan turn opens up the transnational arena of political action. This is at least one way in which realistic answers can be found to the climate problem and other matters of global concern to people on a daily basis. Even those who have been steamrollered by modernity need a cosmopolitan vision in order to transform their vulnerability, step by step, into strength.

Transnationalism refers to the social conceptualisation driven centrally by the increased connections between people and the eroding of the concept of nation-state boundaries.

> A transnational community is based on specific mobility know-how, 'migration expertise'; the inhabitants of these places, so strongly marked by migration, have made it their essential activity. (Bruneau 2010, p. 44)

Global environmental risks cannot be tackled by a single government or a nation state alone (Haas 1999, p. 107). Despite a seemingly global nature of environmental hazards such as the impacts from global environmental change, the spatial distribution of such risks is uneven. Actions to adapt to such threats hence require a contextual approach. Nevertheless, in an increasingly cosmopolitan world, new avenues for adaption actions that defy national borders are present.

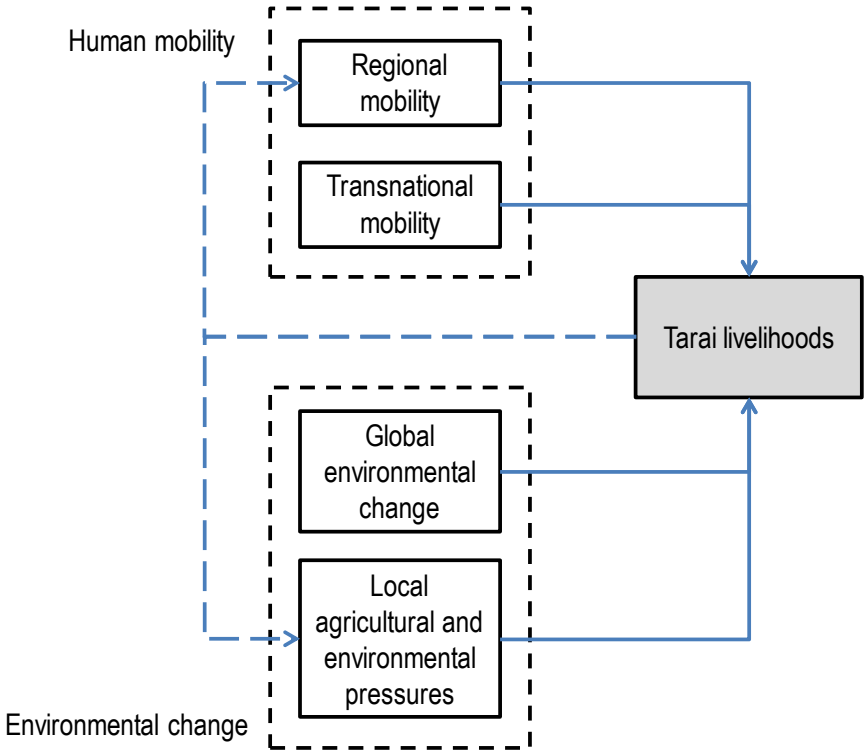
Beck's theory was conceived to explain industrialised societies in the West but has been applied in the context of Asia [see Calhoun (2010)] and other developing countries [see Leonard (2014)]. Furthermore, while recognising that migration of humans for work had existed since historic times, (Beck & Levy 2013, p. 15) argue that "middle-class" families in the developing world have

also become part of the cosmopolitan world. Viewing the case of the Tarai here as a risk society as at least transitioning to a risk society is thus justified. In the case of the Tarai, transnational mobilities in particular can be seen as an approach to minimise global risks at the local level. The reliance on mobility again ties to reflexive modernisation as it introduces a compulsion of mobility (Beck 2000).

2.7 Conceptualising human mobility and environmental change as key drivers impacting Tarai livelihoods

This thesis presents a critical examination of environmental change and human mobility in three discussion chapters, to explore their relationships with the livelihood systems. This conceptualisation of key drivers influencing livelihoods is represented in Figure 2.6. This is a clear distinction from the popular “vulnerability analysis” based approaches, which focus on examining the system's’ vulnerabilities first, then evaluating how impacts would affect the system. Rather than theorising the interactions between the multiple subsystems and examining the impact of change, this method examines the two important components in depth and detail examining how they influence Tarai livelihoods and how changing livelihoods influence them. The extensive examination of the Tarai livelihoods to human mobility, and to environmental change aims to reveal the important pathways through which the three subsystems interact. The influence of environmental change can be seen as interfaced by livelihoods rather than a direct causal link. Furthermore, the focus on two main drivers gives the opportunity for the researcher to examine the interactions at a broader level and integrate influences from global scales. An integrated vulnerability analysis of the socio-ecological system may be unable to capture the full extent of the global drivers of change, which as will be demonstrated in this thesis, have a considerable influence on rural livelihoods. By focusing on the two sub-systems in detail, the key points of interaction will be highlighted. The ultimate aim is still to suggest pathways to enable the Tarai socio-ecosystem to prepare for future impacts from local and global changes. The role of regional and transnational circular migration in Tarai livelihoods establishes human mobility as an invaluable adaptation tool currently as well as in anticipation to future changes.

Figure 2.6 Conceptualisations of human mobility and environmental as key drivers of change impacting Tarai livelihoods.



The state-led settlement programs and allocation of the Tarai land have been highly controlled by the contemporary government and biased towards those close to the ruling class. Any study of land and other natural resources in the Tarai will inherently require discussion of the politics and governance frameworks. A range of research has tackled the environment, land management and livelihoods from socio-ecological and socio-political perspectives—see for e.g. Shrestha (1989), Brown (1998), Blaikie and Muldavin (2004), Iversen et al. (2006), Sugden and Gurung (2012), (Ojha et al. 2016), The aim of this research is to explore the agriculture and livelihood issues from a migration and environmental angles and is primarily biased towards these aspects. Although political aspects are discussed in the analysis, they are not politicised to the extent as the some of the other literatures mentioned above. The focus here has been to acknowledge the internal political ecology aspects and expand on the risk society and cosmopolitan theory to examine livelihood adaptation, particularly circular migration. The theme here is to examine how the local socio-ecosystems to regional and global systems interact through evolving livelihood systems.

2.8 Conclusion

The behaviour of human societies in relation to environmental systems can be studied through a variety of theoretical lenses. The ability to cope and adapt is an inherent property of any socio-ecological system. Impacts from global environmental change are likely to put stresses

unprecedented in modern times on such systems, potentially causing irreversible damages. The capability of a system to adapt depends on a variety of factors and is collectively reflected by the resilience of the system. In addition to environmental pressures such as those brought about by climate change, socio-economic and socio-political factors such as inequality, freedom of entitlements can undermine the resilience of the system. Although the socio-ecological system of the Nepali Tarai has continued to generate livelihoods for increasing populations, the system is under increasing duress. Partly that as a frontier region, the Tarai has not received proportional investment from the heavily centralised Nepali governments. This research, in trying to unravel the complex dynamic relationships between environmental change, agricultural practices and migration aims also to generate a critical discourse of opportunities for future planning to improve overall resilience of local socio-ecological systems. The next chapter, Methods, explains the analytical framework applied in this research.

3. Methodology

3.1 Introduction

This chapter describes in detail the methods adopted to fulfil the research aims and the various stages of the research process. It begins with an outline of the philosophical foundations of the research design, selection of sites and the overall research process, followed by research procedures and an account of how ethical issues were addressed. The reasons for selecting a mixed method framework for this study are described in detail. The local context and values, which shaped how the study was conducted, are also discussed. A brief introduction of the study sites, describing their geographic settings and main physical features follows. The sampling method for selecting research participants, dependent upon both biophysical and social elements are also discussed in detail, along with the process for conducting the questionnaire surveys and interviews. Techniques and tools used for data entry, data processing and analysis are also elaborated upon. The researcher's own field experiences and challenges encountered during the field work are detailed in the final section.

3.2 Epistemological foundation

The philosophical position of the researcher is a determining factor in any research, because the researcher's inclination towards a particular dictum influences the tools used and even the formulation of the research problem (Bailey 1987). While an array of methods are available to address any particular question, to provide answers, it's beneficial to adopt a method that best matches the philosophical inclination of the researcher (Bailey 1987; Stewart 2014). A methodology dictates how the study is structured, how researcher-subject interactions are framed and the manner in which data are assembled (Mills 2014). "Method" in this context refers to the techniques applied or the tools used to gather data, while "methodology" includes the underlying philosophy on which the overall research is based. Although this study primarily involves social science research, there are some components such as the analysis of temperature and rainfall records, which are predominantly biophysical analyses. Together, the research draws from both the physical and human branches of geography to develop a holistic analysis of Tarai socio-ecosystems at two locations. In this study, the research questions were described first and then the methods were selected to address those questions in a practical manner while respecting time and budget constraints.

The researcher's understanding of valid paradigms for creating knowledge can ensure the selection of acceptable methods for querying and ratifying new information. Often defined as "the theory of knowledge", the term "epistemology" describes a researcher's position on what can be

classified as knowledge and in what ways can valid knowledge be assembled (Bryman 2012). The two popular epistemological fronts that influence social science research are “positivism” and “interpretivism” (Bryman 2012). The positivist approach advocates that similar tools and principles to the pure sciences be used in social science research. This allows for data analysis and hypothesis testing using the “scientific” methods based on the established laws of mathematics. Intrepretivism on the other hand, acknowledges the differences between the study subjects of the natural and social sciences, and posits that the subjective meaning behind social actions should be explored (Bryman 2012). Both the interpretivist and positivist paradigms are used in this research. In particular, for the overall review of the Tarai socio-ecological system and the undergoing transformations of the system, an intrepretivist approach is adopted. The focus to explore and critically review the actions of individuals, households and communities in the Tarai in relation to emerging risks. An example of this approach is the use of open-ended questions and in-depth interviews to seek information on societal experiences of how people perceive environmental and social changes; how they are affected by the change; and how they are managed.

Although intrepretivist methods are able to describe the existing socio-ecological system and the complex interactions within the system, positivist methods of statistical analysis were also applied to detect group differences and inter-variable relationships. An example of this is the use of Chi-squared tests to see if respondents who had experienced flood in the past were more (or less) likely to have a negative or positive perception of the changing weather patterns than other respondents. Additionally, the analysis of climate data (Chapter 6) takes a predominantly positivist approach by adopting rigorous statistical procedures to test and analyse data to look for possible trends, and to quantify the degrees of change, before making comparisons with people’s perceptions.

In the overall thesis, the statistical analysis is supplemented by indicators from questionnaire surveys thus combining the two epistemological paradigms in an attempt to holistically examine the local situation. Together, the two dominant research approaches are used to construct a narrative on the risks and opportunities facing rural communities in the Tarai. Nevertheless, the actual tools used to resolve positivist and intrepretivist queries also differ and fall into two different camps, which are again analysed in detail below.

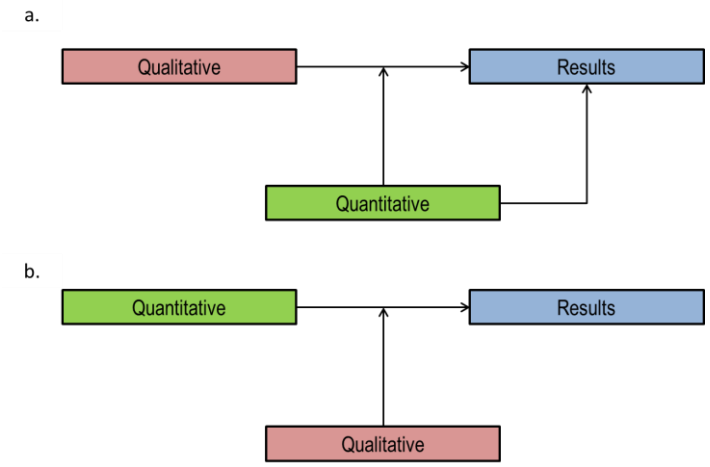
3.3 Mixed methods approach

The adoption of tools for collecting and analysing data are generally divided into two camps – 1) qualitative and 2) quantitative. Quantitative research deals with facts and figures that can be numerically represented. Various statistical methods to test the robustness of hypotheses can be

applied directly to such data. The alternative approach is to use qualitative analysis to interpret perceptions and meanings from social phenomenon, behaviours and expressions. Often, the term mixed methods is used to describe research that encompasses both quantitative and qualitative components. The goal of using separate methods in this particular research is to generally complement any findings gathered from multiple techniques to triangulate knowledge. Over time, the mixed methods approach has been regarded as a distinct research methodology for data collection, analysing and presenting results in its own right (Clark & Creswell 2007). The mixed methods approach informs the range of approaches adopted for data collection, retains authenticity of collected information (separate or integrated analyses) and presentation (inference based on separate or integrated analyses). Data itself can be collected at the same time or in succession and the integration done at a later stage (Clark & Creswell 2007).

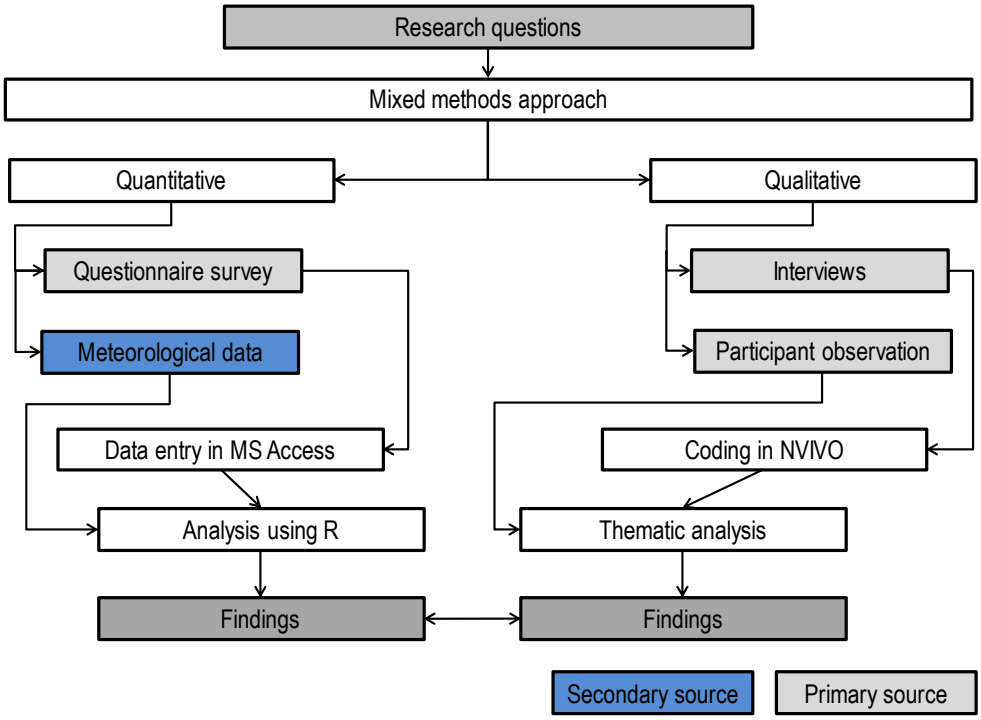
Figure 3.1 illustrates the distinctions between the two approaches used in this research. Approach 'a' was used for identifying adaptation to environmental change and livelihood diversification (Chapters 4, 5 and 6) and draws from quantitative data from the questionnaire survey, which are further explained using qualitative findings. Qualitative information from open-ended survey responses and narratives gathered from interviews serve to elaborate and explain the survey results in the analysis phase. For climate trends and perception analyses (Chapter 6), approach 'b' was applied, with the qualitative data gathered on individual perceptions, compared against quantitative data on statistical analysis of climatic records. Since the collection of both qualitative and quantitative (both primary and secondary) data occurred around the same time, the order of using the information rather than the actual order in which the information was obtained is important for the analysis.

Figure 3.1 The order of quantitative and qualitative information in the two approaches used in this research.



In this research, qualitative data analysis and quantitative data analysis were carried out separately. This type of mixed methods strategy, with separate data analysis and integration of qualitative and quantitative findings to discuss results holistically, is also referred to as a "concurrent triangulation method" (Clark & Creswell 2007). The following schematic diagram shown in Figure 3.2 illustrates the overall organisation of this research.

Figure 3.2 Overall framework of research using mixed methods approach.



Research methods are central to the philosophical beliefs of the researcher (Bryman 2012) and while the researcher fully acknowledges the potential subjective bias of qualitative techniques, such a methodology is necessary to explain the complexity of the society-environment interface. In particular, it has been shown that a sole reliance on physical analyses like remote sensing and

Geographic Information System (GIS) modelling can lead to simplified views of human activity and land-use changes (Guthman 1997; Meyer & Turner 1992).

3.4 Maintaining research coherence

Bryman (2012) has outlined reliability, replication and validity as the three essential categories for judging social research. Birks and Mills (2011) have listed three dimensions for assessing the rigor of qualitative research as 1) Researcher expertise; 2) Methodological congruence; and 3) Procedural precision. While the researcher is at an early stage of a research career, full commitment was made to undertake the research in a professional manner. During the course of the research, the relevant theories and developments were explored to understand the social phenomenon related to human-environment interactions. The researcher also participated in various workshops and international conferences, and undertook training to share research and get peer feedback. He also had prior experience in conducting field-work involving consultation with locals in Nepal (his home country), including in the Tarai region, which was useful in planning and executing the field research.

A wide range of methods were adopted to address the research questions. However, the core philosophy of imperative exploration has been preserved. By using both qualitative and quantitative components, it is hoped that the findings will complement each other and also help in achieving triangulation. Utmost care has been taken to ensure the proper execution of research steps and to ensure the conditions adhere strictly to the required conditions. Procedural precision can be defined as the "deliberate, planned and consistent application of methodological strategies in the conduct of research" (Birks 2014, p. 226). All data from questionnaires, interview recordings and raw meteorological records have been preserved in their original forms. Reproducibility can be defined as the ability of the analysis to be carried out again, either by the same researcher or by someone else working independently. All data processing on the original data has been documented to facilitate transparency and ensure reproducibility. The R code used to process data and generate descriptive and inferential statistics are provided in Appendix I.

3.5 Unit of analysis

The unit of analysis in research refers to "what or who" is being investigated (Ezzy 2010). In social science research, the basic unit of analysis varies according to whether a group or an individual is being studied (Bailey 1987). Although the phenomenon of climate change is interconnected to regional, national and global issues, this research draws from case studies of two municipalities, so for the overall comparative study, the municipality serves as the key unit of analysis. The questionnaire was designed to seek household details, livelihood strategies and

motivations for those livelihood strategies. The household, therefore, forms the basic unit of inquiry for the questionnaire survey. In case of the Tarai, a household consists of a family or an extended family with multiple generations living together and sharing a single kitchen. The questionnaire also asked for perceptions of change of climatic variables like temperature and rainfall over the past years, as well as changes in environmental resource indicators, such as access to fodder. The answers to such questions represent individual perceptions, rather than collective reactions of the household. Thus, for perception type questions, the basic unit is the individual. Table 3.1 summarises the three units of analysis based on the three levels of research focus.

Table 3.1 Unit of analysis for this research by the study focus

Study focus	Unit of analysis
Case study – comparative study	Municipality / selected less-urbanised wards of two municipalities
Questionnaire survey – demographic details; socioeconomic details; livelihood strategies; motivation for livelihood strategies	Household
Perception of changes in climatic variables and environmental resource indicators	Individual

3.6 Selection and access to sites

The sites for this research were selected based on the prevalence of water-induced hazard incidents and accessibility of the sites for research purposes. To identify the number of hazard incidents in the last five years, disaster incident records from the DesInventar (2013) dataset was used. The desInventar dataset has an archive of recorded incidents of flood, drought and landslide incidents, amongst other hazards, for Nepal from 1979 to 2011. A district-wise summary of flood related records shows the districts in the Tarai are hotspots of flood incidents in terms of the number of events, as well as extent of damage as indicated by loss of lives and property. For the purpose of this research, a micro-level analysis in terms of spatial distribution of the flood incidents was required. The district is a convenient measure for political boundaries, but they do not reflect spatial variations within the district or ecological composition. For instance, districts in the Tarai may include foothills in the north with environmental characteristics not akin to the plains. Each district has several Village Development Committees (VDCs) and/or Municipalities, while each Municipality is further divided into Wards, which form the lowest administrative structure of the local development ministry. Thus analysis at a finer level can be performed using the micro divisions such as the VDC or Municipality boundaries.

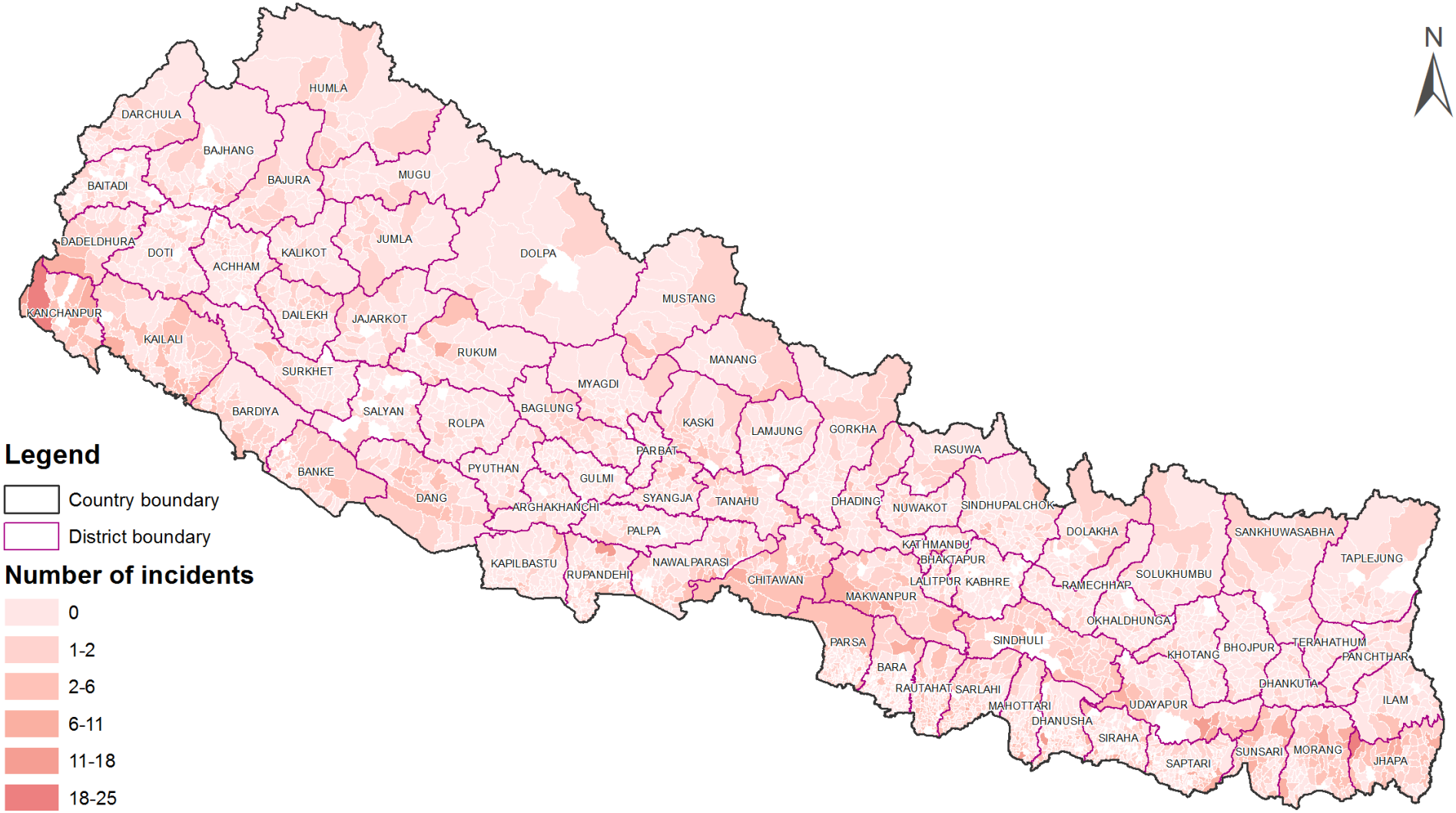
Although the dataset has basic records at the VDC / Municipality level, data summaries at those levels could not be undertaken directly due to the following issues:

1. Not all records specify the name of the VDC affected by the incident.
2. Some records indicate multiple VDCs but do not list their names.
3. Some records indicate all VDCs affected.
4. The names and the codes of the VDCs often do not match the standard codes used by Department of Survey (DoS) or the World Bank.
5. Some contiguous VDCs have merged to form municipalities resulting in counting errors.

The records were matched at the VDC level with the spatial data obtained from DoS in Microsoft Excel. Due to naming variations and lack of universal code for VDCs, some records had to be matched manually. Overall, out of 3,520 records, 651 remained unmatched. Figure 3.3 shows the distribution of incidents of flood hazard according to the desInventar dataset.

Damak Municipality was selected in the East as it has one of the highest incidents of floods in Eastern Tarai and also provides a favourable study site due to ease of accessibility. In the Western Tarai, Dhangadhi Municipality was selected following the same principles. Despite being roughly the same size, the two sites are different in terms of socio-economic indicators and proximity to the border to neighbouring country India. The underlying socio-economic differences between these two municipalities will be discussed more in Chapter 4, but a brief introduction to the two sites and their main features are presented next.

Figure 3.3 Flood incidence map based on 1971-2011 records.



Source: Constructed using flood data from DesInventar (2013) and map data from DoS.

3.7 Site context

One objective of the research is to generate local data from the field in terms of perceptions of changing weather patterns, difficulty of resource access, and the subsequent impact on livelihoods of residents. It is important to be aware of the social and cultural context of the research and to be sensitive to the implications of the results (Jensen & Glasmeier 2010). For example, the concepts of environment and socio-ecological relations demand a highly contextual interpretation. Gathering perceptions from local people is an essential step. However, locals' perceptions of changing climates and environmental conditions do not always reflect reality (Carr 2005b; Mbow et al. 2008). This research compares the local perceptions with available daily records to triangulate results. What constitutes an "environmental problem" also is relative (Meze-Hausken 2000a), and adaptation response actions are often based on cultural and personal conceptualisations of the threat (Hulme 2008b). In the Nepali culture, natural resources like forest, water, rain and sun are idolised and revered. For example, the onset of rainfall, the beginning of planting season, and harvest times are marked with festive celebrations with cultural and religious connotations. A change in local weather patterns and livelihood practices can be expected to be recorded in the cultural memory. This situation is not unusual, with the meaning of the term "climate change" in the micro context often varying locally to the actual observed changes in regional weather patterns, as highlighted by Marino and Schweitzer (2009) in the case of Alaska.

It is at the local level where the response often is initiated and the mediation of vulnerability most visible (Urwin & Jordan 2008). Local interaction with people helps to understand collective experiences and cultural positioning. Additionally, the study of institutional arrangements includes overlaps, hierarchies, inter-dependencies and the role of informal/shadow institutions in local resource management. These were examined through the subjective lens of local perceptions, as well as interviews with respondents working in the development sector.

Table 3.2 summarises the methodology used to address each of the objectives of this research.

Table 3.2 Summary of methods used to achieve objectives of research

Research questions	Methods used to attain the objective [source / respondent]
To what extent has the climate of the Tarai changed in the last three decades?	Statistical analysis on climatic data [Department of Hydrology and Meteorology (DHM)] Observation of data collection practices [field observation] Literature review [statistical methods for weather/hydrological data analysis]
To what extent have the locals perceived changes to the local environment and climatic patterns?	Semi-structured interviews [Locals, Local government officials; environmental practitioners] Field observation Questionnaire survey [locals]
To what extent is the Tarai socio-ecological system able to adapt to current and future impacts of climate variability and change?	Demographic data [Secondary sources such as Census report; District reports; VDC reports; earlier published studies] Socio-economic data [Secondary sources such as Census report; District reports; VDC reports; earlier published studies] GIS data [NGIIP, GLCF, field observation] Environmental data [Environment census report] Field observation Questionnaire [locals] Semi-structured interviews [locals]
To what extent are the Tarai farming households able to diversify their livelihood to include off-farm opportunities?	Literature review [peer-reviewed journals] Content analysis [literature review summary] Semi-structured interviews [Locals, Local government officials; environmental practitioners] Field observation Questionnaire survey [locals]
To what extent is circular migration helping the Tarai farming households adapt to agricultural pressures?	Semi-structured interviews [Locals, Local government officials; environmental practitioners] Field observation Questionnaire survey [locals] Literature review [peer-reviewed literature on environmental governance; case studies on roles of institutional arrangements in environmental resilience]

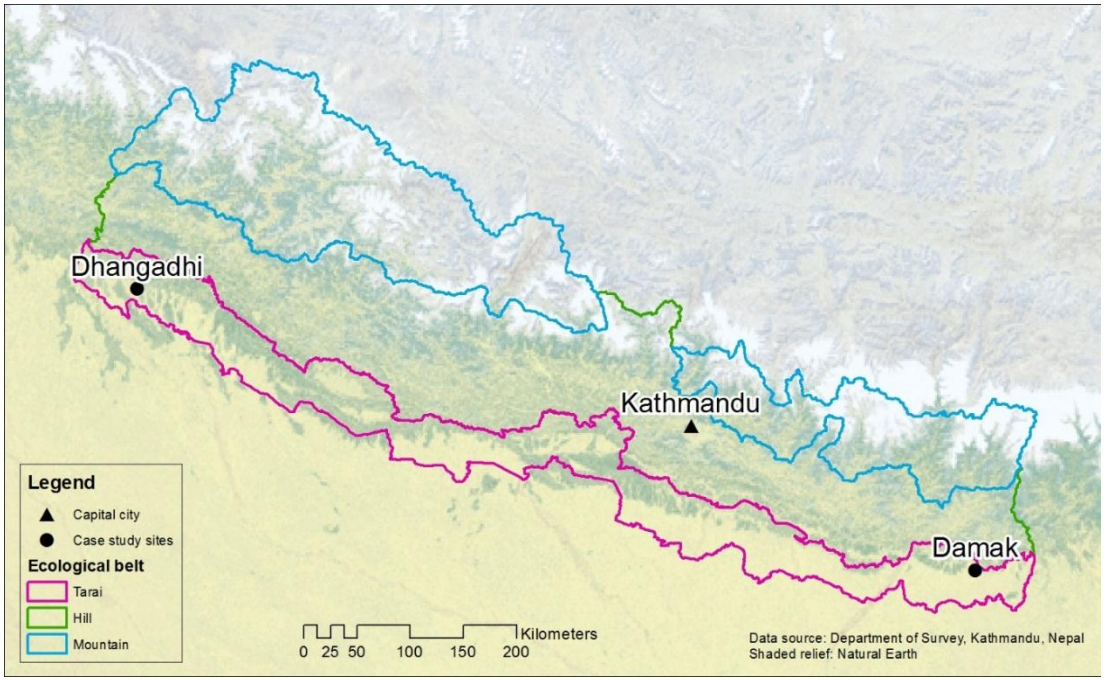
Building upon the premise that hazards are not only the product of physical systems alone but are intricately tied to economic, social and political realities (Adger 1999; Pelling 1999), this research investigates the historical roots of vulnerabilities and adaptations to understand current responses and response capacities. The aim was to understand the contemporary responses of the individuals and their community to a range of social, cultural and ecological changes, to guide a discussion of potential, anticipated future changes.

3.8 The Tarai

The topography of Nepal is predominantly mountainous except for a narrow strip of level land along the southern border. Starting from the highest points on the planet on mountain summits along the Himalayan range, the altitude of the terrain rapidly drops until it reaches the Tarai plains, just under one hundred meters above sea level. Besides the administrative boundaries, Nepal is divided into three distinct ecological zones, viz. the Mountains, the Hills, and the Tarai or plains. Although the administrative boundaries do not lie exactly where the transition in altitude occurs, each of the seventy-five districts have been classified into Mountain, Hill or Tarai districts. For the purpose of this thesis, the strip formed by the Tarai districts is referred

to as the Tarai region. Figure 3.4 shows the three ecological zones as represented by the classification of the districts as being in one of the three zones.

Figure 3.4 Ecological zones of Nepal as identified by administrative strips crudely matching the physiological belts.



Source: Constructed using boundary data from DoS, and shaded relief data from Natural Earth.

The three physiological zones in Nepal have different climate and scope for rural livelihood opportunities. Some 43 percent of the Mountain region has a mean annual temperature of less than 5°C and only about 38 percent of the region has a climate appropriate for agriculture, with a growing season more than 150 days in length (Shrestha, 2005). Unlike the case of remote Hills and Mountains, where the pressures from a harsh climate can be attributed to resource depletion and food security, the fertile lands of the Tarai—the plains, which already provide food for the majority of the country, provide opportunities for agricultural intensification. The Tarai is also privileged with access to all-weather roads and proximity to regional hubs in neighbouring India. Partly for these reasons, the Tarai has also been a rate of higher population growth about 1.6 times that of the Hills (Central Bureau of Statistics, 2012). The Tarai landscape once consisted of *sal* (*Shorea roubsta*) and other mixed hardwood forests. Now, however, much of the region has been cleared for paddy, grazing and fruit trees like mango, litchi, and jackfruit, which have been planted mostly for household consumption and production of fodder (Chapagain 2000).

3.9 The Tarai socio-ecological system

The Nepali Tarai constitutes the plains south of the Hills along the country's southern border. The Tarai was covered with dense forest, and populated by sparse indigenous populations until the 1960s but now is relatively densely populated with 392 persons per sq. km. compared to 180 persons per km^2 national average (CBS 2012d). The two sites for this study were selected on the basis of high occurrence of and the likely subsequent impact on agriculture and human security. Although the sites are defined as municipalities, only small areas are urbanised and vast sections resemble a rural landscape lacking proper infrastructure.

A socio-ecological system constitutes the relationship between the physical environment and its inhabitants. The physical environment shapes the livelihoods of the inhabitants in many ways but the interactions happens both ways as people modify the physical environment to meet their needs. Any changes to the physical environment like the impacts from climate change, may translate into impacts on the livelihoods of the inhabitants depending on the exposure and sensitivity of the system to such changes. A brief introduction of the physical aspects of the study sites, and demographic details of respondents in the field survey conducted in 2013-14 are presented next. The livelihood systems of the sites, especially households' use of a combination of in-situ and ex-situ earning options, will be discussed in Chapter 4. The topic of circular migration will be explored in detail in Chapter 5. Trends in local climate and local perception of change will be examined in Chapter 6 using daily climate records, and primary data collected from questionnaire survey and interviews.

Forest resources as discussed in Chapter 4 are crucial to many Tarai residents as they continue to rely, albeit to much lesser extent than in prior decades, on forests for firewood and fodder. Among the respondents, only a small number reported having access to community forestry resources--this could be due to the fact that the sample wards in both Damak and Dhangadhi do not have a sizeable forest. Although this research examines the usage of forest resources, detailed analysis of the workings of community forest are not covered. For background on the evolution of forest management in the Tarai and the current management practices which are considered to be unique—see for e.g. Brown (1998), (Iversen et al. 2006), Springate-Baginski and Blaikie (2007), and Ojha et al. (2016).

Both Damak and Dhangadhi municipalities have their urban functions concentrated at one central location and the peripheral wards primarily retain rural land-uses. As this research endeavour started off to explore responses to flood events, the two municipalities in question provide good examples of impacts on rainfall variability on livelihoods. Although the locations are municipalities, the sampling frame excludes the urbanised areas. As the sampled wards

are identical to the neighbouring VDCs, the sample arguably captures the households that are similar to hamlet settings rather than urbanised cores which the places are known for. The peripheral wards are in fact very similar to the adjoining VDCs across the Tarai in terms of livelihood activities and access to facilities. According to Nepal Human Development Report 2014, the eastern Tarai has a slightly higher HDI at 0.485 value compared to the far western Tarai at 0.466. Tiwary (2005) reports that, farmers in the western Tarai are the most disadvantaged in terms of livelihood strategies and incidences of poverty. Although both sites are in the Tarai, and they have several parallels in terms of landscape transformation from forest to agricultural land and history of new-settlers, there are also wide differences such as proximity to India and linkages to the central government. Hence, it should be acknowledged that direct comparisons between Damak and Dhangadhi has its own caveats. In this thesis, many of the findings have been discussed separately for Damak and Dhangadhi, and are discussed in relation to the differences, especially those pertaining to socio-economic dissimilarities.

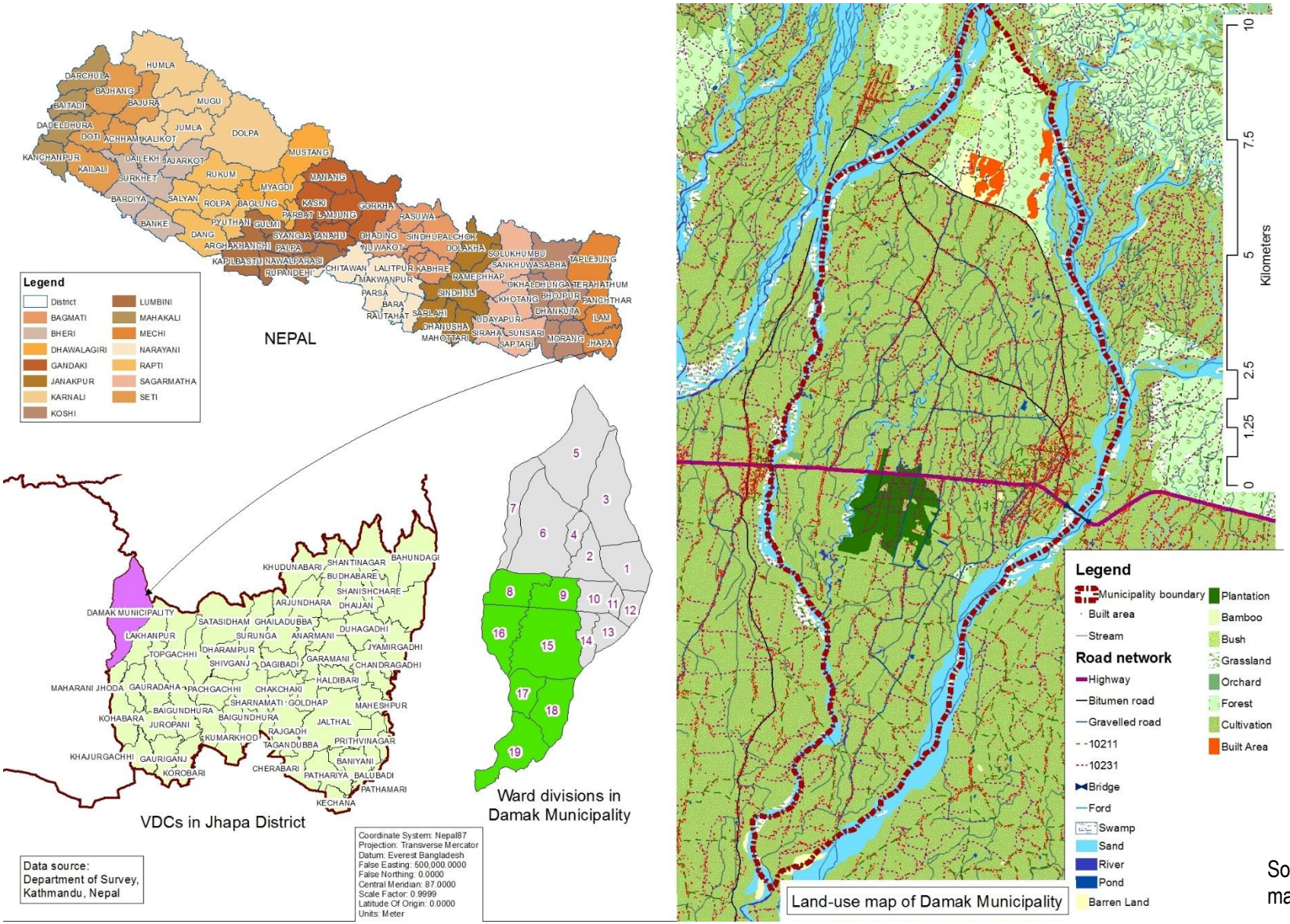
3.9.1 Damak landscapes

Situated in the eastern district, Jhapa, Damak became a *Nagar* (city) *Panchyat* in the year 1981. Figure 3.5 shows the location, ward divisions, and land-use map of Damak Municipality. It is also the second largest municipality in Jhapa district with an approximate area of 75.1 km^2, and is further divided into 19 wards. The central urban area of Damak comprises shops, open-markets and government offices. The East-west Highway / Mahendra Highway (H1/AH2) dissects the municipality horizontally, almost at the centre, dividing its area into two halves. The highway connects Damak with the rest of the country and to neighbouring India. It takes around ten hours by public bus to reach the capital city, Kathmandu from Damak Bus Park. The closest domestic airports are at Biratnagar (50 km west) and Bhadrapur (40 km east) with flight times of thirty-five minutes and fifty minutes respectively, to and from the capital city where the nation's only international airport is located. Damak is only about thirty kilometres away from the Nepal-India border. Regular bus services to major Indian cities can be accessed from Kakarbhitta (55 km east) – a transport hub at the eastern end of Mahendra Highway or from Jogbani (65 km south) – a border city served by the Indian Railways network. According to the political divisions defined by Schedule 4 of the new Constitution of Nepal, adopted on 20 September 2015, Jhapa, along with thirteen other existing districts are classified under Province No. 1 with the proposed name of the Koshi Province ('The Constitution of Nepal' 2015 Schedule 4).

The north-south elongated municipality is flanked by two rivers on either sides – Ratuwa River on the eastern side and Mawa River on the western side. The two rivers are colloquially referred to as “the sorrow of Damak” due to the negative impacts of regular flooding brought about by these rivers during monsoon months. There are also numerous smaller rivulets and canals flowing through the interior which serves the inland agricultural lands. Given the urban development that has occurred, some of the natural flows of water have been restricted or blocked by urban infill, which enhances overflows during periods of heavy rainfall. The urban core of Damak has a bus park, a vegetable market and a livestock market.

One noticeable feature of the Damak landscape from the East-West Highway is a large tea estate with rows of tea plants canopied under trees, which is managed by a private business, Himalaya Mahalaxmi Tea Garden Pvt. Ltd. The tea estate occupies around 50 ha of land and provides employment to about one hundred locals (Plate 3.1). The plantation's management is historically linked to the past royals of the country and has provided land and housing to many poor farmers. The banks of the Ratuwa and Mawa rivers near the East-West Highway corridor have been occupied by informal settlers with some homes very close to the river and highly exposed to monsoonal floods. Damak also currently hosts 20,705 Bhutanese refugees in three UNHCR-established refugee camps in Beldangi (UNHCR/WFP 2014). The establishment of the three camps has provided direct and indirect economic opportunities for many in Damak, as well as others in the region. As the number of refugees in the camps continues to decline (UNHCR/WFP 2014), employment opportunities can be expected to be lost forcing locals to look for alternative livelihood options.

Figure 3.5 Location and land-use map of Damak.



Source: Constructed using map data from DoS.

Overview of surveyed wards of Damak Municipality

Wards 8 and 9 are located to the north of the East-West Highway and house the northern portion of the tea-estate. Ward 8 is flanked by Mawa River to the west. During winter, the river can be crossed by wading, but during monsoon season it swells, flooding the banks and depositing silt and sand across vast sections of the ward and areas further downstream. The sand deposits along this section of the river are a necessary construction material, and quarrying also serves as an income source for many labourers, as well as generating revenue through tax for the municipality (Plate 3.1). In ward 9, residential housing for around fifty households involved in work on the tea-estate has been provided, although the actual ownership of the land is unclear due to the unofficial transfer of land. Despite the uncertainty of ownership, families have been staying in the area for several decades and are hopeful of gaining full ownership. Most families in this settlement have only one or two members working in the tea-estate, while the remaining household members practice other livelihood options.

Plate 3.1 Left: A tractor arriving at the banks of Mawa River to collect sand. Right: Tea plants underneath a canopy of trees.

Source: Field Survey 2013-14.

In contrast, wards 15 and 16 lie immediately to the south of the East-West Highway. More than half of ward 15's area fall with the tea estate and is fenced off from the public. In the remaining area, there are more settlements towards the highway and these closely resemble an urban core. The settlements in ward 16 are located away from the Mawa River, which borders the ward to its south, probably due to historic incidents of flood events.

Wards 17, 18 and 19 are located at the confluence of the Ratuwa and Mawa rivers. The proximity of the rivers makes these wards more prone to flooding. These areas are also the furthest from the urban core of Damak and inhabited by the poorest households. There are also extensive flood mitigation efforts in place along the river banks. Some residents stated that families who were well-off had shifted to the wards closer to the urban core and only the poorest group of households remained. Mawa River has changed its course significantly over

the decades especially along the ward 17 sections, with the river originally marking the boundary of the ward, but the river now flows about a kilometre inland. Damak houses around 115,000 residents—the majority of the population concentrating in and around the urbanised core as shown in Table 3.3. Plate 3.2 shows the state of a culvert after being damaged by flood and a farmer walking his oxen in Damak.

Table 3.3 Population of Damak Municipality by ward and gender. Wards selected for survey are in bold.

Ward	Households	Males	Females	Total
1	1,777	3,696	7,095	10,791
2	506	1,105	2,086	3,191
3	552	1,279	2,416	3,695
4	313	737	1,418	2,155
5	742	1,749	3,337	5,086
6	680	1,612	2,935	4,547
7	542	1,300	2,390	3,690
8	**390**	**900**	**1,713**	**2,613**
9	**803**	**1,809**	**3,365**	**5,174**
10	2,661	5,307	10,040	15,347
11	1,343	2,967	5,781	8,748
12	1,531	3,567	6,825	10,392
13	2,293	4,721	8,986	13,707
14	1,178	2,432	4,645	7,077
15	**1,140**	**2,638**	**4,887**	**7,525**
16	**539**	**1,189**	**2,305**	**3,494**
17	**390**	**903**	**1,667**	**2,570**
18	**287**	**698**	**1,255**	**1,953**
19	**437**	**1,055**	**1,956**	**3,011**
Total	18,104	39,664	75,102	114,766

Source: CBS (2012b).

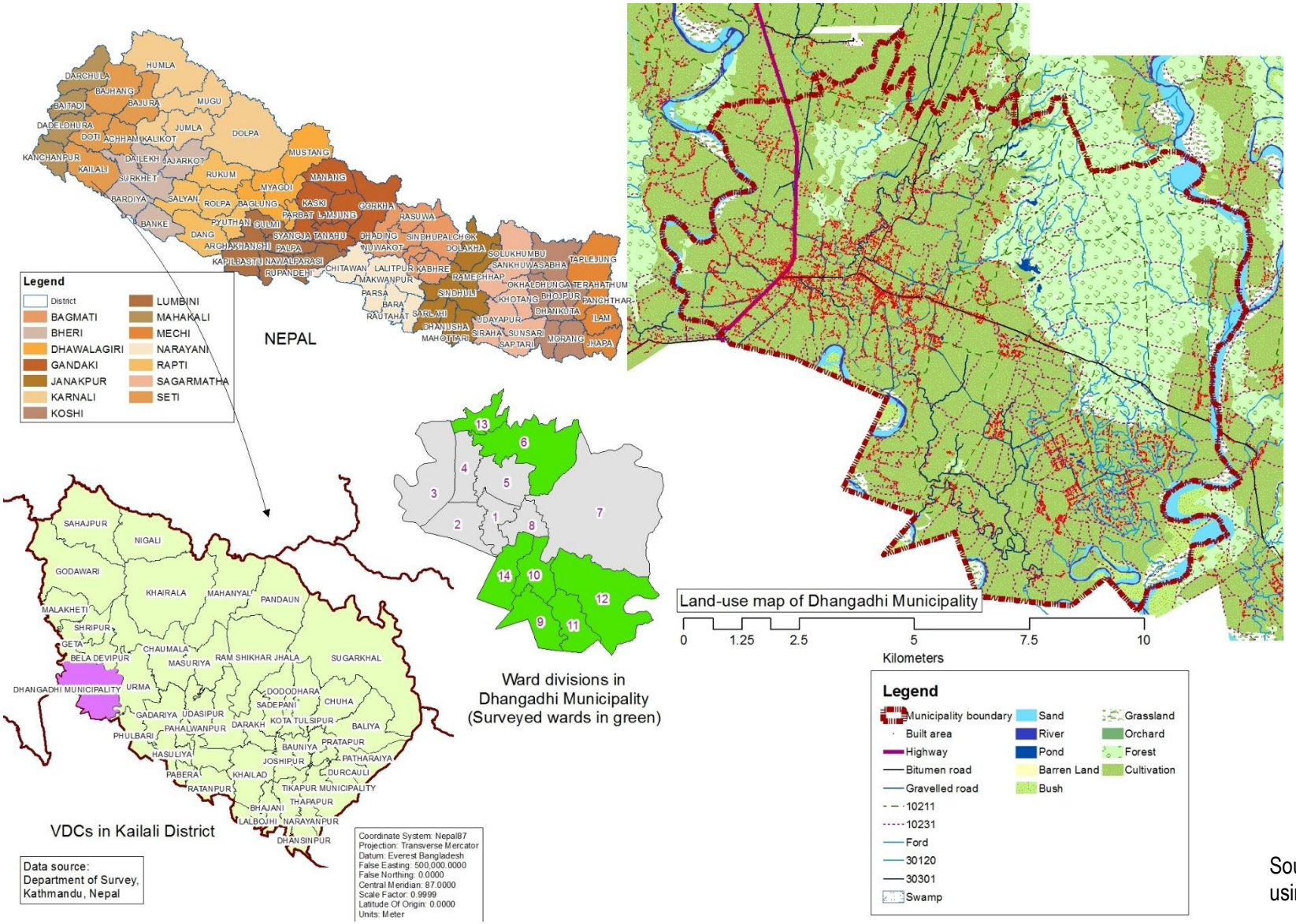
Plate 3.2 Left: A culvert damaged by flood in Damak. Despite the damage, the river could be crossed by foot during winter. If not rebuilt, the locals must take a detour to reach the other side during monsoon months. Right: A farmer taking in his oxen for grazing.

Source: Field Survey 2013-14.

3.9.2 Dhangadhi landscapes

Situated in the far-western district, Kailali, Dhangadhi became a municipality in 1976. The central urban area comprises shops, open-markets and government offices. The East-West Highway/Mahendra Highway (H1/AH2), which connects Dhangadhi with the rest of the country, is only twelve kilometres away from the city centre. Dhangadhi is also connected to the Nepal-India border at Mohana and the Hill districts towards the North by Mahakali Highway (H14) running north-south through the district. It takes around twelve hours by bus to reach the capital city, Kathmandu from Dhangadhi. Dhangadhi also has a domestic airport, although it is technically on an adjacent VDC but managed by the municipality. The flight time from the capital city to Dhangadhi airport is around seventy minutes. Dhangadhi also shares its southern border with Uttar Pradesh, India. Wards 2, 14, 9, 11 and 12 have at least part of their southern boundary as the international border. The Mohana border check post is just two kilometres from the city centre, Chauraha. About a kilometre across the border, a market sells consumer goods targeted at Nepali shoppers. Buses to New Delhi and other major cities in India can be accessed from the bus station on the Indian side of the border. The bus journey from the border to New Delhi takes about six hours. The Mohana and Khutia rivers are the two major rivers that serve Dhangadhi. The urban core has a bus park, a vegetable market, a public park and a livestock market. According to the political divisions defined by Schedule 4 of the new constitution of Nepal, Kailali, along with nine other existing districts are classified under Province No. 7 with the proposed name of the Far West Province ('The Constitution of Nepal' 2015 Schedule 4). Figure 3.6 shows the location, ward divisions, and land-use map of Dhangadhi Municipality.

Figure 3.6 Location and land-use map of Dhangadhi.



Source: Source: Constructed using map data from DoS.

Overview of surveyed wards of Dhangadhi Municipality

The criteria for selection of wards in Dhangadhi was similar to that for Damak with an emphasis on areas away from the urban core with a high livelihood reliance on agriculture. Since the urban centre of Dhangadhi is situated amongst the eastern wards, the selected wards are in the south-west and north-west of the municipality. The selected wards are separated into two clusters described below by a large forest in ward 7. Ward 13 is bordered by the Mahakali Highway on its west. Ward 6 is bordered by forest on the west. Smaller patches of forest are scattered in the wards. These wards are popular for aquaculture as demonstrated by the number of small scale commercial ponds. Plate 3.3 shows one of the ponds used for aquaculture, and forest patches near fields in Dhangadhi.

Plate 3.3 Left: A pond being used for aquaculture. Right: A patch of forest next to wheat fields.

Source: Field Survey 2013-14.

The southern wards, 9, 10, 11 and 14 are flanked by the Mohana River which roughly marks the Nepal-India border. The course of the river fluctuates, but the actual international border is delineated by regular marker stones. The southern edge of the wards is shaped by sharp straight lines as the border is defined by these marker stones. Despite the existence of a formal border check point at Mohana, the border across these wards is porous for people and goods. Except during monsoon months, citizens of both Nepal and India frequently cross the river via many informal routes along this section of the border. The flood plains along the border on the Nepal side is either barren or used for agriculture. The forest in Uttar Pradesh, India, just across the border from ward 9, is a protected forest area within the Dudhawa National Park. Dhangadhi houses around 102,000 residents—the majority of the population again concentrating in and around the urbanised core as shown in Table 3.4. Plate 3.4 shows the Dhangadhi landscape along the Mohana River.

Plate 3.4 Mohana River flowing along the Nepal-India border (left). Two arrows mark the location of a border marker pillars—the area behind the pillars is Nepal and in front of the pillars is India. Workers wading to cross the Mohana River (right).

Source: Field Survey 2013-14.

Table 3.4 Population of Dhangadhi Municipality by ward and gender. Wards selected for survey are in bold.

Ward	Households	Males	Females	Total
1	3,105	7,326	7,007	14,333
2	2,758	6,410	6,049	12,459
3	2,868	6,795	6,754	13,549
4	2,142	4,886	4,289	9,175
5	2,675	6,064	5,580	11,644
6	**940**	**2,610**	**2,755**	**5,365**
7	1,706	4,610	4,433	9,043
8	1,152	3,102	2,939	6,041
9	**354**	**787**	**995**	**1,782**
10	**250**	**858**	**921**	**1,779**
11	**309**	**1,149**	**1,162**	**2,311**
12	**1,998**	**4,637**	**5,372**	**10,009**
13	**501**	**1,517**	**1,465**	**2,982**
14	**272**	**688**	**810**	**1,498**
Total	21,030	51,439	50,531	101,970

Source: CBS (2012c).

3.10 Fieldwork timeline

The fieldwork period started in mid-September 2013 and continued until the first week of March 2014, and was carried out in multiple stages involving a mixture of background work in the capital city, reconnaissance visits to the study locations, and data collection via questionnaire surveys and interviews. Table 3.5 provides a summary of key fieldwork stages and actions taken at each stage. Before the field visit, a range of secondary data sources were reviewed to plan the details of the extensive field study. Prior to embarking on the first reconnaissance field visit, detailed maps were made using the 1:25000 scale data layers

procured from DoS. Maps were prepared for each ward as well as for the whole municipalities. Prior to the field visits, field maps were prepared using the DoS data and priority areas were identified. Procurement of daily climatic records from DHM were also carried out during this time.

The first visits to both sites were carried out in early November 2013 when the entire nation was preparing for a national election. The first visits served as reconnaissance visits and provided a clearer understanding of the ground conditions by observing local social customs, daily livelihood activities and community functions. During the reconnaissance visits, the field maps were updated to reflect any discrepancies or changes observed on the ground. The updated maps were used to make a random selection of households for the questionnaire survey as described later in Section 3.10.5. Field visits were not carried out from mid-October to end of November to anticipate the national festival holiday breaks and the general elections. For security reasons, the main surveys were carried out only a week after the 19 November election, starting from Damak in December 2013 and Dhangadhi in January 2014. Written letters were submitted to the local district officers in each location, informing them of research scope and activities. Written permission was also obtained to ensure the research team's safety in case of adverse situations. A few local contact persons were approached to help with travel logistics for each site. A research assistant accompanied the researcher during the questionnaire surveys at each location. The assistant was involved in administering household questionnaires along with the researcher. Selected locals met during this visit were asked to participate in interviews by the researcher. In some cases, follow-up interviews were conducted. The researcher was hosted by a local family on the first visit to Damak municipality. As it was harvest time, the researcher had a chance to follow along with the host family, and visit farms and talk to other farmers who came to help with the harvest. Similarly, on the reconnaissance visit to Dhangadhi municipality, the researcher was guided by local contact people to areas of interest, enabling observation of farmers tending wheat, sugarcane and oilseed crops on their farms. The researcher was able to view the progress of the crops over successive visits to Dhangadhi.

Table 3.5 Summary of key research activities

Fieldwork stage	Activities for each study site	People
Pre-field visit stage	Collection of climate data; collection of map data and preparation of field maps	Researcher
First visit	Reconnaissance survey; collection of reports from municipality offices; ground verification of settlement locations on field-maps; visitation of key locations to identify wards for survey; informing local government office regarding research project activities	Researcher
Field visit preparation	Printing of surveys, participant information sheets, consent forms and complaints forms; correction of field maps for final survey; sample selection and marking on maps	Researcher
Second visit	Conducting questionnaire surveys; conducting field interviews	Researcher and one research assistant at each site for questionnaire surveys; researcher for interviews
Data checking	Data entry of selected variables, analysis of climate data	Researcher
Third visit	Conducing field interviews; collection of reports from local organisations	Researcher

3.11 Secondary data

The main aim of the secondary data review was to enable the researcher to establish a baseline for the research based on what is known—especially the methods and tools in the field, and theories that have been applied for similar studies (Bryman 2012). A literature review also served to identify a niche in the field which may not have been addressed, and provides basis for research questions (Bryman 2012). In this case, secondary data was also used to inform an integrated mixed methods approach (see section 3.3). An extensive review of the existing literature was conducted on topics covering the adaptive capacity and resilience of communities in the Tarai prior to the field survey phase. The review of literature continued throughout the analysis phase, with particular emphasis on the migration literature which stemmed from a greater understanding of that important adaptation factor from the fieldwork.

Secondary sources of data from reports, district profiles, municipality brochures, progress reports and other published literature were consulted to aid in understanding the context of the study region, as well as in building the complex arguments to explore core issues. In the course of the research, the researcher reviewed literature on climatic changes in the region; flood impact in the site areas; agricultural practices; climate change adaptation and coping mechanisms; government reports on climate change adaptation programs; environmental policy documents; journal papers; reports from central and local governments; maps of the study area; and demographic data. During the primary field work, the researcher visited local government offices to access a range of reports, pamphlets, profiles and maps of the study areas, as these were not available through mainstream sources. Secondary data sources like

census and administrative reports were also useful in understanding broad characteristics of the population.

After selecting the two municipalities as case study candidates, a range of secondary data sources were consulted to gather demographic details, socio-economic features and environmental settings of the places. The “District Profile” reports published by the Government of Nepal (GoN) provided the official account of the physical, cultural, environmental and socio-economic indicators at the district level. Pamphlets, yearly progress reports and bulletins were also collected from the municipality offices in Damak and Dhangadhi. Some of these documents were brought to Adelaide and are in the researcher’s possession.

Analysis of data on precipitation patterns, temperature records, and hydrological records are essential elements in the analysis of climate variability. Temperature, precipitation and hydrological data from 10 stations were collected from the DHM in Kathmandu and analysed for trends and extreme events using standard indices described in detail in Section 3.10.3. For spatial analysis and visualisation, GIS map layers were purchased from the DoS, Kathmandu for use in this research. All the standard spatial maps were projected using the Nepali standard projection system of modified Uniform Transverse Mercator (UTM) with parameters outlined in Table 3.6. The map data were used for site selection (section 3.6), sample selection (Section 3.10.6) and as field guides.

Table 3.6 Standard projection system for Nepal

Projection parameter	Value
Ellipsoid	Everest Spheroid 1830 (semi major axis, a = 6,377,276.345 m. and semi minor axis, b = 6,356,075.413 m.)
Central meridian	3 zones with width of 3 degrees with meridians at 81°, 84° and 87° longitudes where applicable (The map for Damak was projected using the 87° datum and the map for Dhangadhi was projected using 81° datum.)
False easting	500,000 m
False northing at the equator	0 m
Scale factor	0.9999

Source: DoS.

For visualisation of data over a satellite image, the modified UTM data was converted from the Nepali standard projection system to the World Geodetic System (WGS) 1984 coordinate system in ArcGIS, using the conversion parameters outlined in Table 3.7. The overlay of road and settlement data on satellite base maps were used to create ward-level field maps used by the researcher to identify locations of sample households. Examples of such field maps with locations of selected households marked is given later in section 3.12.2.

Table 3.7 Parameters for conversion between WGS and the standard projection system for Nepal

Parameter	X translation	Y translation	Z translation
Value	296.207	737.545	273.001

Source: DoS.

3.11.1 Daily climate records in the Tarai

Daily records of rainfall and temperature for ten stations in the Tarai were collected from the DHM office in Kathmandu for the period of 32 years (1980-2013). The data was then audited for discrepancies like unrealistic values and values deviating more than two standard deviations from the mean. Long-term records for the exact village study sites were not available, so records were sought from nearby stations to explore the major climatic features. The location of the meteorological stations are shown later in Figure 3.7.The original data sets of selected stations were obtained as text files which were read, and compiled using code written in R software (R Core Team 2015). Due to a large number of missing values in some of the stations, only four stations, namely, Dhangadhi Atariya (station code 209) for rainfall records, Nepalgunj Regional Office (station code 416) and Tarahara (station code 1320) for both temperature and rainfall records and Chandra Gadhi (station code 1412) for rainfall records were selected for detailed analysis as shown in Table 3.8. The selected stations still had some missing values (as shown in Table 3.8) which can impact upon the rigidity of the trend analysis. Irrespective of these limitations, the DHM dataset is the only source for long-term ground station records for the Tarai, so it is necessary to work with it.

The meteorological stations are not situated precisely within the study areas and for that reason may not reflect the exact rainfall of the study sites, but can be considered as close climate proxies. The data that is directly reflective of the study location in the east come from Damak station, but only the records since 2000 were available. When comparing the rainfall data from Damak, Chandra Gadhi and Tarahara stations in the east, Chandra Gadhi's climate is found to closely resemble Damak.

Days with trace amounts of rainfall, which are stored as "T"s in the DHM raw data, were regarded as nil rainfall and replaced with "0"s, signifying 0 mm rainfall. The temperature records for Nepalgunj Regional Office had more than three months of missing data in the year 2013 so the analysis was limited to the 1980-2012 period. Analysis of other missing records revealed that most of the missing values for temperature were consecutive. Hence, the missing temperature values were replaced by a proxy based on the average value of the same variable on the same day in the preceding two years and the following two years. There was also a

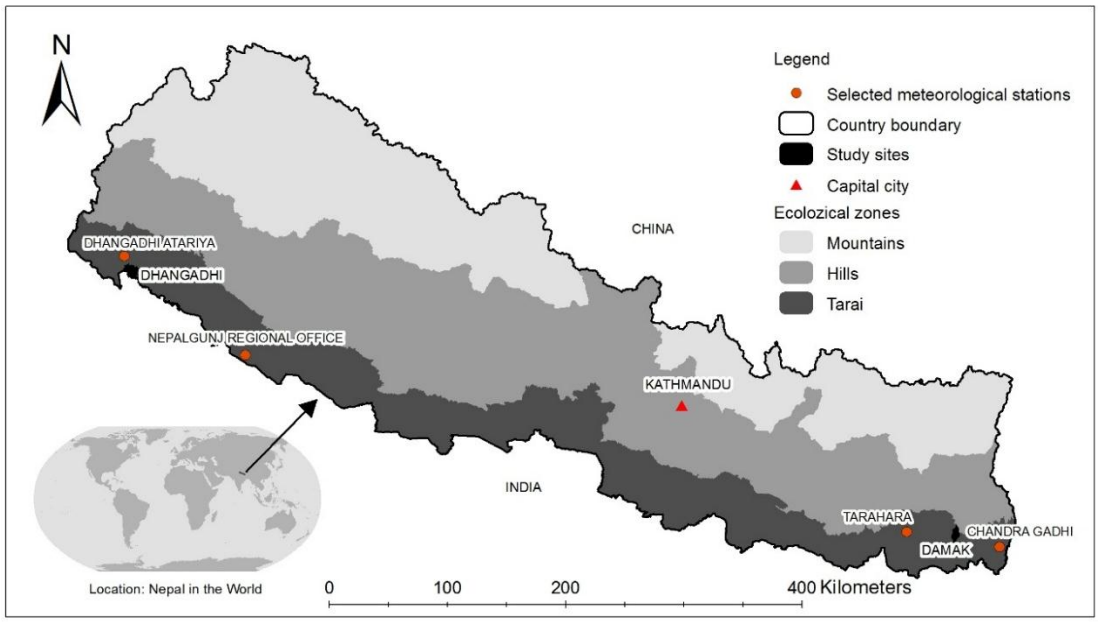
considerable gap in the temperature records from Tarahara station in 1980s, so only the data for 1987-2013 period were analysed.

Table 3.8 Details of selected metrological stations from the Nepali Tarai.

Station Name	Station Code	Altitude (masl)	Rainfall records			Temperature records			
			Period selected	Missing records	Missing %	Period selected	Missing records		Missing % [4]
							Max	Min	
Mahendranagar	105	176	1980 - 2013	2515	20.2512	-	-	-	-
Dhangadhi Atariya	209	187	-	-	-	1983 - 2013	19	43	0.3798
Nepalgunj Regional Office	416	144	1980 - 2013	2	0.0161	1980 - 2012	119	181	1.5016
Dharan Bazar	1311	444	2000 - 2013	0	0.0000	-	-	-	-
Chatara	1316	183	2000 - 2013	75	1.4666	-	-	-	-
Tarahara	1320	200	1980 - 2013	30	0.2416	1987 - 2013	45	48	0.4867
Damak	1408	163	2000 - 2013	16	0.3129	-	-	-	-
Anarmani Birta	1409	122	2000 - 2013	45	0.8799	-	-	-	-
Chandra Gadhi	1412	120	1980 - 2013	116	0.9341	-	-	-	-
Gaida Kankai	1421	143	2000 - 2012	0	0.0000	-	-	-	-

Note: Although there are ten stations listed, only two of the stations have records on both the rainfall and temperature. Station names marked in bold have been used to analyse trends.
Source: DHM records.

Figure 3.7 Ecological zones and selected meteorological stations in the Nepali Tarai



Source: Constructed using boundary data from DoS, world map data from Natural Earth, and location of meteorological stations from DHM.

[4] Percentage based on variable having the largest number of missing records

3.11.2 Indices to measure climate extremes

Much research has been conducted in Nepal to compute trends in climatic conditions—e.g. Chaulagain (2006), Diodato et al. (2012), Sheikh et al. (2015), Shrestha et al. (2012), Shrestha et al. (1999b), and Qi et al. (2013). However, analysis of extreme climatic events has been limited, and most studies do not focus on the Tarai, but rather the Mountains or the macro region of South Asia. Qi et al. (2013) analysed annual mean temperatures, temperature anomalies, and days with temperature above 30˚ Celsius from ten meteorological stations of Nepal. Shrestha et al. (1999b) evaluated maximum temperatures, while Chaulagain (2006) analysed annual mean temperature and total annual precipitation from Rampur station. Klein Tank et al. (2006) assessed daily temperature and precipitation extremes for the macro regions of South and Central Asia, although no specific Nepali data were included in their study. Of the current research available, Sheikh et al. (2015) conducted an analysis most similar to the present study, however, averages were generated from twenty stations from around Nepal. Considering the spatial variability in climatic conditions across the country, such a generalisation in trends in climate extremes may present a misleading picture of the situation in any one location.

Changes in the climate variability is more likely to manifest as extreme events than overall shifts in mean conditions (Katz & Brown 1992). It is particularly beneficial to analyse trends in climatic extremes for guiding climate change decision-making, because averaged values can hide the threshold characteristics which are most likely to cause deleterious impacts (Zhang et al. 2011). In order to provide a means for objective measurement and characterisation of climate variability, indices defined by the ETCCDI conception by the joint World Meteorological Organisation (WMO) Commission for Climatology (CCI), Climate Variability and Predictability (CLIVAR) and Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) ETCCDI. The creation of a standard set of indices has the advantage of enabling both the coordination of international climate change detection studies and in the comparisons of findings (ETCCDI 2013). To overcome the limitations of previous studies, twenty-four indices have been used to explore trends on climate extremes in the study sites as listed in Table 3.9. The indices are based on definitions from the ETCCDI/CRD, with a few minor modifications to better suit the local climatic conditions. For instance, indices such as frost days, icing days and growing season length were excluded from analysis because they are not relevant to the Tarai. The analysis, in conjunction with findings from other literature will help assess trends in climate extremes and relative thresholds for understanding the impact of extreme weather conditions. Subsequently, the findings from the analysis are also compared with field data generated from locals' perceptions of climatic characteristics.

Table 3.9 Selected extreme temperature and precipitation indices recommended by the ETCCDI.

Indices symbol	Indices name	Brief definition	Unit
TXx	Max Tmax	Monthly maximum value of daily maximum temperature	°C
TNx	Max Tmin	Monthly maximum value of daily minimum temperature	°C
TXn	Min Tmax	Monthly minimum value of daily maximum temperature	°C
TNn	Min Tmin	Monthly minimum value of daily minimum temperature	°C
DTR	Diurnal temperature range	Monthly mean difference between daily maximum and minimum temperature	°C
TN10p	Cool nights	Percentage of days when daily minimum temperature is less than 10th percentile	%
TX10p	Cool days	Percentage of days when daily maximum temperature is less than 10th percentile	%
TN90p	Warm nights	Percentage of days when daily minimum temperature is greater than 90th percentile	%
TX90p	Warm days	Percentage of days when daily maximum temperature is greater than 90th percentile	%
SU25	Summer days	Annual count of days with maximum temperature greater than 25 °C	days
TR20	Tropical nights	Annual count of days with minimum temperature greater than 20 °C	days
RX1day	Maximum single day precipitation amount	Monthly maximum single day precipitation	mm
RX5day	Maximum 5-day precipitation amount	Monthly maximum 5-day precipitation	mm
SDII	Simple daily intensity index	The ration of annual total precipitation to the number of wet days (≥ 1 mm)	mm/day
R10	Heavy precipitation days	Annual count of days with precipitation ≥ 10 mm	days
R20	Heavy precipitation days	Annual count of days with precipitation ≥ 20 mm	days
R50	Very heavy precipitation days	Annual count of days with precipitation ≥ 50 mm	days
R100	Extremely heavy precipitation days	Annual count of days with precipitation ≥ 100 mm	days
CDD	Consecutive dry days	Maximum number of consecutive days when precipitation is ≤ 1 mm	days
CWD	Consecutive wet days	Maximum number of consecutive days when precipitation is ≥ 1 mm	days
CDDm	Consecutive dry days for monsoon	Maximum number of consecutive days when precipitation is ≤ 1 mm during monsoon season (June to September)	days
R95p	Very wet days	Annual total precipitation from days > 95th percentile	mm
R99p	Extremely wet days	Annual total precipitation from days > 99th percentile	mm
PRCPTOT	Annual total wet-day precipitation	Annual total precipitation from wet days (≥1 mm)	mm

The climatic indices generated differ in their format. For example, indices SU25 and TR20 are based on fixed bio-physical thresholds to human comfort and agriculture, while indices TXx, TXn, TNx, and TNn are based on monthly extremes. Percentile base indices such as TN10P, TN90P, TX10P, and TX90P are calculated based on the number of days that exceed a fixed percentile value, while other indices like the DTR are based on relative differences between

the maximum and minimum extremes. For rainfall, indices R10, R20, R50, and R100 are based on the days exceeding a fixed threshold of rainfall, whereas indices like the CDD and CWD are based on an annual assessment of the maximum occurrence above some threshold. R95p and R99p are based on percentile precipitation thresholds for all available years. The SDII is based on the distribution of rainfall throughout the calendar year, with wet days only counted if rainfall exceeds 0.85 mm in a 24-hour period. This wet day definition is standard practice for rainfall analysis, albeit with the use of different thresholds – see Karmacharya (2010); Kenway et al. (2011).

Temperature indices that use percentiles depend on benchmarks defined by a base-period for comparison. Although, typically, a thirty-year base period is sought for such analysis [e.g. Kenway et al. (2011), Klein Tank and Können (2003) and Vincent et al. (2005)], due to the lack of data from the Tarai stations, the base period was set to the first decade of the available datasets. The indices requiring a base period were calculated using the climdex.pcic package by Bronaugh (2015), which uses the robust bootstrapping techniques described by Zhang et al. (2005). The CDDm index has been modified from the original CDD to include dry days only during the monsoon season, to reflect the focus on the period which is most important for paddy farmers. The monsoon season here is defined simply to include dates from June to September, not taking into account the official onset dates set by DHM, which are based on complex criteria, and vary from year to year.

The daily records from DHM were used to compute the 11 temperature related and 12 rainfall related indices using the calculation methods detailed by the ETCCDI. Each of the indices were then tested for possible trends the results of which are discussed next.

3.12 Primary data

This study used primary data collected from questionnaire surveys, interviews and participant observation and secondary data from various reports, documents, datasets and published sources.

3.12.1 Questionnaire design

Stewart (2014) points out that case studies are especially important tools for answering “how” and “why” inquiries as they provide the space for detailed analyses and enable “interaction with participants”. Case studies also typically incorporate a myriad of tools catering to a wide range of philosophical inclinations. A case study is also termed as a “nominalist” approach to research as the researcher is inherently biased in making judgments about the subject being studied (Stewart 2014). Selecting a case study approach when utilising mixed methods can

capture a range of data drawn between a “highly-interpretivist” approach and a more “realist” approach. A balance of the two has been attempted in this research. The questionnaire asked for demographic details of the household as well as individual perceptions and experiences, and was structured into 10 sections according to the type of information sought as listed below.

1. **Section A:** Questionnaire form details like form number, date and time when the questionnaire was conducted, location, and initials of the person conducting the survey. This section was used to identify the responses by study sites, and for quality control checks including identification of differences in responses between enumerators. The checks were performed by analysing responses to selected variables at the end of each day of the survey and ensuring similar patterns of answers regardless of the enumerator. The questionnaires are numbered starting from 1 for Damak and starting with 200 for Dhangadhi.
2. **Section B:** Demographic details like gender, age or birth year, ethnicity, and if a non-indigenous family, the district of origin and the reason for moving from the previous location. Additionally, it also sought basic demographic details like marital status, education level, gender, main occupation and secondary occupation or acquired skills of all members of the family. The demographic details of the family members gave a clearer picture of the composition of the household and their combined human capital.
3. **Section C:** Fixed asset details like total land owned by the family, type of ownership of each land owned, type and size of dwellings, ownership of mobile phones by household members, and primary, secondary and tertiary occupations of the household. Additionally, it also asked for the type of crops grown in their fields, details of livestock owned, and the income made from agriculture and livestock and their perception on changes in harvest in the last five years.
4. **Section D:** Environmental resources like forests, river, grazing lands and ponds which they access regularly. The inventory of resources and their access frequency showed their reliance on local environmental resources and how the access has changed in recent years. This section also recorded the types of fuel used for cooking by the household.
5. **Section E:** Perceptions of climate trends and their perceived impacts using the Likert scale. Perceptions of a range of climate indicators such as hotness of summer, length of summer etc. as well as trends in rainfall patterns were sought. Additionally,

open-ended responses on how perceived impacts affected them and any actions to adapt or mitigate the impacts were collected.

6. **Section F:** Water use and drought events like trends in use of different water sources, the type of water sources used regularly and their experiences with changes in access to water sources. The respondent's experience with water scarcity, drought, and the actions to remedy such events were also captured. Open-ended responses captured the individual's particular experience with water scarcity events.
7. **Section G:** Flood events experienced by the respondent was captured in this section. Details like the extent of the floods, the time period, damages caused, any warnings received, measures practiced to mitigate flood and their thoughts on additional measures to prevent flood damages.
8. **Section H:** Help or compensation from institutions including the organisation offering help, type of help received and its effectiveness.
9. **Section I:** Migrant worker details associated with destination, duration of work, type of work, frequency of remittances, amount of remittances received in the previous year, frequency of return visits, reason for being a migrant worker, access to social networks, financial help received and the sources of financial help.
10. **Section J:** Additional opinions that the respondent wanted to express.

The full questionnaire and English translation are provided in Appendix A.

3.12.2 Sample selection

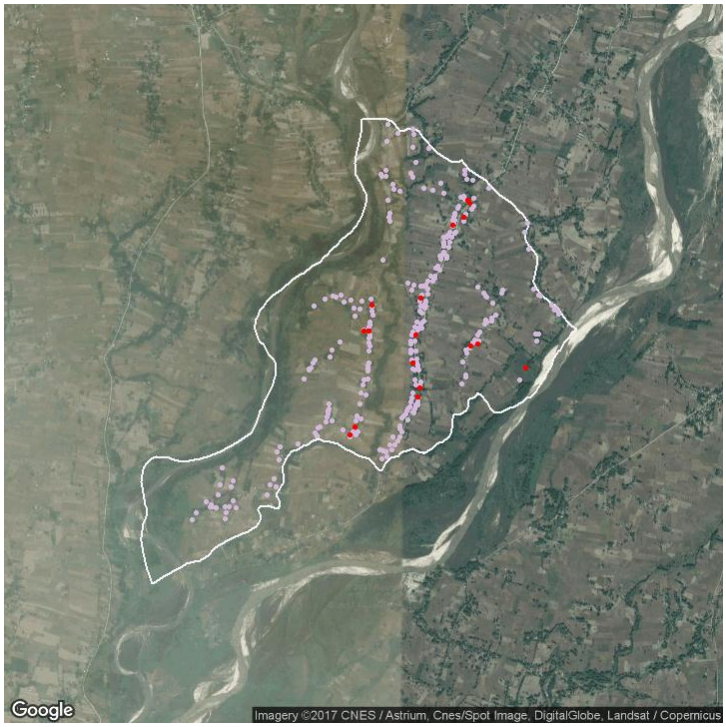
The best or perfect method of sample selection is probability sampling, which creates a fully representative sample with any error terms following a predictable mathematical pattern. However, it is normal practice for research to adopt non-probability sampling methods when probability sampling is not feasible (Neuman 2014; Taranter 2010). The sample selection method for selecting households for the questionnaire survey aimed to provide a close representation of probability sampling that could be carried out with the limited data available. The municipalities do not have a system of numbering houses making a sample selection from the complete list of houses difficult. Moreover, there is no system of naming of the streets except for major roads, again making it difficult to keep track of individual houses.

The DoS data provides the location of building structures as point data without any additional information. As the map data was more than a decade old, the number of actual buildings had increased and did not match the DoS data perfectly. The DoS data was updated from a more recent vector map (2011/2012) that was obtained from Damak municipality office. No recent data were available for Dhangadhi sites however, so the original data was used for sample

selection there. In the final updated map for Damak, each building was marked by a point. The number of points indicating houses or settlements however did not match the exact number of household numbers from the 2011 national population census. The reason for the mismatch is due to the different dates for the data, and more importantly, due to the fact that one building does not necessarily mean one household. The purpose of mapping the houses was not for an accurate depiction of the location of houses, but to make sure that the houses selected for the questionnaire survey were chosen at random.

The selection of households was planned to be as random as possible by making a selection of the required number of households from each ward using a random selection procedure in R software. The sample size for each ward was proportional to the number of households in that ward. The selected points representing location of buildings were highlighted to produce maps for every wards at the two sites (see Figures 3.8 and 3.9 for examples). During the survey, the researcher visited locations close to the highlighted points and then undertaking a survey in that vicinity before moving to another location close to the next highlighted point. In case a suitable respondent was not found due to cases like no one aged above18 years was present at the house; the house was locked; or if the person declined to participate, another household adjacent to the highlighted point was approached. This technique ensured that a broad distribution of the selected households was maintained and the selection of respondents from only one neighbourhood was avoided.

Figure 3.8 Map of Damak ward 19 with showing ward boundary (white line), house points represented by dots with randomly selected houses highlighted in red.



Source: Ward boundary obtained from DoS; house or settlement points obtained from DoS with updates from map provided by Damak Municipality office; background satellite image from Google maps.

Figure 3.9 Map of Dhangadhi ward 9 with showing ward boundary (white line), house points represented by dots with randomly selected houses highlighted in red.

Source: Ward boundary and house or settlement points obtained from DoS; background satellite image from Google maps.

The surveys were undertaken by the researcher and two research assistants—one for each site. It was not possible to administer the questionnaire equally among males and females and the possible reasons are discussed in detail in Chapter 4.

3.12.3 Interviews

Interviews and participant observation are the two most popular methods for gathering qualitative data (Bryman 2012, p. 493). For this research, semi-structured interviews were carried out with selected farmers and development practitioners. The questions were based on a list of pre-determined topics but it was conducted so that replies could be open-ended and follow-up questions could be asked to further elaborate on a particular issue.

The interviewees were selected during the field visit as persons of interest who could give further information on personal experiences with the changing physical and social environment. The identity of the interviewee was not recorded and no information identifying them has been revealed. The interviewees are referred in the text by their "person number". The anonymity was especially important as the researcher also wanted to know about any activities that could be classified as illegal. The interviews were used to capture detailed experiences on themed topics like migration, farming, historic events and flood events. Unlike the selection of questionnaire survey respondents, the interviewees were selected on their availability. The interviewees were approached based on their experiences with one or more of the themed topics like circular migration, flood events, early settlement, or their witnessing of an historic event. The questions were mainly based on a pool of pre-determined themes like resource use, livelihood practices, variation in climate and migration experiences, but were asked in an unstructured manner depending on the conversation. All interviews were conducted in Nepali language and recorded using a digital audio recorder. Important sections of the interviews were transcribed and translated into English. A couple of interviews were also conducted with experts working in the development sector. They were selected based on their familiarity with working in the region and with similar communities in environmental and disaster mitigation sectors.

The interviews were carried out from November 2013 to March 2014, and all were carried out by the researcher alone so that the range of responses could be treated in the same manner. Moreover, this enabled the researcher to clarify any questions about the research with the interviewees. In a few cases, the researcher conducted follow-up interviews to get additional information and clarification on some answers.

3.12.4 Participant observation

Participant observation consists of the researcher taking part in community activities, while adhering to professional conduct and recording crucial observational data (Bryman 2012). Participant observation is very useful to understand daily experiences of the subjects and the manner in which they interact with each-other and the environment. Such observation is inherently biased from the perspective of the observer, and also requires considerable time in the field to understand key behaviours and actions.

Being a Nepali helped the researcher to engage directly with the community. The small talk, including sharing the background of the researcher, was helpful in striking up conversations to gain insights into their lives. Prior to conducting the actual field survey, the researcher spent some time to get familiar with the local cultural norms and settings of both study sites. This involved staying at a local's house for a week and getting to know the people met along the way while exploring the spatial extent of the study area and its situation. Information was also gathered while interacting with the locals on the street, in local tea-shops, on public transport, or while asking for directions. Culturally, the Tarai people (and Nepali people in general) are very keen to talk with strangers and share their thoughts and opinions. The information gathered from such observations were not recorded outright but noted down each night of the field visit for possible use in interpreting meanings to explain social/cultural phenomena. Overall, preliminary visits in the field provided some background on the context of the sites and gave a more lucid picture of livelihood problems, especially regarding their interactions with the local environment. Moreover, it provided the researcher with knowledge to re-evaluate the importance of issues and provided ground to adjust the focus of the research. During the site visits, photographs were taken to record selected observations. When used in the text, the photographs are sourced as "Field Survey 2013-14".

Focus group discussions (FGDs), which are a widely-used technique for qualitative data collection, were not employed in this research. The decision not to use FGDs was based on the researcher's prior experience with the method in projects conducted in the Tarai region and in Nepal. While FDGs provide an efficient way to get a broad range of issues, it is also common for the discussion to be influenced by one prominent participant. This is especially true when including participants who are members of political parties and are vocal about issues close to their party's agenda. Besides the recorded interviews, specific information like cropping calendar, important events, recruitment process of migrant workers etc. were noted while talking with the locals and from local print media and local radio broadcasts. Table 3.10

summarises the different types of primary data sources and how they have been referenced in-text in this research.

Table 3.10 Summary of primary data sources and their referencing in this thesis.

Primary data source	Type of information	In-text reference
Questionnaire survey	Textual information recorded by the enumerator while administering questionnaire survey	Respondent number signifying the survey respondent
	Descriptive or inferential statistics from quantitative analysis	Field Survey 2013-14
Interviews	Textual information recorded and transcribed into English	Person number signifying the unique number given to each interviewee
Photographs	Visual	Field Survey 2013-14
Personal observation	Observation	Personal observation

3.13 Theoretical saturation

Interviews and participant observation were carried out using a theoretical sampling method in which the number of respondents is not pre-determined, with the process continuing as the findings evolve (Bryman 2012, p. 419). Typically, such a process is continued until no new information emerges on a particular topic (Bryman 2012, p. 421). For this research, interviews with locals were carried out until a sufficient saturation of information was achieved. Interviews of development practitioners on the other hand, were carried out to understand important programs and policies regarding socio-environmental issues in each region and no information saturation was expected. The answers to the open-ended questions in the questionnaire were also used to check the overlap of information as many of the points raised in during interviews were also recorded during the questionnaire survey.

Information gathered from the questionnaire survey are attributed as "Field Survey 2013-14". Besides the descriptive statistics from the survey, quotes from open-ended responses have also been cited to illustrate the respondents' views whenever applicable. The responses to many open-ended questions in the survey provided rich information reflecting the direct experiences and thoughts of the locals. Direct quotes from interviewees are attributed by a unique number and referred to in the text by their "person number". Direct quotes and snippets from the questionnaire survey are referred to by their "respondent number", which reflects the serial number of the corresponding questionnaire form.

3.14 Analysis of data

Data constitutes all of the information that is collected to address the research questions. In typical social science research, data is first “collected” and then “analysed” (Phillips 2010). Different analytical tools and techniques are used based on the type of data and the question

being answered. As stated above, some of the qualitative research was generated in a reflexive manner, where findings led to new directions of enquiry and further data gathering. The primary data here were collected through field observations, questionnaire surveys, and key-informant interviews. With the aim to remove any bias in collection of such information, the response of variables was collected in a Likert-type format, with neutral being no changes perceived and any increase or decrease being rated higher but in opposite directions. The original Likert scale was developed by Likert (1932) as a tool to measure character and personality traits using five response alternatives viz. strongly approve-1, approve-2, undecided-3, disapprove-4, and strongly disapprove-5. The responses from different questions were combined to form a measurement scale. Clason and Dormody (1994) define Likert-type items as individual questions that utilise aspects of the original Likert response alternatives, but responses to each question are treated separately without any attempt to form a combined score. The scores from such scales are discussed using descriptive statistics like modes or medians to explain central tendencies variability respectively. While data on the ethnic background was collected for each respondent, the findings have not been discussed by subgroups based on ethnicity. Some level of differences in ethnic background are covered by whether the household belongs to indigenous group or are Hill/Mountain settlers. Moreover, due to the extent of diversity, there are more than a hundred ethnic subgroups (CBS 2014b) which made comparison at the ethnicity/caste level impractical. Rather, group differences based on factors such as indigenous status, education levels and migrant members are presented in the discussion.

3.14.1 Quantitative analysis

Quantitative data represents key attributes of a system as numeric values. As discussed, quantitative data were collected from both primary and secondary sources to inform analyses. Data collected from the questionnaire survey provided the primary quantitative data whereas meteorological and spatial data was sourced from secondary data.

Every question of the questionnaire were assigned a variable code to store all possible values that could be generated from those questions. This process of assigning codes or tags to data is referred to as coding (Bryman 2012). Microsoft Access software was used to create a data entry form interface to facilitate the data entry process for questionnaire survey data. Using a form interface for data entry as opposed to directly entering data on a spreadsheet, it was possible to use validation rules to check for entry errors and also providing full textual descriptions that automatically translated data into predefined codes. For open-ended responses, the answer was translated into English and stored as text. The survey data was

saved as a relational database file with multiple tables linked by an identifying column. Each table was exported as a separate Excel file for analysis in R software.

The meteorological data from DHM was obtained as individual text files for each year at every location, and were batch processed to form a master dataset. The daily rainfall records are in the *AS####YY.yy* format, where *####* represents a four digit station code (leading 0 required for three digit codes), *YY* represents the first two digits of year and *yy* represents the last two digits for the year. For instance, a file *AS142120.14* is a daily rainfall record file for year 2014 for station 1421, which is Gaida Kankai in Eastern Nepal. While the raw data can be opened in any text editor and copied to a spreadsheet, that process is unwieldy when dealing with decades of data from multiple stations. The rainfall record files of multiple stations were read and evaluated using R to create a continuous time-series for each station and saved in csv formats for each station.

Similarly for temperature data, the records obtained from DHM are named in the *TA####YY.yy* format, where again *####* is a four digit station code (leading 0 required for three digit codes), *YY* represents the first two digits of year and *yy* represents the last two digits for the year. For instance, a file *TA131120.14* is a daily temperature record file for year 2014 for station 1311, which is Dharan Bazar in Eastern Nepal. The first line of each of the files for temperature data consists of the corresponding 4 digit year number and name of the station. The second line consists of column headings for maximum and minimum temperatures. From the third line onward, each text file in the dataset consists of one year of temperature records with each line represented by DOY, maximum temperature and minimum temperature for the corresponding DOY in Celsius (°C). The DOY value ranges from 1 to 365 during non-leap years and from 1 to 366 in leap years.

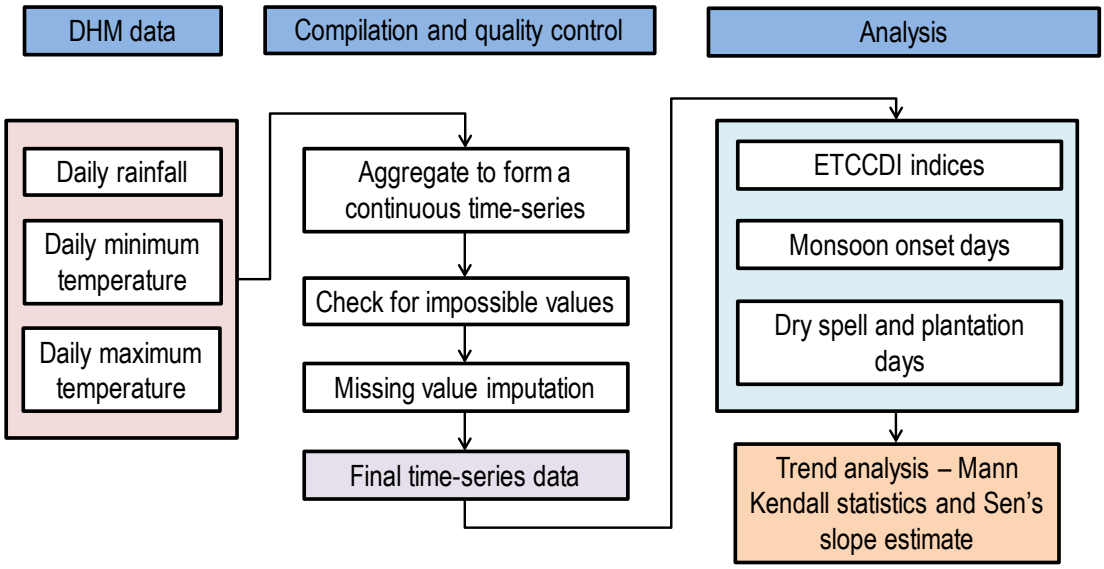
Prior to statistical analysis, the compiled raw datasets were tested for quality control, violations of normality and homogeneity of variance assumptions. The following checks were performed on the daily data obtained from DHM:

1. Gross error checks by flagging impossible values—e.g. two values for one station were found to be triple digit numbers and were corrected.
2. Tolerance test by checking of values exceeding three times the SD of the mean.
3. Internal inconsistency test by checking for coherency between associated elements—e.g. maximum temperature for the day smaller than the minimum temperature for the same day.

4. Temporal coherency test by checking for values exceeding the expected amount of change between successive observations—e.g. large inter-daily differences in maximum and minimum temperatures.

Daily temperature data are normally auto-correlated, which violates the assumption of some statistical tests like the regression model and the Mann-Kendall (MK) test (von Storch 1999; Zhang & Zwiers 2004). The auto-correlation was checked in R using the Kendall (McLeod 2011) package. As the spatial interpolation of precipitation data is not recommended for the complex Nepali terrain (Hormann 1994), the missing rainfall was replaced by a proxy based on the value of the day in the previous year and the value for the day in the next year. The imputation algorithm did not take into account the leap years. In a case when the first year's data is missing, only the value from the next year was used. For missing temperature data, a similar algorithm was used to interpolate the missing value based on the previous year and the next year. The final dataset with missing values replaced by proxies was used to create the climatic indices, and other monsoon-related indicators. Finally, trend analyses were performed on the indicators to look for statistically significant deviations. A flowchart of the climate data analysis process is shown in Figure 3.10.

Figure 3.10 Flowchart showing steps in climate data collection, processing and analysis.



3.14.2 Qualitative data

Qualitative data for this research were gathered from interviews as well as from participant observation and the review of literature. Open-ended answers from the questionnaire survey also provided qualitative data for analysis. All interviews were recorded using a digital recorder and the audio files were imported in NVivo qualitative data analysis software developed by

QSR International Pty Ltd. for transcription and coding. Additional qualitative information was collected from the transcription of radio advertisements from employers and migration agents broadcasted in local Frequency Modulation (FM) radio stations. The radio adverts were translated into English for analysis in NVivo. All original audio files and transcripts are stored in a secure drive provided by The University of Adelaide.

All audio transcripts were coded according to predefined themes for thematic analysis. The themes were created to help the researcher link the text with theoretical concepts to aid in building arguments to answer the research questions. Direct quotes from the interviews and opinions from open-ended answers have been used in the discussion chapters to illustrate opinions from the interviewees in the preceding chapters.

3.15 Ethical considerations and management of research data

During the course of any research, it is important to inform the participants that they are being studied and ensure that no harm is caused to anyone (Bailey 1987, p. 406). The research was approved by the University of Adelaide Human Research Ethics Committee on 27 March 2013. As per the University of Adelaide Human Research Ethics Committee guidelines, each participant was given the details of the survey, handed the participant information sheet and an independent complaints procedure sheet in Nepali language, and consent was obtained before commencing the questionnaire. There were only a few cases where the selected respondent declined to participate in which case the interviewer moved to another household in the vicinity. The completed survey forms were brought back to Adelaide and are archived at The University of Adelaide.

For interviews, each interviewee was given the details of the survey, handed the participant information sheet for interview and Independent complaints procedure sheet in Nepali language and consent was obtained before commencing the interview. All digital recordings are now saved in a secure network storage provided by The University of Adelaide. Copies of participant information sheet, independent complaints form and consent form are attached in Appendices B-F.

3.16 Post study reflections and limitations

Being a Nepali and having prior experience in field work in the region helped the researcher in gaining relatively easy access to the study sites. Although there are no official organisations to regulate and oversee social-science research work in Nepal, the local authorities like the Chief District Officer (CDO) of the respective districts were informed of the scope of the study and the field-work dates. Informing the local authorities was deemed necessary, especially as the

preliminary visits were carried out just before the general election in November 2013. As the entire country was preparing for the constituent assembly elections with the aim of electing a fresh assembly to draft Nepal's constitution, all major political parties were actively campaigning in all parts of the country. It is not uncommon for political events to turn violent in Nepal, and thus for safety reasons, travel to the sites was not carried out in the weeks immediately prior to and after the election. Fortunately, both Damak and Dhangadhi did not witness any post-election violence so the researcher was able to visit soon after the election. It must also be noted that although being able to mingle with the locals, the author was also an "outsider" with a cultural background associated mostly with the Hills where he was born. Typically, during interviews, questionnaire surveys and any verbal communication made with the locals, the name and home location of the researcher was shared. Although there was no indication that the researcher's background lead to any biases in responses, some respondents would perhaps have shared more information had the researcher been from the Tarai.

Coincidently, the field-work started just after a particularly wet monsoon, the memory of which was fresh in the respondents' minds and that event might have influenced responses on perception regarding trends in rainfall and river flow patterns during monsoon as explained in detail in Chapter 6. The responses to trends in rainfall and river flows was however, not limited to a few perception questions, but were accompanied by open-ended response questions that allowed for respondents to elaborate on their individual experiences. Furthermore, important topics were explored through in-depth interviews which allowed the researcher to ask follow-up questions to seek further explanation of experiences and to clarify responses.

Conducting surveys at the opposite ends of the country meant undertaking extra travel because flights to the nearest airports would only originate from the capital city. Since the airports would only operate on days with high visibility, there were also frequent flight cancellations and redirections due to fog during winter months. This resulted in some last-minute travel plan changes, and prolonged the overall field study timeline.

3.17 Conclusion

This chapter discussed the research approach and methods utilised to conduct this research. The philosophy behind the selection of methodologies and methods were also discussed. It provided an overview of the administrative divisions in Nepal and the methodology adopted to select the case study sites. This chapter also provided arguments for combining qualitative and quantitative approaches to best answer the research questions. Detailed descriptions of how mixed methods were used and how the various secondary data sources were analysed,

were also outlined. Overall, this chapter outlined the mixed methods approach including the questionnaire survey, participant observation and in-depth interviews which were considered appropriate methods to address the research questions. The following chapters will discuss the results in relation to key theoretical and practical considerations.

4. Environment, livelihood and the underdevelopment in the Tarai

4.1 Introduction

A common interpretation of the contemporary situation in the Tarai has been that of a region that has been grappling with poverty, social inequality and internal political conflicts. Tarai has been a hotbed of political unrest since the abolition of the monarchy and the formation of a Constituent Assembly in 2006 (Pfefferle 2015; Shrestha & Chaudhary 2014). Political skirmishes have escalated in the Tarai in the last decade, especially after the adoption of the latest constitution on 20 September 2015. Such incidents, however, have not dominated the region's recent history, and for the most part, the many ethnic groups of the Tarai and other regions of Nepal have integrated peacefully into a broader cohesive society. The distrust of the Tarai's land-poor farmers and indigenous population of the government has historical roots, which in part is a result of the ruling class allowing certain groups of people to hoard land at the expense of others. The recent movements in the Tarai, however, are concerned at gaining political power rather than facilitating broader socio-economic development (Hattlebakk 2007). Environmentally, the Tarai has seen a total transformation from forests to agricultural fields and despite a range of challenges, has been serving as the granary of the nation. As explained later in Chapter 6, the Tarai's environment and the diverse groups of people living there are facing additional issues brought about by climate change and global trends which generate demand for planned action to adapt.

This chapter details the contemporary socio-ecological conditions in the Nepali Tarai in an attempt to provide a background on the local environment, the people and their livelihoods, before exploring the issue of circular migration, and contemporary threats in Chapter 5 and Chapter 6 respectively. First, the recent history of the Tarai is briefly discussed. Secondly, the conceptualisation of the Tarai's socio-ecological system is presented. Most livelihoods in the Tarai are still directly derived from agriculture and livestock rearing. Nevertheless, while more than 90 percent of respondent households engaged in agriculture and livestock rearing, most also practiced a range of off-farm earning opportunities to generate supplementary income. The demographic details of the respondents and their household members are presented to provide further context to their survey answers which will be examined in detain initially here and then also in the following two discussion chapters.

4.2 Livelihood challenges and opportunities in the Tarai

The three physiological zones in Nepal have different climate, geographical and bio-physical features resulting in varied scope for livelihood opportunities. Some 43 percent of the Mountain

region has a mean annual temperature of less than 5°C and only about 38 percent of the region has a climate appropriate for agriculture, with a growing season more than 150 days in length (Shrestha 2005). Unlike Mountains, where the pressures from changing weather patterns has can be been attributed to resource depletion and food security (Gentle & Maraseni 2012), the fertile lands of the Tarai already provide food for the majority of the country, and provide further opportunities for agricultural intensification. The Tarai is also privileged with access to all-weather roads and proximity to urban centres.

The Tarai has also been experiencing higher population growth at about 1.6 times the rate of Hills in 2011 (CBS 2012a). Historically, migration to the Tarai had been fuelled by government-led resettlement programs which brought people residing in Hills to the low-lands (Eckholm 1976; Elder et al. 1976; Hrabovszky & Miyan 1987; Shrestha 1989). The Tarai also enjoyed a larger share of income from international remittances estimated at 57 percent of the total compared to 34.3 percent for the Hills and 8.7 percent for the Mountains in 2009 (NIDS & NCCR North-South 2010). Still, Tarai society remains one of the least developed regions in Asia. In fact, an average resident there rarely has access to facilities which would be considered very basic in the modern world. Access to welfare from the state is virtually non-existent. Furthermore, due to the highly centralised nature of the government, most state-led development efforts have been disproportionately focused in the capital city and the surrounds to cater for the elites (Lawoti 2003). Many of the problems being faced in the Tarai are from the direct consequences of the development efforts that have been carried out. The transformation of forest into agricultural fields and then the proliferation of haphazard settlements has taken its toll on the availability of natural resources, and increased dependence on outside regions (Adhikari & Bohle 1998; Hrabovszky & Miyan 1987). Moreover, the compulsory reliance on trade with external regions means that external economic shocks have direct impacts on the financial wellbeing of even underdeveloped regions like the Tarai. This reliance is explored in detail in chapter 6 with the case of Tarai circular migrants.

The Tarai residents depend directly on natural resources such as forests, grazing lands, wildlife and fisheries, and water resources on a daily basis. Due to the development that the Tarai has undergone in the past decades, the ease of access to such resources for individual households has decreased significantly. The reduction in natural resource availability impacts the poorest section of farmers more because of their inability to afford alternatives. Any impacts from climate change affecting availability or access to these resources will further impact on farmers' livelihoods, a topic which will be tackled separately in Chapter 6.

4.3 The Tarai context

For a newcomer, the Tarai, with its rustic setting, may seem like an idyllic place where people and nature are very close together. At the same time, for the communities, the problems of social and economic inequalities, poverty, lack of political representation, and natural hazards have continued since the establishment of the Tarai settlements in the 1960s. In fact, the Tarai has seen long lasting conflicts between the dominant elites and minorities (Cox 1990). Moreover, the Tarai is not without influence from international phenomena like climate change, global market failures and demand for cheap labour. The case studies of the Damak and Dhangadhi municipalities highlight how global economic and environmental phenomena have implications even in the lives of poor farmers situated in a seemingly isolated rural region.

Nepal's Tarai was once regarded as the nation's "frontier" land (Shrestha et al. 1993)—an area near the borderline which acts as a transition space where the influence of the state fades as the distance from the capital increases (Prescott 1965). In fact, the name Nepal itself was used by the locals to describe only the Kathmandu valley and its vicinity (Singh & Wright 1877, p. 2). The Tharu people have been said to be the first inhabitants and living in the Tarai for more than six centuries (Cox 1990, p. 1319). Although there are methodological issues in counting the ethnic population, according to the 2011 census, Tarai indigenous population referred to as *Madhesi Adibasi* / *janajati* stood at 7.7 percent of Nepal's population (CBS 2014b). The influx of migrants began after the eradication of malaria disease in the 1960s. The Tarai malaria is caused by *Plasmodium vivax* and *Plasmodium falciparum* parasites. The indigenous population has been found to have seven times lower rate of malaria infections compared to the non-indigenous population (Terrenato et al. 1988). The indigenous population of the Tarai had developed strong cultural links to the place prior to the eradication of the mosquito-borne infectious disease, possibly due to their immunity to the parasites.

The Nepali Tarai has long been characterised by a high level of internal and international migration, especially to the neighbouring country of India [see Kansakar (1985); Hrabovszky and Miyan (1987); and Gurung (1989) for more detailed accounts]. The modern history of Nepali out-migration to India dates back to the early 1800s (Dahal & Chaitanya 1987) but the major internal migration to the Tarai started in the 1960s. A government-led planned resettlement program to move people from the Hills to settle in the newly cleared land on the plains started in the late 1960s (Kansakar 1985; Shrestha 1985). The resettlement was initiated in 1970 to Jhapa district, where Damak is situated, and in 1976 to the Kailali district, where Dhangadhi is situated (Kansakar 1985). Many elderly respondents and interviewees recounted the early days of the

settlement around the 1970s when the forest was systematically cleared for agriculture and the timber exported.

Prior to the influx of in-migration, Damak for example was mostly inhabited by the ethnic Dhimal people. Many early settlers in Damak remember a small market with a few shops accessible only by foot from the smaller villages. Today, Damak is one of the most rapidly urbanising municipalities in Nepal (CBS 2014a). Similarly, in Dhangadhi, the ethnic *Tharu* people engaged in farming long before the state-led population distribution. Based on the 1991 census data of ethnic migrants who moved to the Tarai, 95 percent originated in the Hills (Niroula 1998). The exodus of Hill migrants has been discussed by many researchers, e.g. Gurung (1989) and Shrestha (1985), and the Tarai has been the recipient of much of that movement.

Nepal shares a long and open border with India. As per the "1950 Indo-Nepal Treaty of Peace and Friendship", Nepali citizens have freedom to move across the border without restriction. The same treaty also allows for citizens of both countries to freely move, work and/or settle in any part of either country. As travellers crossing the international border from either side are not required to submit any documents, the movement goes largely unrecorded. Due to the nature of the temporary mobility, it is difficult to quantify and is often not captured by most surveys and censuses (Hugo 1982).

The majority of current residents in the Tarai have migrated from the Hills, but some also moved from the Mountains. Looking at the vast plain paddy fields with dotted buildings and urban centres in the Tarai, it is hard to imagine that much of the region was a woodland only fifty years ago. Currently, the Tarai is the most densely populated region in Nepal and over half of the nation live there. Although there are important settlements throughout the Tarai, most of the population live in or around regional cities, like Damak and Dhangadhi—the two municipalities used as case studies in this research.

4.3.1 Municipality or a village?

The criteria for a municipality in Nepal are defined in the Municipality Act 1992 and the Local Self-governance Act 1999, and are based on population size, annual revenue and level of infrastructure. The minimum threshold for annual revenue of a settlement to qualify as a municipality is Nepalese Rupees (NPR) 5 million (USD50,000) for Tarai settlements. The minimum population threshold for Tarai settlements to be classified as a municipality is 20,000. By population, Dhangadi is ranked 11th and Damak 18th amongst all Nepali municipalities. The Municipality Act 1992 specifies "minimum urban facilities such as electricity, road, drinking water, communication and other similar facilities" but does not provide specific requirements. In the two

municipalities, even basic facilities are missing in areas away from the urban core. Many urban areas, especially newly established ones, possess rural characteristics in terms of physical facilities and socio-economic indicators (CBS 2014b). In Damak for example, wards furthest from the urban core have no water supply or land-line telephone although, in some wards, underground infrastructure for water supply was being installed during the field work. There were various ongoing infrastructure development projects being carried out at both sites such as: a drinking water pipeline project supported by international aid agencies under a project to improve wards affected by the refugee camps in Damak, various road expansion and improvement projects in Damak and the expansion of public bus network in Dhangadhi (Plate 4.1). Yet, many infrastructure projects, which have been promised, have not been initiated, and among the ones that were started, only a few have been completed. Locals shared their frustration on lack of infrastructure despite being classified as a municipality and the lack of competency of local governments in executing projects. A 40-year-old male farmer and entrepreneur from Damak stated:

> *The urban development team [from the government] decided on which locations to classify as municipalities, but there are no services in many areas. Even after declaring a municipality, there has not been much development. Roads and drainage are the same. There is a lot of dust from the streets especially during winter. This is a municipality, but the facilities are non-existent. … We rely completely on tube wells for drinking water. There's no piped water supply in this ward. Some wards have received funding from Lutheran World Federation Nepal (LWF Nepal) for water supply project. Only the wards that have been deemed "refugee affected areas" will receive the water supply pipelines. Ward 8 has not been defined as a "refugee affected area" so the pipelines will not reach us. I don't agree with their assessment of affected areas. We are also affected because the waste from the refugee camps flow through the same river. We receive indirect impacts. I think they should declare all [Damak] wards affected. (Person 4)*

A 40-year-old male entrepreneur from Damak stated:

> *Development has stagnated in this area. The ring road project which is being constructed was actually conceived by the municipality 15 years ago, can you believe that? The bridge project [across the Mawa River] has finally been budgeted for. For many infrastructure projects, the municipality takes care of 75 percent of the costs while the locals bear the remaining 25 percent. Projects are delayed for years and years. We are lobbying to bring [government] funding for one more primary school teacher. The government has allocated only one primary school teacher [for the local school]. (Person 8)*

Similarly, a male farmer in his 40s, said:

We collected NPR2,000 (USD20) from each household for installing electricity infrastructures. I made a lot of personal requests to the officials to make it happen. The process is very slow. ... The

road has been completed only recently... just a couple of years ago. We had to request many officials from the municipality for this. (Person 10)Plate 4.1 Trenching works being carried out for laying underground water pipes in Damak (left). Inner roads being prepared for black topping in Damak (right).

Source: Field Survey 2013-14.

Both Damak and Dhangadhi are witnessing rapid urbanisation and the urban core areas are constantly expanding. Consequently, land values in the urban core and its surrounds have skyrocketed. A number of respondents were concerned about the prohibitively expensive land prices. Some respondents shared anecdotes of neighbours who had sold their agricultural land and moved to the urban centre transitioning away from farm-based livelihoods. Although the surveyed wards are in close proximity to the urban centres, the majority of households practice agriculture and animal husbandry and rely on direct inputs from natural resources such as river, common grazing lands and forests (the detail breakdown of respondents' family members by occupation is discussed in Section 4.9). Furthermore, reliance on firewood for cooking, use of self-grown produce, and use of grain in lieu of cash to procure household supplies provide evidence of the rural nature of the wards covered by the field survey.

4.3.2 Population structure

According to the 2011 national census, Damak had a population of 114,766 compared to 101,970 for Dhangadhi (CBS 2012a). The annual growth rates are 1.7 percent and 2.3 percent for Jhapa and Kailali districts respectively—both rates higher than the national average of 1.4 percent per annum (CBS 2014b). This structure is reflected in the demographic details of survey respondents' households with Dhangadhi households having a larger average size. Selected demographic details of Kailali and Jhapa districts are presented in the table below (Table 4.1).

Table 4.1 Key population details of Kailali and Jhapa districts compared to National figures.

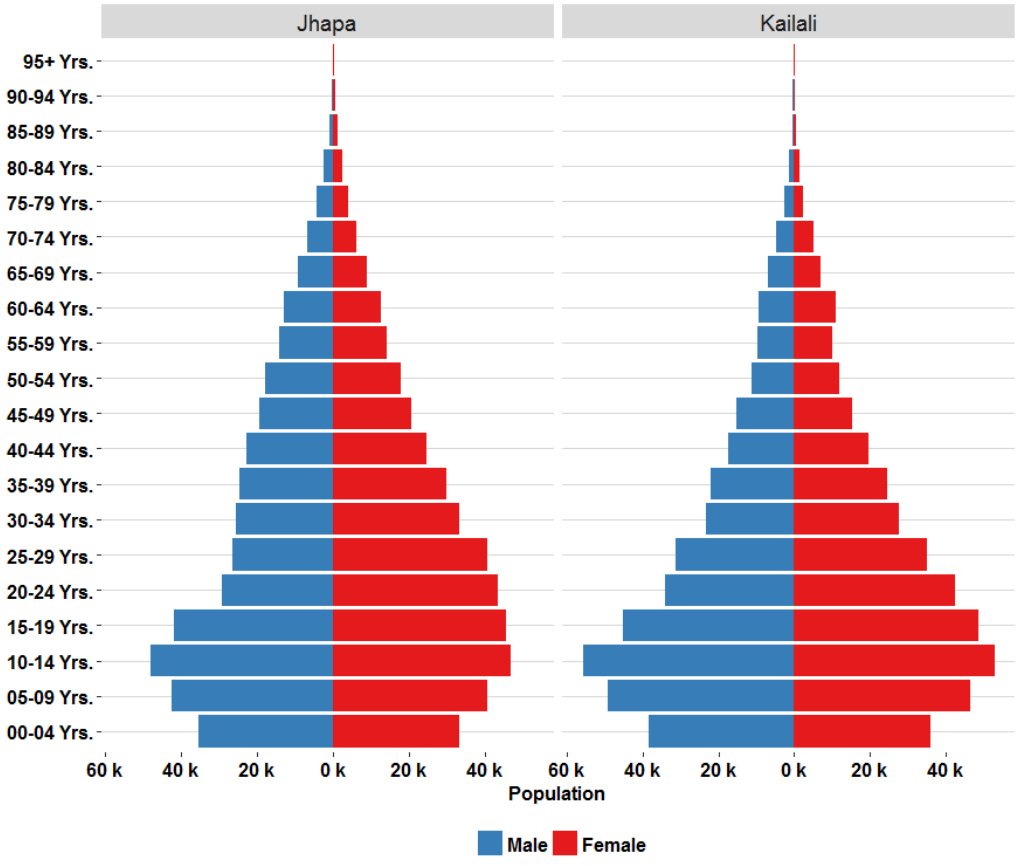
	Kailali District—West	Jhapa District—East	National
Total population	770,279	810,636	26,620,809
Males	378,970	385,284	12,927,431
Females	391,309	425,352	13,693,378

Sex ratio (males per 100 females)	96.8	90.6	94.4
Percentage annual growth rate	2.2 %	1.6 %	1.4 %
Absentee population	61,271	135,674	1,917,903
Absentee males	48,569	67,837	1,663,237
Absentee females	12,702	67,837	254,666
Absentee percentage	7.95%	16.74%	7.20%
Total households	146,431	188,085	5,659,984
Average household size	5.260	4.310	4.703
Population density (persons per sq. km.)	238	505	181

Source: CBS (2012a).

Besides Kailali having a markedly higher growth rate, there are key differences in the population structure of the two districts (Figure 4.1). Firstly, the proportion of the younger people is higher in Kailali district, which could be attributed to larger family sizes. Secondly, there are fewer people aged seventy-five or above in Kailali compared to Jhapa.

Figure 4.1 Age-sex population structure for Jhapa and Kailali districts—2011.



Source: Constructed using data from CBS (2012a).

4.3.3 Findings: respondent characteristics

A total of 143 households in Damak and 151 households in Dhangadhi were surveyed. In Damak, the majority of respondents were male, whereas in Dhangadhi, it was the opposite with more

female respondents. A brief outline of household characteristics from the survey of both sites is presented in Table 4.2.

Table 4.2 Summary of basic characteristics of the survey.

	Damak	Dhangadhi
Households sampled	143	151
Total households (2011 census figure)	3,989	4,624
Total population in surveyed wards	15,909	25,726
Total household members covered	729	1,186
Median age of respondents	44	35
Median age of household members	31	22
Sex ratio[5] of respondents	284	72
Sex ration of household members	126	112
Median household size	5	6

Source: Field Survey 2013-14.

4.3.4 Gender, age and family size

The attempt to get equal number of male and female respondents for the survey could not be achieved in the field. In some households, the researcher had the option to administer the questionnaire to either an adult male or an adult female. In many households in Damak, when both male and female adults were present, the female member was often reluctant to answer the questions, which led to more male respondents. In the case of Dhangadhi however, many households did not have a male adult present during our survey visit, which lead to more female respondents (Table 4.3).

Table 4.3 Questionnaire survey male and female respondents

	Damak % (n=142)	Dhangadhi % (n=153)
Male	73.9	41.8
Female	26.1	58.2

Source: Field Survey 2013-14.

There are distinct gendered divisions of labour in farm and household related activities in the study sites. In the Tarai, as in the country and much of South Asia, women generally have limited power and influence in making individual and household decisions. Access to facilities like education, health services and food are often restricted to women (Acharya et al. 2010). In the Tarai, women commonly spend considerable time collecting resources such as firewood, fodder, grass and water. In case of the study sites, both men and women were at times reported to be engaged in such collection however, traditionally, women are expected to fulfil those roles.

[5] Sex ratio defined as $\frac{Number\ of\ males}{Number\ of\ females} \times 100$

Other demographic differences between the two districts were reflected in the household members covered by the field survey. Both sites had a higher number of males (Table 4.4). Dhangadhi, which is in Kailali district, had a generally a younger population, with the median age of household members in Damak being 31 compared to a median of 22 for Dhangadhi. Furthermore, households in Dhangadhi have, on average, significantly more population under the age of 18. The median number of children per household in Damak was 1 compared to median of 3 for Dhangadhi.

Table 4.4 Total household members by male and female respondents.

	Damak % (n=731)	Dhangadhi % (n=1,150)
Male	55.8	52.9
Female	44.2	47.1

Source: Field Survey 2013-14.

4.3.5 Negotiating livelihoods in the Tarai

Agriculture is the primary occupation for the majority of Tarai residents, many also rely on a range of off-farm occupations. Agriculture in the Tarai is generally not modernised and relies on manual labour for the most part. The labour input required for agriculture is highly seasonal. The paddy crop, for example, requires intensive labour during the transplantation and harvesting phases, but only requires regular tending during the growth phase. Regular household labour for the remaining period is required for maintaining crops, arranging feed for livestock and household chores. Some level of mechanisation is emerging in paddy farming with the use of harvester machines. However, these are still not widely practiced. In the Tarai, even transportation of harvest is mostly achieved using oxen powered carts. The lack of investment in agriculture in Nepal is also reflected in the relative contribution to national GDP from the agriculture sector, which has declined significantly from 68 percent in 1971 to 37 percent in 2011 (Table 4.5). This shift in GDP income away from agriculture is also the result of economic reforms adopted by Nepal which opened up avenues of international trade in the 1990s.

Table 4.5 Contribution from income sectors to Nepal's GDP—1971 to 2011.

	Percentage share of GDP by sector				
Sector	**1971**	**1981**	**1991**	**2001**	**2011**
Agriculture, Fishery and Forestry	67.51	60.9	47.68	36.58	36.83
Mining and Quarrying	0.01	0.23	0.5	0.43	0.54
Manufacturing	9.15	4.12	6.8	9.03	6.2
Electricity, Gas and Water	0.22	0.26	0.7	1.82	1.85
Construction	1.51	7.75	9.54	6.01	6.88
Industry	10.89	12.36	17.54	17.29	15.47
Trade, Hotels and Restaurant	3.56	3.74	11.11	18.42	15.43
Transport and Communications	2.62	7.42	5.65	7.39	8.15
Finance and Business Services	9.89	8.16	9.42	10.98	12.04
Other Community, Social and Personal Services	5.53	7.42	8.6	9.34	12.06
Service	21.6	26.74	34.78	46.13	47.68
Total (rounded value)	100	100	100	100	100

Source: Gyanwaly (2014, p. 71).

Damak and Dhangadhi are both regional centres and therefore, contain the government offices related to security, health, telecommunication, banking etc. The core urban areas (much like the central business district according to the western concept of urban areas) are active commercially and industrially and provide substantial off-farm work opportunities for many. For most families living in the nearby wards of these municipalities, however, a stable off-farm job in the city is very unlikely. Formal jobs, especially in the government sector, often require political connections on top of educational qualifications. For poorer farmers, the only option is to look for other ways to work as a casual labourer, like working in brick factories, or temporarily migrating to India to find work as a fruit picker, security guard or kitchen hand.

4.4 Agriculture in the Tarai

Agriculture and livestock has been the mainstay of Tarai residents' livelihoods, which parallels the Nepali experience more generally. Agriculture and forestry industries contributed 34.8 percent to nation's GDP in fiscal year 2011–2013 (Ministry of Agricultural Development 2013). According to official figures, 60.4 percent of Nepali aged ten and above engage in agriculture related occupations (Table 4.6). In rural areas, the percentage is even higher, standing at 67.6 percent. Males and females are equally engaged in agriculture and allied sectors in the study sites, although at the regional level of the Tarai, more males, at 56.4 percent, are involved in agriculture compared to 43.6 females in terms of absolute numbers.

Table 4.6 Proportion of population aged 10 years and above active in agriculture, forestry and fishery sector by gender.

Area	Population active in agriculture	Active %	Males	Male %	Females	Female %
Jhapa district	177,036	54.1	91,017	51.4	86,019	48.6
Kailali District	174,367	64.4	85,396	49.0	88,971	51.0
All Nepal	6,000,479	60.4	2,856,516	47.6	3,143,963	52.4
Mountain	619,432	79.9	264,699	42.7	354,733	57.27
Hill	2,851,214	62.2	1,165,760	40.9	1,685,454	59.1
Tarai	2,529,831	55.3	1,426,056	56.4	1,103,775	43.63
Rural	5,697,167	67.6	2,709,868	47.6	2,987,299	52.4
Urban	303,311	20.1	146,647	48.4	156,664	51.7

Source: CBS (2012a)

There is very minimal agricultural mechanisation in the region. Direct agricultural activities like seeding, hoeing, applying fertiliser, transplanting, and harvesting are done manually by men, women and children. During the field work, only a few forms of mechanisation were observed, including the use of a mechanical thrashing machine during harvest and of tractors for tilling soil before plantation or transplantation. Moreover, other related activities like preparing fertiliser from livestock manure; digging temporary canals to redirect water; puddling of paddy farms; weeding; and preparing fire-bricks from livestock manure are entirely done by hand. Even irrigation was carried out manually in some cases, and especially during the winter months, when many households water their vegetable crops manually by carrying buckets from hand-pumps or a nearby river to the crops. Transportation of fodder, firewood and straw were done manually at both sites; in Dhangadhi, bullock drawn carts were regularly used for transportation of harvest and people to and from the farmlands (Plate 4.2).

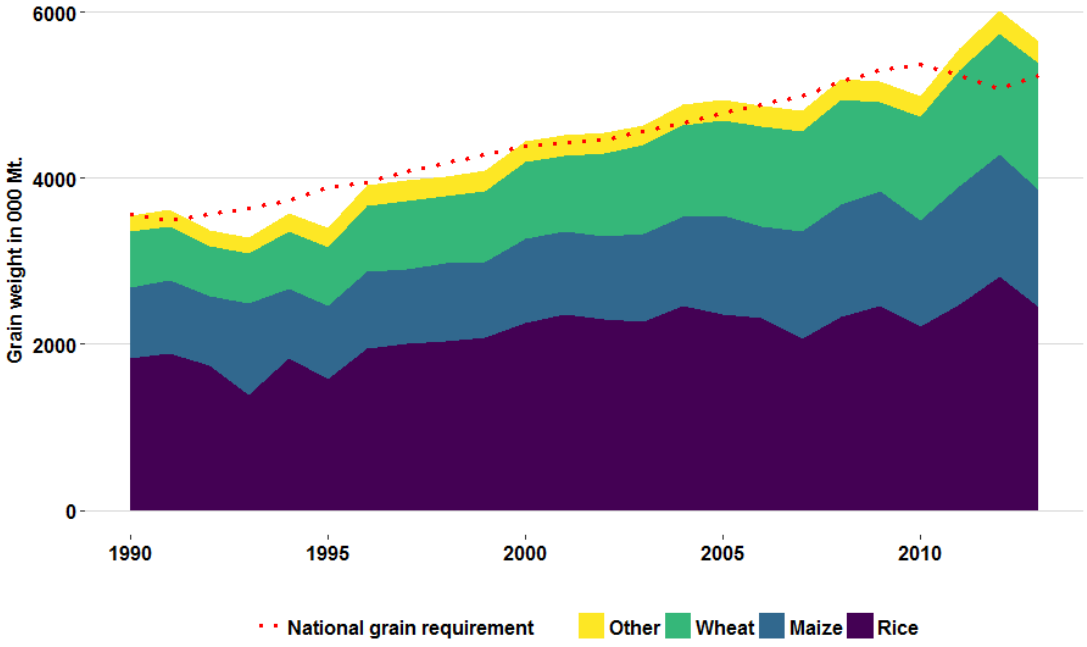
Plate 4.2 Women carrying fodder in Damak (left). A typical bullock cart powered by two oxen carrying a family to their farm in an early morning. Such carts are a popular means of transport of agricultural goods and provides the main justification for owning oxen (right).

Source: Field Survey 2013-14.

Livestock rearing is also entirely managed by manual labour, with feed preparation, feeding, cutting and fetching fodder, and milking all done by household members. In many cases, children also provide regular labour input in such activities. Children as young as ten were seen actively taking part in herding livestock to and from grazing lands, preparing feeds, fetching fodder, and weeding.

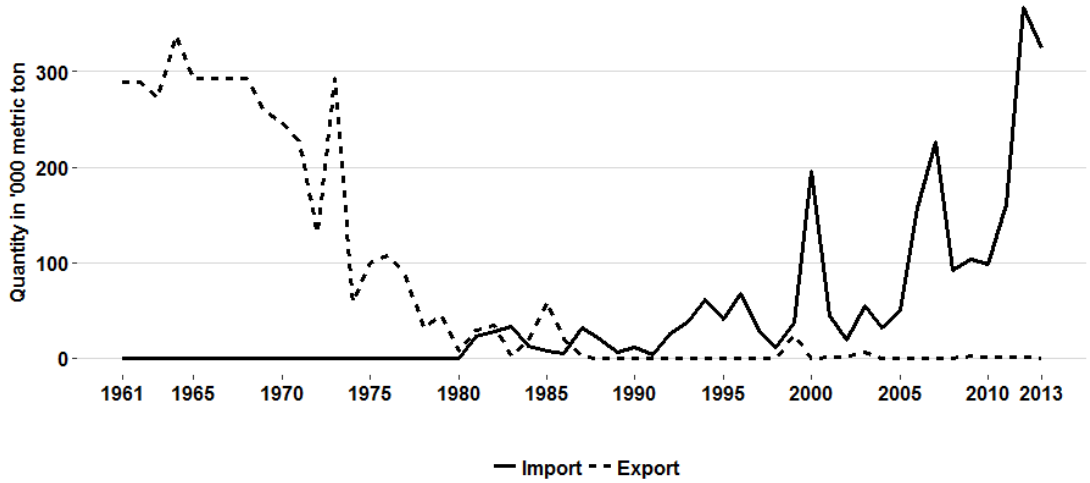
Total output from paddy has been increasing across Nepal (Figure 4.2) albeit at a slow rate (Ministry of Agricultural Development 2013). At the same time, national grain imports have risen, especially since the 2000s. In contrast, Nepal used to export significant quantities of grain in the 1960s up until mid-1970s (Figure 4.3). There is still significant potential for improvement through modernization in the region's agricultural and livestock sectors. With improved irrigation facilities, for example, agricultural outputs could become more consistent and increase. Despite having relatively easy means to increase production, there are certain barriers to agricultural production in the Tarai during off season—winter crops have to rely highly on irrigation, which raises the input cost and makes it impractical for the poorest farmers to even attempt out-of-season production. Moreover, the market-oriented crops have to compete with produce from neighbouring regions in India as well.

Figure 4.2 Trends in national grain production and requirement by major grain types 1990-2013.



Source: Constructed using data from Ministry of Agricultural Development (2013).

Figure 4.3 Trends in import and export of rice in Nepal.



Source: Constructed using data from FAO (2016).

4.4.1 Living off the land

Farming activities in the Tarai revolve around the phonological stages of cultivated crops. With paddy rice, planting, transplanting, weeding and harvesting are the key stages that demand large amounts of labour. Land clearing and preparation of the field is done just prior to the planting season sometime in June using manual hoeing, ox plough or tractors. Seedlings are planted on a small section of the farm land in anticipation of the rain. Once regular rain commences, the labour intensive task of manually transplanting seedlings onto the entire field is carried out. The transplantation must be carried out in a short window of intensive rainfall. According to respondents, in the past, most farmers managed transplantation entirely with shared labour. The migration of young people has led to shortages of labour during peak times and now-a-days, most field hands have to be paid in cash. In the absence of cheap credit, the cost of essential farming tasks can be a substantial economic burden to a household, especially as all the payments have to be made prior to the harvest. Table 4.7 lists some of the costs associated with farming at the study sites.

Table 4.7 Summary of farming related labour expenses.

Activity	Cost and unit	Remarks
Transplanting	NPR 400 day^{-1} for males NPR 300 day^{-1} for females	Labour intensive tasks.
Weeding	NPR 400 day^{-1} for males NPR 300 day^{-1} for females	Carried out multiple times during the growth period.
Irrigation	Pump: NPR 7,000 to 35,000 Pump rental: Fuel cost:	Puddling during transplantation and early growth phase.
Harvesting	NPR 400 day^{-1} for males NPR 300 day^{-1} for females	Labour intensive tasks. Some form of mechanisation observed.

Source: Field Survey 2013-14.

Plantation activities has cultural significance for Nepali farmers. Referred to as '*ropai diwas*' (plantation day), the 15th of the month of *Asar* (falls around the end of June or the beginning of July) marks the task of successful transplanting. Traditionally, the day is celebrated by playing in mud, singing and eating curd and beaten-rice. Since 2005, the day has also been officially celebrated as Paddy day across Nepal.

Farmers also have the option of planting high-value crops such as vegetables and fruits. Both Damak and Dhangadhi have small cottage and agricultural production / processing industries, but no large-scale production or manufacturing plants like those in Tarai cities such as Biratnagar, Birgunj and Chitwan. Besides seasonal crops, households typically have fruit trees on their farm, especially near to dwellings, the produce of which are mostly used for domestic consumption. Farmers could potentially increase their earnings by switching to high value cash crops like vegetables and fruits. However, only around 27 and 22 percent of respondents in Damak and Dhangadhi respectively, reported growing horticultural cash crops (Table 4.8). This figure may be an under-representation of the true situation because respondents may not have wanted to reveal their full income sources. Nevertheless, most families, consume much of the output from crops such as paddy, wheat and maize. Grains was also seen being used in lieu of cash as traded commodities in the study sites – farmers in Dhangadhi for example were seen exchanging grain for necessities like oil and spices in corner shops.

Table 4.8 Breakdown of households by income made from agricultural produce at study sites.

	Damak % (n=142)	Dhangadhi % (n=153)
No income from produce	73.2	77.8
Made income from produce	26.8	22.2

Source: Field Survey 2013-14.

There have been many initiatives to exploit the agricultural potential of the land for financial and broader development goals at the individual or community level with varying degrees of success. A group of young returnee migrants turned entrepreneurs in Damak had invested in vegetable farming which was still struggling three years after inception. Another group of young entrepreneurs had recently started a commercial pig farm. While the success of these ventures are yet to be seen, the reaction from the local business owners was not very positive. A 40-year-old male farmer and entrepreneur from Damak stated:

> *We leased 5 kattha (0.2 ha) land for the livestock shed and 1 bigha (0.7 ha) land for growing crops to be used for feed. We have undertaken a NPR 50-60 thousand (USD500 to 600) loan from a local co-operative. This business has been established by three return migrants including myself. We decided to invest locally instead of going abroad for labour work. There have been a few additional local initiatives in farming and livestock locally. … The*

> *interest rate is 12 percent per annum, which is better than the going rate of 18 percent. We have not been able to reap any profits in these early years. It is really hard to get return on investments in agriculture. Some locals had invested in organic vegetable business but it was not successful. (Person 8)*

In Dhangadhi, sections of river banks are used to plant high value produce during winter and pre-monsoon months when the river is low. Horticultural plants such as watermelon, cucumber, bitter melon and bottle gourd are planted along the river during winter months and harvested before the first monsoon rain which floods the plots. Although these plots are public land and not suitable for year-round agriculture, farmers divide the land into separate plots and invest their time and money in managing their plots. To protect the crops from vandals and stray or wild animals, farmers have to guard the fields day and night. Tiny huts built on or near the plots are used by the farmers to sleep at night and guard their fields, especially when the crops are close to harvest as shown in Plate 4.3.

Plate 4.3 Left: Plots along the river bank being used for horticultural crops. Right: Huts used by farmers to sleep at night in order to guard their crops.

Source: Field Survey 2013-14.

There are however, limited areas for such type of farming and only a handful of farmers can take advantage of it. Furthermore, the use of public land for private commercial gain was seen as improper practice by some respondents. A 60-year-old male farmer from Dhangadhi said:

> *I have seen some farmers from this ward (Ward 10) farm along the river banks. I don't know how they manage it and whether the municipality controls it. The land does not belong to anyone ... it is part of the river area. (Person 15)*

A female development practitioner, in her 20s, from Dhangadhi stated:

> *We should not promote farmers farming in the river banks. Such practice is essentially an encroachment. If they are allowed to farm along the river banks, they will claim the land later on and create more issues. (Person 20)*

Nevertheless, many farmers were seen actively taking part in preparing the banks for new harvest during the field visits. Those practicing river bank farming reported the difficult nature of the work and high risk due to inevitable flood. A 34-year-old farmer from Dhangadhi said:

> *We plant bottle gourd, watermelon, cucumber, bitter melon and some other vegetables. This area will be fully submerged during monsoon. The river will overflow and cover all of this. We have to take all the harvest by Jestha (mid-April to mid-May). … We must stay and guard the plants. Once the watermelon starts to fruit, we have to be more careful to protect them from thieves and stray animals. Sometimes wild foxes damage the fruits. We have made temporary shelters next to our fields where we will sleep during the night. We take turn standing guard. When it is closer to harvest, all of us will stay here. … This is not a new practice, but the scale at which this is done has expanded in the last few years and now being done entirely for commercial purposes. It the past, it was mostly for household consumption. This practice has proved to be very profitable for the farmers. (Person 22)*

Forests provide important functions for Tarai livelihoods. Firstly, they are the source of firewood for 79 percent of Tarai households (CBS 2012). Secondly, farmers gather fodder from the forest in the forms of twigs and undergrowth plants. Forests along river banks also provide protection from erosion and landslides, and protect agricultural fields. Much biodiversity conservation in the past focused on the strict protection of nature by excluding humans (McNeely 1994). Modern conservation efforts however increasingly consider human systems as a critical component (Poffenberger & McGean 1998). For example, conservation within National Parks in the Tarai have regarded human sustainable use of the resources as an important component—see Brown (1997). The study sites are not situated close to any of the five protected areas (two national parks and three wildlife preserves) in the Tarai. The conservation efforts for forests in the vicinity of the study areas are at mostly managed at the community level with varying degrees of accessibility by local residents. In Damak, respondents of Ward 17, 18 and 19 reflected on the lack of benefits from community forests because of restricted access. The already dwindling forest area has come under threat from rapid urbanisation of core areas of Damak and Dhangadhi, which in turn pushes the settlements further towards the periphery. The demand of forest resources increased upon the establishment of refugee camps in Damak (KC & Nagata 2006). In Damak, the Rama Community Forest has been established to protect the banks of Mawa River. Locals reported that the forest had been a saviour for agriculture land, as waters from small floods have been stopped to some extent by the forest and undergrowth. The forest is protected by fences and locals are allowed to enter twice a year to collect firewood from. Trees in the protected forest that have come of age are felled and sold as timber and firewood but the sales are restricted due to high demand. It was reported that households can purchase timber and firewood, only on special occasions such as weddings or funerals. During one of the preliminary visits to the site, the researcher witnessed a funeral procession which ended in a cremation at the banks of Ratuwa River. It was revealed that the firewood for the cremation was procured from a nearby community forest. Many locals still feel that they have been denied their rights to use communal resources like forests and grazing lands on a regular basis. Regardless of

the restrictions in place, farmers regularly trespass protected areas for fodder, grass and firewood.

Similarly, in Dhangadhi, various pockets of forests which have been preserved are allowed for daily use with restrictions. Locals are only allowed to collect resources such as fodder and twigs on rare occasions, which has resulted in regular trespassing as revealed by the locals. The protected forest on the Indian side of the border is also frequently accessed by Dhangadhi farmers to collect firewood, fodder and even to graze cattle. This task of trespassing in protected forest comes is punishable and can result in large fines, but respondents understand the risks. In the absence of locally accessible firewood and fodder, farmers are faced with a choice to either procure expensive firewood or risk being caught stealing. An older male carpenter from Dhangadhi stated:

> *Access to forest resources has been restricted. We are now old and cannot fetch firewood ourselves. In the past it was easy to get twigs from the forests. The forest is only open on rare occasions. It was open during the Tihar festivals (November) for just two days. (Person 16)*

Similarly, female farmer in her 40s from Dhangadhi said:

> *We get some firewood from the local forests, but it is not easy these days. We also have to buy firewood. It is expensive ... one bhari (bundle) costs NPR 100-150 (USD1-1.5). One bhari lasts only 3-4 days. Whenever we can, we collect firewood from here and there. (Person 17)*

This was also reflected by an older male farmer from Dhangadhi, who said:

> *Access to firewood and fodder from forest has been restricted. The government is strict about protecting the forest. In the past we used to collect firewood regularly. These days, the forest is open for collection only occasionally. (Person 19)*

Again from Dhangadhi, a 34-year-old male farmer from Dhangadhi said:

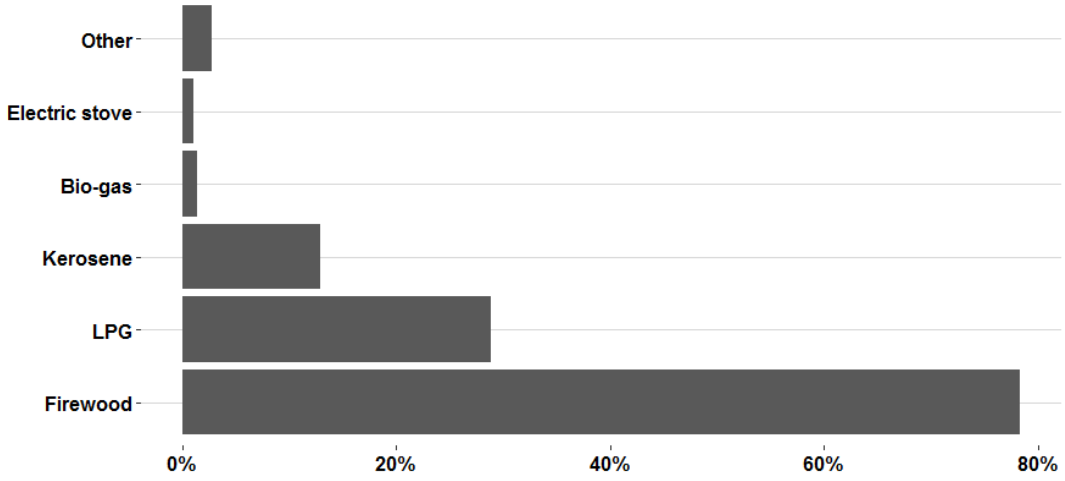
> *We buy twigs from the Indian forest for firewood. They collect twigs and sell us in bundles. We don't have other options here. We only get access to wood from local forests on special occasions. The local committee allocates firewood for households for wedding ceremony and funeral pyre. [They give an example of someone in the community who passed away the previous day and whose body was cremated earlier that day about a kilometre from where we were standing] (Person 22)*

A male farmer in his late 30s from Dhangadhi stated:

> *There's no firewood here. We must bring from India. I have never bought any firewood till date, but I know many farmers buy from India. During monsoon, I collect branches and tree trunks brought about by the river. We all do that. (Person 23)*

With growing demand, the existing resources are simply insufficient, and alternatives are needed. Traditional alternative sources for firewood like disks made from dry animal dung mixed with straw are still popular, especially amongst poor farmers. Modern alternatives like electric stoves, kerosene stoves and liquefied petroleum gas (LPG) canisters are increasingly being used as shown in Figure 4.4.

Figure 4.4 Fuel type usage among respondent households.



Source: Field Survey 2013-14.

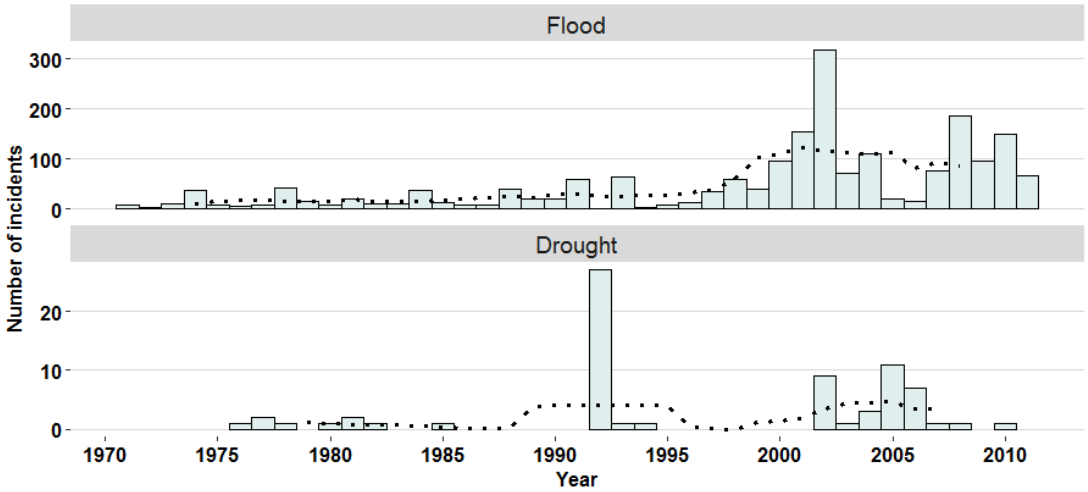
4.4.2 Agricultural risks

The Tarai landscape provides favourable conditions for agriculture in terms of soil, climate and water availability. The soil is fertile, being composed largely of recent post Pleistocene alluvial deposits (Dijkshoorn & Huting 2009). Thanks to the shallow water table, groundwater is also easy to extract compared to the Hill and Mountain regions. Winter temperatures do not go below freezing, allowing for a favourable growing period even during winter. Additionally, the region has historically received a regular monsoon bringing heavy rains from June to September, making the Tarai fields suitable for paddy farming. The region produced about seventy percent of the nation's paddy in fiscal year 2012-13 (Ministry of Agricultural Development 2013). Moreover, the flat terrain ensures ease of movement for travel and trade. The monsoonal rainfall, which is essential for crops can also cause havoc if the rainfall in the Tarai or in upstream regions is excessive.

As will be discussed further in Chapter 6, the Tarai experiences high rainfall variability resulting in some years with deficit rainfall or excess rainfall. In general however, it receives large amounts of rainfall and is also served by major glacial-fed rivers. Together, these situations generate significant natural hazards. For example, in 2011, there were 66 incidents of flood in Tarai districts as shown in Figure 4.5. Among the ecological regions in Nepal, the Tarai endured the

most economic losses from disasters in 2014 in part from flood impacts (Disaster Preparedeness Network-Nepal 2014).

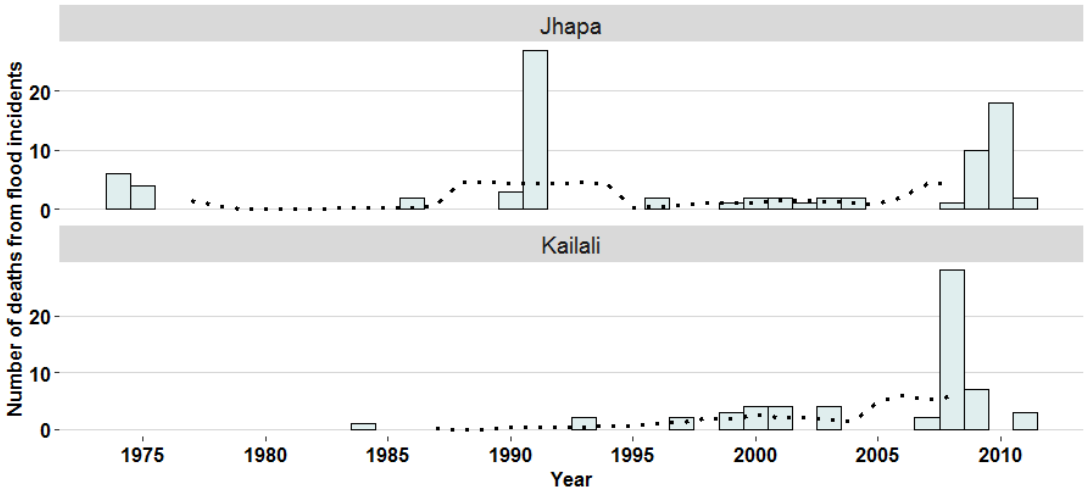
Figure 4.5 Flood and drought incidents in the Tarai districts from 1971 to 2011. Dotted lines represent seven-year moving average.



Source: Constructed using data from DesInventar (2013). Dotted lines show seven-year moving average.

The study sites, Damak and Dhangadhi are two of the municipalities / VDCs with some of the highest incidents of floods recorded historically. Around half of the survey respondents had experienced floods in the past decade. Analysis of historical records supports the perception that floods recur regularly in the Jhapa and Kailali districts—the two districts where study sites Damak and Dhangadhi are located respectively. Fatalities from floods are also a common occurrence in the two districts as shown in Figure 4.6.

Figure 4.6 Fatalities from flood incidents in Jhapa and Kailali districts.



Source: Constructed using data from DesInventar (2013). Dotted lines show seven-year moving average.

A flood's propensity to cause damage depends on a variety of physical factors such as the volume and the velocity of the flow, the percolation rate of the soil as well as the sensitivity of the

assets. For that reason, the impact of flood on the communities is partly mediated by the socio-economic conditions of the households. In a study on the 1993 flood, Pradhan et al. (2007) found that flood victims of low socio-economic background had higher mortality rates, mostly attributed to the poorer standard of dwellings. Masonry construction is least likely to have extensive damage due to their sturdy construction. In contrast, wood and thatch construction easily allow flood to enter and can generate substantial damaged. An older farmer from Dhangadhi stated:

> *In 2040 Bikram Sambat (BS) (1983), there was a big flood. It rained for an entire week. Water slowly entered our house at night. My family along with others in my neighbourhood walked to higher ground. A woman with her young child was swept away by flood but she managed to use a sickle to grab onto a tree and managed to save herself and her child. All the crops were destroyed by the waters. (Person 14)*

The residents of Damak and Dhangadhi are no strangers to flood damage. The recurring floods can reshape the landscape by sweeping away agricultural fields or filling fields with sand. Past floods have defied district and ward boundaries in Damak. The Mawa River delineates the western border of Damak and also the western border for Jhapa district along its length. Now, part of ward 19 lies to the west of the river as the river has changed its course, detaching tens of households from the rest of the municipality. Besides the obvious loss of physical land, this has caused administrative problems as well, due to the fact that the police station for the southern wards is located on the isolated section, which takes an hour long walk to get to from the centre of Damak. Similarly, in Dhangadhi, the Mohana River flowing along the Nepal-India border frequently changes course snaking back and forth across the international boundary. The border demarcation markers mean little to the farmers as they compensate for the loss of their land as it is taken by the river, and take every opportunity to utilise sand filled areas left by the river moving away from their fields for agriculture. Understanding such micro characteristics of the surveyed households, which will be discussed next, will aid in understanding the role of social and human capital in navigating changing livelihoods.

4.5 Findings and discussion

4.5.1 Livelihood characteristics

Analysis of household members' primary occupation reveal that although many household's practice agriculture and livestock rearing, a range of off-farm livelihood options are also widely utilised. In many households, there is one or two members who engage in only agriculture or livestock related activities, while other members primarily engage in their own occupations but provide labour input during crucial times. Children and adult students also actively participate in agricultural or livestock rearing activities.

Table 4.9 lists the breakdown of the occupation categories in Damak and Dhangadhi. The occupations have been categorised into eight categories for simplicity: Agriculture and livestock, Own a business, Salaried job, Wage labour work, Migrant work, Tea estate work, Student and Other. Agriculture and livestock category includes those engaged in farming, animal husbandry or poultry owned by the household. Those who "own a business" include entrepreneurs or shop owners. Due to the rural nature of the sites, any businesses are mostly small and do not employ external labour: e.g. rickshaw owner, selling snacks on the street, bicycle repair shop etc. The "Salaried job" category includes individuals engaging in formal employment in the government or private sector. Popular jobs in this category are government service, school teachers, and the police. Wage labour work includes individuals with low-level skills who work on a set wage rage rather than a monthly salary. These individuals tend to shift from one job to another depending on market demand. Migrant work involves travelling to a different location temporarily for a certain period—usually six months or more for work. Migrant worker is the second-most popular work category with around 17 percent of respondents' household members being categorised under the occupation (see Chapter 5). The actual work done by the migrant workers varies by destination and skill level: e.g. most migrant workers in India work as security guards or as helpers in restaurants whereas migrants working in the Gulf countries however engage in construction works. Tea estate work classification has been used only for Damak, as this unique employment opportunities related to the local Tea plantation. This work involves various labour intensive work related to maintaining, harvesting and processing of tea plants. Students include those enrolled in educational institution. Although this list only includes people aged sixteen or over, some students in secondary school can be included. Other occupations include people who have retired; working in household chores only; and disabled.

Table 4.9 Employment by type of work at study sites.

S. No.	Occupation	Damak % (n=535)	Dhangadhi % (n=735)	Both % (n=1,270)
1	Agriculture and livestock	44.7	42.3	43.3
2	Own a business	7.1	4.6	5.7
3	Salaried job	4.7	7.6	6.4
4	Wage labour work	3.0	3.9	3.5
5	Migrant work	15.5	17.3	16.5
6	Tea estate work	8.2	-	3.5
7	Other - Unable to work or house chores only	4.9	8.0	6.7
8	Student	12.0	16.2	14.4

Source: Field Survey 2013-14.

Analysing the breakdown of primary livelihood by gender (Table 4.10), reveals that the proportion of females engaging in agriculture is larger than males. Whereas, those people with a salaried job or migrant work are biased disproportionately towards the males.

Table 4.10 Employment by gender and type of work at study sites.

	Damak		Dhangadhi	
	Males % (n=306)	Females % (n=228)	Males % (n=394)	Females % (n=341)
Agriculture and livestock	39.5	51.7	33.0	53.1
Own a business	7.2	7.0	5.6	3.5
Salaried job	7.5	0.9	11.7	2.9
Wage labour work	3.6	2.2	5.1	2.6
Migrant work	24.5	3.5	28.2	4.7
Tea estate work	4.2	13.6	-	-
Other—Unable to work or house chores only	2.0	8.3	0.8	16.4
Student	11.4	12.7	15.7	16.7

Source: Field Survey 2013-14.

As discussed earlier in this Chapter, Tarai residents employ a myriad of farm and off-farm livelihood options and for the younger, more educated generation, the livelihood opportunities in the Tarai are changing. Armed with a college degree, a Tarai youth can opt for salaried work, which promises a more secure income source, independent of the risks of farming. The change in livelihood will also come from the environmental pressures, particularly, from ongoing hazards interacting with climate change (as will be discussed in Chapter 6), which are already making farming more difficult and consequently a less attractive livelihood choice. For that reason, a range of coping and adaptive strategies that are already being practiced by the Tarai communities are introduced next in relation to a discussion of livelihood options.

4.5.2 Land holdings

Land is the primary source of income and employment for the majority of Nepal's population, especially in rural areas where the proportion of livelihood relying on agricultural is higher. In an agricultural setting, the amount and the quality of land at a household's disposal is directly tied to available livelihood options. The distribution of agricultural land is such that the vast majority of agricultural land users have access to small amounts of land. More than 53 percent of land holdings[6] in Nepal consist of land with areas less than 0.5 hectares (Table 4.11).

[6] An agricultural holding is defined as "an economic unit of agricultural production under single management comprising all livestock and poultry kept, and all land used wholly or partly for agricultural production purposes" (CBS 2013b, p. 108).

Table 4.11 Size distribution of arable land in Nepal.

Holding type	No. of holdings	Holdings %	Cumulative %	Area	Area %
Holding without land	16,180	0.4		257	0.0
Holding with land	3,708,469	96.8		2,162,494	85.6
< 0.1 ha	352,109	9.5	9.5	14,214	0.6
0.1 ha - < 0.2 ha	460,574	12.4	21.99	56,729	2.2
0.2 ha - < 0.5 ha	1,168,387	31.4	53.3	343,282	13.6
0.5 ha - <- 1 ha	983,391	26.5	79.8	599,635	23.8
1 ha - < 2 ha	548,576	14.8	94.5	641,021	25.4
2 ha - < 3 ha	129,281	3.5	98.0	264,622	10.5
3 ha - < 4 ha	39,507	1.1	99.1	114,453	4.5
4 ha - < 5 ha	14,881	0.4	99.5	56,949	2.3
5 ha - < 10 ha	10,710	0.3	99.8	60,148	2.4
10 ha and over	1,053	0.0	99.8	11,441	0.4
Total	3,724,649	97.2		2,162,751	85.6

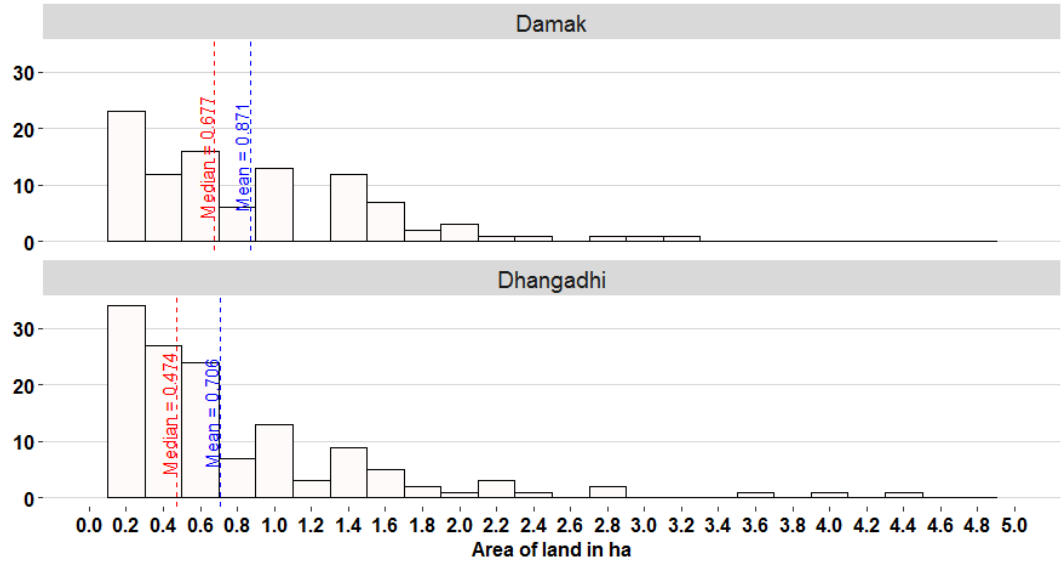
Source: CBS (2013b).

The highly uneven distribution of agricultural land results in the practice of land rentals, which in the Tarai, exists in many forms. Most popular forms of land rental include rental for a fixed proportion or amount of produce and rental in exchange for services provided, like labour. The rental for fixed proportion is also known as the *adhiya* system, which requires the grower to pay the equivalent of half of the harvest to the landowner. For the tenant household, the harvest left over provides primarily for basic needs. This nature of owning no, or very little, land has resulted in renting land even for subsistence production in exchange for a share of the harvest—a labour arrangement that is unfair to the poor farmers. Lack of ownership also restricts access to credit which could be used for enhancing the means of production by the use of technology. The practices of land renting by land-lords could be seen to hinder innovation mostly because there is little incentive to increasing agricultural outputs as a large portion of the yield has to be returned to the owner. Furthermore, access to basic agricultural needs such as fertiliser, electricity, fuel etc. are restricted at times, making agriculture even riskier in the Tarai.

With the two study sites, Dhangadhi had more households holding smaller lands (Figure 4.7). The median land owned by respondent households were 6,772 m^2 (1 *Bigha* in local units) and 4,740

m^2 (13 *Kattha* or ~0.7 *Bigha* in local units) in Damak and Dhangadhi respectively. This is partly understandable, as Damak ranks higher in terms of socio-economic indicators.

Figure 4.7 Distribution of households' land (fully or jointly owned, excluding adhiya land) at Damak and Dhangadhi.

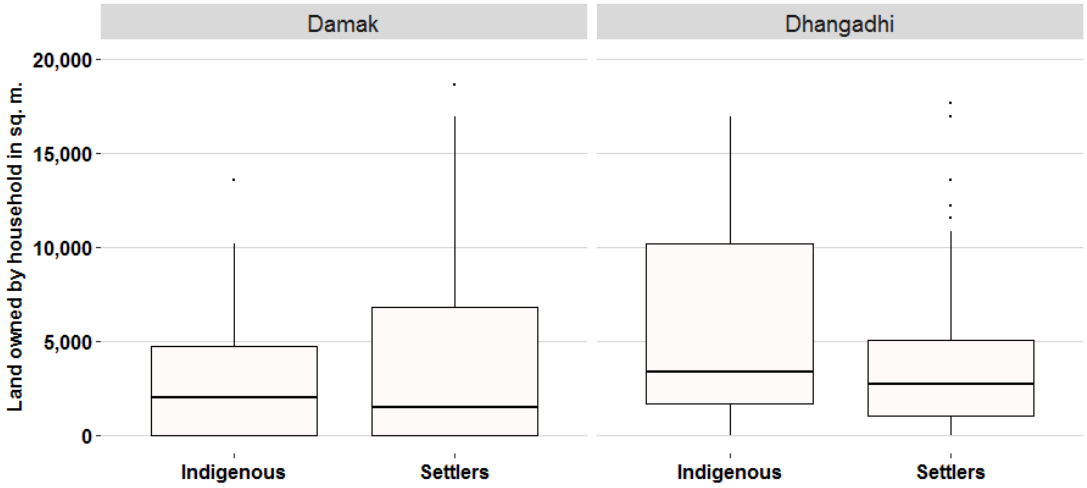


Source: Field Survey 2013-14.

It must be noted that many respondents were hesitant to reveal detailed information regarding their land, so, the figures should be regarded as estimates on the lower side of possible area holdings. However, the figures are consistent with the Nepali land holdings data from the 2011 census described in Table 4.11.

Nepal's land reform policies in the 1950 were aimed at ensuring at safeguarding the rights and interests of the farmers who toil on the land (Regmi 1961). The state-led land reform has been described by some as a failure because it was misused by those close to power—the elites who migrated from the Hills, tended to hoard land resources or redistribute it amongst their family members (Rose 1966). In fact, it is maintained that the settlers from Hills were able to grab and claim land in the Tarai due to their connections with the ruling class rather than their agricultural needs (Sugden & Gurung 2012). Indigenous households with low economic status were often left with little or no land despite many reform initiatives to distribute land more evenly. No significant difference in the amount of land ownership was found between people of indigenous or settler backgrounds as shown in Figure 4.8.

Figure 4.8 Comparison of land area by indigenous status at Damak and Dhangadhi.



Source: Field Survey 2013-14.

Changes in the amount of land available for utilisation can reflect on changes to household livelihood strategies. The survey sought information on any change in land ownership or utilisation in the last five years. As shown in Table 4.12, results suggest that in Damak and Dhangadhi, 16 and 18 percent of respondents respectively reported change in land being utilised. Selling of land was the most prominent reason for changes in land utilised. None of the respondents reported buying land in the last five years. Due to the popularity of modern construction methods and the subsequent high cost of building materials, erecting a standard dwelling can be prohibitively expensive for most families. Selling a portion of land to fund construction is thus common in the Tarai and other parts of the country. It is also common for households to sell part of their land in order to fund family initiatives such as a marriage ceremony, funding for education or supporting a member to migrate.

Table 4.12 Reasons attributed to change in land area being utilised by households at Damak and Dhangadhi.

Reason for change in land utilisation	Damak % (n=142)	Dhangadhi % (n=153)
Bought land	0.0	0.0
Sold land	7.0	9.1
Taken *adhiya*	8.4	5.9
Given for *adhiya*	0.0	1.3
Other	0.0	1.3
No change	84.5	73.4

Source: Field Survey 2013-14.

Land assets are predominantly owned by males in the Tarai. According to the last National census, 69 percent of females in Jhapa and 87 percent of females in Kailali were reported to have no land or building assets to their name (CBS 2012d). This is also an indicator of the low

level of gender equality and female empowerment, as female ownership of land among farming households in Nepal have been shown to strongly correlate with their level of engagement in household decision-making, and better health outcomes of offspring (Allendorf 2007).

4.5.3 Residential dwellings

The type of dwelling strongly reflects the economic status of a household. Locally available materials like wood, bamboo and mud are the traditional building materials in the Tarai. Much of the contemporary buildings in core urban areas of Damak and Dhangadhi resemble those in bigger cities—brick masonry with reinforced concrete structures. In the more rural parts of the study sites, such modern constructions represent about a third of the buildings (Table 4.13). In Damak, 42 percent of surveyed households lived in a dwelling constructed with wood panel walls in that manner. In contrast, the most prevalent construction method in Dhangadhi was with mud and stone construction within a wooden frame, which accounted for 58 percent of surveyed households.

Table 4.13 Respondents' primary dwelling by type of wall construction at Damak and Dhangadhi.

Type of wall construction	Damak % (n = 141)	Dhangadhi % (n = 151)
Temporary	11.3	6.0
Mud and stone	13.4	57.6
Wood panel wall	42.2	6.0
Brick and cement mortar	33.1	30.5

Source: Field Survey 2013-14.

Table 4.14 shows that dwellings outside of the urban core are predominantly single storied and are much more likely to use traditional building materials. Poorer households in particular live in smaller dwellings with substandard structures built from traditional building materials.

Table 4.14 Floor height of respondents' primary dwelling at Damak and Dhangadhi.

Height of dwelling	Damak % (n = 141)	Dhangadhi % (n = 151)
Single storey	81.6	90.1
Double storey	18.4	9.9
Three storey or higher	0.0	0.0

Source: Field Survey 2013-14.

Typically, a traditional household site in the Tarai will contain a main residential building, a kitchen extension, a shed for livestock, a hand operated tube-well and a kitchen garden. The kitchen, which comprises of a cooking and an eating space, is usually detached from the main living spaces. The toilet also stands detached and usually situated at the edge of the site. Livestock are kept tied in the shed except when they are taken for grazing. A typical Dhimal traditional house in Damak is built on two levels, with the main living spaces on the upper level and the semi-open

ground level used for household activities like preparing food, hosting guests, resting etc. Wood is a popular traditional construction material in Damak. Larger tree trunks are used as primary columns and beams; smaller wood posts and planks form the vertical walls. Tree trunks hold the upper living levels, leaving the ground level open and used for storage and sitting space during the day. The walls on upper level are made from wooden planks or weaved bamboo lined with mud plaster. Corrugated metal sheets, have largely replaced wooden planks—the more traditional roofing material. The cooking space is either attached to the corner of the house or built separately. Cattle-sheds, hay stacks, and toilets are also constructed separately, often at the maximum possible distance from the main house. A typical traditional house in Dhangadhi consists of a rectangular single-story structure with sloping roof from thatch or terracotta tiles. The construction materials are wood, mud and thatch. While the size of the house and the number of rooms vary depending on factors like the family size and socio-economic status of the household, the cooking space is usually adjacent to the house. Cattle-sheds, hay stacks, poultry cages, and toilets are also constructed separately, often at the distance from the main house. Plate 4.4 shows examples of houses in Damak and Dhangadhi.

Plate 4.4 Left: A typical wooden post house in Damak. Right: A typical mud-plaster walled house in Dhangadhi.

Source: Field Survey 2013-14.

Buildings in the urban core in the study sites mostly have reinforced concrete roofs. Such construction however was not found to be popular in the non-urban wards. Due to local differences in customs and material availability, most of the houses in Damak have a corrugated metal sheet roof, whereas in Dhangadhi, clay tile was the most common roofing material (Table 4.15). Among the buildings that are newly built or being built, many are brick and cement mortar construction with reinforced cement concrete (RCC) columns and beams especially the ones being built with remittance money (details on respondents' use of remittance is discussed in detail in Chapter 7).

Table 4.15 Respondents' residence by type of roof construction at Damak and Dhangadhi.

Type of roof construction	Damak % (n = 142)	Dhangadhi % (n = 151)
Straw	13.4	0.00
Wood planks	5.6	0.7
Jhingati (clay tiles)	0.0	62.2
Corrugated sheets	74.6	16.6
Reinforced cement concrete (RCC)	6.3	20.5

Source: Field Survey 2013-14.

Farmers' dwellings are located close to, if not immediately adjacent to the farmed agricultural land. Once again, the floor area of the house reflects the economic status of the residents, but the design is also influenced by the local customs and climate. It must be noted that the floor areas of dwellings were estimated from visual observation as part of the questionnaire survey and no actual measurements were taken. Table 4.16 shows that more than half of the dwellings in Damak had an area between 10 to 20 m^2, whereas the largest category of dwellings in Dhangadhi (45 percent), had an area from 20 to 40m^2. The percentage of dwellings with area greater than 40m^2 were also double those of Damak.

Table 4.16 Area of dwellings at Damak and Dhangadhi.

Total floor area (m2)	Damak % (n=140)	Dhangadhi % (n=150)
Up to 10	5.7	2.7
> 10 to 20	55.7	32.0
> 20 to 40	27.9	44.7
> 40	10.7	20.7

Source: Field Survey 2013-14.

4.5.4 Access to education

From the pool of household members aged five to sixteen, more than 95 percent were reported as going to school, with a slightly higher percentage of girls than boys attending as shown in Table 4.17. This is not surprising given the fact that access to education is almost free in Nepal and educational institutions, including university campuses are accessible from both sites. The new constitution of Nepal (Article 31 section 1 & 2) declares basic education as a fundamental right and free education up to secondary level is set to be compulsory and free. Despite this goal, the actual impact on universal education can be expected to face considerable challenges. For instance, although the number of students enrolled are close to target, significant numbers of children do not attend classes regularly (Lohani et al. 2010). Although the literacy rate among the younger residents can be expected to be very high, many adults have very limited levels of formal qualifications. There are a range of small scale community programs for teaching basic literacy

skills to illiterate adults, especially for females. Plate 4.5 shows an example of an adult literacy class being conducted at Dhangadhi.

Plate 4.5 An adult literacy class being conducted at Dhangadhi.

Source: Field Survey 2013-14.

Table 4.17 Population aged 5 to 16 going to school in study sites.

	Damak	Dhangadhi
Males	62	129
Males in school	58	121
% of males in school	93.55	93.80
Females	39	114
Females in school	38	113
% of females in school	97.4	99.1

Source: Field Survey 2013-14.

Over half of the respondents' adult household members (aged sixteen or above) had less than five years of formal education. Among the two sites, Damak has a greater percentage of adults with high levels of formal qualifications (Table 4.18). Less than ten percent of the adult population covered by the survey have completed high school which is marked by completion of the School Leaving Certificate (SLC) examinations held throughout the country annually by the SLC Board. Passing SLC examinations marks the completion of ten years of schooling (grade 1 to grade 10). Completion of SLC is often regarded as a milestone in one's career, but it alone cannot be expected to open up opportunities for employment as further education is necessary for most formal jobs.

Table 4.18 Education levels of respondents' household members among the study sites.

	Damak % (n = 383)	Dhangadhi % (n = 450)	Total % (n = 833)
No formal education	49.3	42. 9	45.9
Primary education	5.7	12. 7	9.5
Secondary education	9.9	17.8	14.2
SLC	24.5	19. 3	21.7
Intermediate	6.5	5.3	5.9
University degree or higher	3.9	2.0	2.9

Source: Field Survey 2013-14.

Nepal's education system has improved over the decades but still faces numerous challenges in student retention and quality of public school education (Mathema & Bista 2006; Thapa 2013). Although the quality varies greatly, private schools in Nepal are said to provide better education and offer instructions in English for subjects which would be instructed in Nepali in public schools. Since most private schools are managed as businesses with a profit motive, the cost of sending a child to such a school can be a significant burden. Many respondents revealed that despite this added cost, they opted for private school as they place a high value on education. Although Nepali and English languages are taught in school, at home most families speak their ethnic language. The Nepali language is the official cross cultural language and is spoken widely throughout the country with slight local variations. Some 44.6 percent of Nepalis identified Nepali language as their mother tongue, followed by 11.7 percent for Maithili and 6.0 percent for Bhojpuri. While the new constitution of Nepal has provisions for provinces to recognise local languages for government work, currently, only Nepali language can be used for official work.

Better education will certainly help in building the adaptive capacity of the individual, as education can greatly widen one's livelihood options with better earning potential and improve social mobility (Barnett & Adger 2007). In Nepal, women with SLC or higher level of education were found to be more active in household decision-making regarding health and household purchases (Acharya et al. 2010). Since agriculture demands high labour inputs, it is common for all household members, including children, to contribute in associated tasks like tillage, weeding, guarding fields against stray animals, fetching fodder for livestock, cleaning sheds, fetching water, fetching firewood etc. Therefore, it is understandable that engagement with such chores can impact upon the time allocated for education, especially for females as they are expected to help with household chores in addition to cooking. Many youths from the survey and interviews shared the lack of job prospects as a source of frustration and were a direct incentive to opt for overseas work. Some migrant members had sought to migrate after failing the SLC examinations multiple times. Most migrants from the sample do not have formal education.

4.6 Discussion—supplementary livelihood activities

The findings from secondary data and primary field survey reveals the study sites as having high incidences of poverty among small land holder farmers, attributed to both insufficient size and low productivity. Historical exploitation of natural resources, especially the forest, has led to significant changes in farmers' lifestyle from the time of initial settlement. Given the current state of farming in the Tarai, additional environmental issues like climate change are expected to exacerbate the stresses and land-poor households may be hardest hit in an absence of adaptation pathways.

Tarai also has many advantages which could be exploited for adaptation: the whole belt has direct road access to national cities on the north and to India on the south. This positions the Tarai as the de-facto entry point of the vast regional and international trade flowing via India. Despite having this gateway status since historic times, the Tarai has lagged behind the capital city in terms of planned development. For instance, to date, there is not a single international airport in the Tarai. The ease of accessibility has also not been fully utilised by farmers, as most product sales occur in the local market. For example, the local vegetable markets in the study sites provide a platform for selling produce such as vegetables and fruits (Plate 4.6). Not all produce that ends up in these markets are locally grown. In Damak, for example, each morning before dawn, fresh produce from India are brought in tens of vehicles for sale at the local vegetable market. Despite having the theoretical capacity to generate such produce, and although the exact figures for the imported produce were not available for the study sites, the Tarai market seemed to be dominated with imported vegetables. Many farmers did bring up the problems of competing with lower prices of vegetables from neighbouring India which they attributed to factors like 1) cheaper cost of production in India due to economies of scale; 2) state assistance to farmers and 3) more reliable and cheaper methods of irrigation.

Plate 4.6 Vegetable market in Damak (left) and Dhangadhi (right). Vendors sell local as well as imported produce in these markets.

Source: Field Survey 2013-14.

A 25-year-old female landless farmer with work experience on farming for large land holders in both Nepal and India reported that the *adhiya* system in Nepal was more burdensome in comparison to similar farming contract practices in India:

> *In India, landlords are responsible for supplying fertilisers, seeds and ensuring constant irrigation. Farming is a lot easier there. As a single mother, I have to put a lot of effort in adhiya farming here. (Respondent 239)*

Despite producing surplus grains and regularly exporting to other districts, there have been reports of chronic malnourishment and food insecurity in some districts of the Tarai, like parts of Kailali (Osei et al. 2010). The field survey revealed a wide economic gap between the poorest and the richest groups but there was no evidence of households struggling for basic food needs, perhaps due to any seasonal nature of food deficiencies. The diversity of food groups in women's daily intake has been known to be associated with a household's socio-economic condition in the Tarai (Campbell et al. 2014). According to Nepal Living Standard Survey (NLSS) 2010-2011 data, 37 percent of rural households' food consumption is fulfilled by home-grown produce and 46 percent from market-sourced produce, compared to 66 percent market-sourced produce for urban areas (Ministry of Agricultural Development & CBS 2016, p. 29).

4.7 Conclusion

In this chapter, the socioecological systems of the study sites are introduced and demographic details of respondent households are discussed. This chapter has provided the background on the study sites and outlined broad demographic categories of the survey respondents. The Tarai society, with its long history of migration, both internal and regional, has sought to diversify household income through ex-situ work engagements. Significant barriers to gaining a high level local employment exists due to lack of education and training. Poorer households, as revealed by the survey, who end up sending a member to work in low-paying jobs elsewhere, are further disadvantaging the agricultural productive capacities of the household. That aspect of migration to and from the Tarai will be discussed in detail in the next chapter.

5. Evolving patterns of human mobility in the Tarai

5.1 Introduction

This chapter outlines the evolution of human mobility patterns in the Tarai starting with the historical migration that brought Hill-origin settlers to the lowland plains. Using primary data, it explores the motivations and the processes of migration in the Tarai, and argues that environmental factors are to some extent responsible for modifying traditional migration pathways. Since the 1960s, the Tarai has been a focus for internal in-migration activities, such that it now shares more than half of Nepal's population. While the region still receives internal migrants, the majority of current migration is circular out-migration to traditional destinations like India, as well as new international locations.

The chapter starts by outlining the basic concepts of human mobility to provide important background to the discussion of migration, especially environmentally induced migration. Then, using secondary data, the historical migrations to and from the Tarai are explored. Thirdly, the migratory histories of respondents' families are discussed. Next, the characteristics of migration in the study sites are analysed using descriptive statistics and qualitative descriptions. Discussion of the findings and implications for the development of the Tarai are also presented. Finally, this chapter concludes by outlining the key points on the shifting patterns of migration, the role of environmental factors in such shifts and the role of migration as a means of adaptation to environmental change. Migration from rural regions in search of off-farm employment is considered a major driver of rural change. Such migration induces demographic, economic, and social transformations in the source communities of the Tarai. The cases presented here are two municipalities with high reliance on agriculture established on cleared land that have experienced immense environmental and social changes. As highlighted in the previous chapter, despite high fertility of soil and reliance on remittances for decades, these municipalities are struggling with poverty, unemployment and environmental impacts.

5.2 What we know about migration to and from the Tarai

5.2.1 Patterns of historic migration

Most pre-modern settlements in Nepal were in the Hills and the Mountains. The pre-modern movement of people was predominantly from the plains to the Mountain cities and any large scale reversal started only around 150 years ago (Hrabovszky & Miyan 1987, p. 264). The Tarai also experienced the inflow of migrants from north India during the mid-18th century, also known as the unification phase, which saw the Shah rulers encourage inhabitation of Tarai as part of expansion

of the state (Stiller 1976). Nevertheless, before the 1960s the Tarai, was almost entirely covered in forest. The Tarai ecosystem provided appropriate conditions for mosquito breeding, thus generating high risks of catching malaria, Japanese encephalitis, dengue and lymphatic filariasis (Ministry of Health and Populaton 2011). Extensive malaria eradication programs were undertaken in Nepal in the 1950s with successful results that significantly reduced the likelihood of residents catching serious diseases (Brydon et al. 1961).

The post-malaria period saw an emphasis on settlement of Hill migrants in the Tarai and that migration accelerated rapidly in the 1960s with nationally funded and planned settlement programs. The introduction of Hill-origin migrants to the Tarai in the 1960s followed a similar pattern of bringing in-migrants to the less populated frontier regions in India during the first quarter of the Twentieth century. The introduction of in-migrants to these under populated fringe regions provided a share of land, often causing indigenous settlers to lose their traditional land tenure practices (Caplan 1970). People from the Hills of Nepal were encouraged by the British to migrate to mountainous regions of India like Assam and engage in forest clearing, road construction mining, plantation and other economic activities (Devi 2007; Nag 2003). The kinship among families in Nepal and many places in India like Assam is still strong. Similarly, the Hill settlers in the Tarai still maintain family ties in Assam and numerous other places in India.

Urban centres in the Tarai are still experiencing above average growth in population due to a combination of in-situ natural increases, with ongoing movements from the Hills and the Mountains. These in-migrants did not receive much further help from the Central government as most state-led development efforts have focused on the capital city and surroundings. Even early on, not all Hill-origin migrants who moved to the Tarai were granted land, and many resorted to illegal occupation of land by clearing native vegetation without official tenure (Feldman & Fournier 1976, p. 451).

The arguments questioning whether such a rapid transformation of the Tarai could not be maintained has been around since the early days of the transformation—see e.g. Hrabovszky and Miyan (1987). The exploitation of the environment in the Tarai has come at a cost. Timber exports to India once generated a sizeable income for the nation and local employment opportunities, but the forests have largely been depleted in protected areas in the Tarai. Land settlement and forest resources were also used as political tools in the by the ruling class (Springate-Baginski & Blaikie 2007, pp. 46-47). Without technological development, the output from agriculture has not increased significantly in many communities.

The attraction of the Tarai as a destination for internal migration has not faded. Data on internal migration from the 2011 Census shows that, Tarai had 1,071,588 Hill or Mountain-born residents

(CBS 2014a). Tarai districts hosted 35.2 percent of Nepal's population in 1952/53, but the figure was 50.3 percent in 2011 (Kansakar 2003). On a national scale, any intensification of agriculture in the Tarai could be expected to attract more people to the Tarai. However, the national population growth rate has been declining in the recent decades and if current trends continue, any further growth is likely to be comparatively small, especially as out-migration has increased from the Tarai.

5.2.2 Contemporary migration streams

Various types of internal and international migration streams can be observed at the study sites. Most of the current migration in the Tarai involves out-migration of circular migrants, but it also some migrants from the Hill and Mountain regions continue to move in. Although the remnants of historic migration patterns are still visible in the Tarai, the overall migration pattern has changed significantly, in the last twenty years, especially in terms of destinations of labour migrants. Data on work permits issued by DoFE for international labour positions puts Jhapa as the district with the second highest number of such permits issued (Ministry of Labour and Employment 2016). Contemporary migrants covered by the Field survey work in twelve countries besides India (Table 5.1). Most international out-migrants are still working in India, which has been established as a primary destination historically, but the growth in other destinations reflects a global pattern of increasing migration complexity.

The underlying pattern among the international destinations in twelve countries other than India reveal a concentration of migrants in mainly two geographical regions, the Gulf countries in the Middle East, and the countries in South East Asia and East Asia. To explore the migrant characteristics based on destination, the destinations were grouped into five destination region categories as outlined in Table 5.1.

Table 5.1 Destination region categories for grouping migrants' destinations.

Destination region categories	Countries or region	Frequency
Gulf Countries	Brunei Darussalam, Kuwait, Qatar, Saudi Arabia, United Arab Emirates (UAE)	58
South East Asia and East Asia	Bahrain, Malaysia, South Korea	41
India	India	104
Internal	Internal migration to other districts within Nepal	23
Other	Other regions not mentioned above	

Source: Field Survey 2013-14.

The following subsection outlines the streams of migration practiced by the survey respondents in Damak and Dhangadhi municipalities.

5.2.3 Out-migration

5.2.3.1 Internal migration to locations within Nepal

Urban destinations in Nepal attract a large number of internal migrants by virtue of the number of job opportunities available. Internal migration involves being away for an extended period and differs from commuting, which refers to daily journeys to work, returning each night to one's normal place of residence. The capital city, Kathmandu is the major destination for internal migrants, as it is the prime population and business hub in Nepal. Migrants in this category can be lumped into two sub streams—1) migrants with formal jobs who have been assigned to work in a different location—e.g. school teachers who have obtained or been assigned to work in remote districts; army personnel assigned at a base in a different location, and 2) migrants who have moved to other locations for low-skilled labour intensive work.

The relocation of household members due to marriage is not recorded as migration in this study. For instance, if a member of a household has moved out after getting married, then the person is no longer treated as a member of the household.

5.2.3.2 Circular migration to India

Circular migration is defined as repeated movements between the source and the destination involving two or more trips. It generally involves the migrants "sharing work, family, and other aspects of their lives between two or more locations" (Hugo 2013). According to the United Nations—UN (2015), 542,947 Nepali migrants were estimated in India in 2015. The destinations in India are not limited to border towns, but span all of India including global cities like New Delhi, Mumbai and Kolkata. Most Nepali migrants opt for low skilled work such as servers or bus boys in a restaurant, or as security guards, but there are migrants with formal jobs across India. Typically, Nepal migrants to India often start off at an early age, some even before finishing secondary school. For example, some respondents reported working in the agriculture sector for large land-holders in India from a young age. Among respondent households, children as young as 10 were reported to be working in India. Out of the 8 reported migrants aged less than eighteen, 6, all from Dhangadhi, were in India. A 39-year-old male farmer from Dhangadhi said:

> *Our son ran away from home and went to work in India. He's 12 now. He has been working at a restaurant in Gujrat. He sent me a mobile phone this year. (Respondent 223)*

The type of circular migration practiced in the Tarai stems in part from the need to find alternative livelihood options and in most cases, is not embedded with the agricultural practice as the migrants are unable to contribute labour for agriculture or livestock. However, there are cases when the migrant can return to contribute labour in agricultural tasks, if the destination is in close

proximity. A few respondents also reported leaving for India after harvest and returning home when the demand for agricultural labour is high. Seasonal agricultural work during fruit-picking or harvest periods in India attracts many Nepali migrants. Most of the seasonal work for Nepali migrants are in mountainous region of Assam during the months of July-August when there's a large demand for labour, mostly for apple picking. Farmers in the Tarai are regularly recruited by agents to engage in such seasonal stints. A 50-year-old, brick-maker and seasonal migrant, from Dhangadhi said:

> *I work as brick maker here but also do seasonal work in the Himanchal [Pradesh] (a state in northern India) three months a year. Many Nepalis go to work there in fruit picking. I have been doing this for more than twelve years. The agent will come to my village to recruit workers. They give us advance payment for travel. The work lasts only for three months. I do not take my family. The work is not for women. It is a difficult work because of the terrain. We have to carry heavy load using a doko (a basket made from bamboo shaped like a cone) on our back and walk on hilly terrain. (Person 12)*

5.2.3.3 Circular migration to other international destinations

By far, the most popular category for out-migrants from the study sites, more and more people are spending periods working in third countries. In recent years, the number of Nepali migrants in India has declined, and at the same time, migrants to destinations in Gulf countries and Malaysia have spiked (UN 2015). Since 2007 Nepal has been sending migrants under the Employment Permit System (EPS) scheme to South Korea as well. This newly added destination has gained popularity among prospective migrants, with 33,960 migrants sent to Korea under the EPS pathway from Nepal (Ministry of Labour and Employment 2014). However, migrating under the EPS scheme requires a higher level of testing and also requires an understanding of the Korean language. The strict requirements create a barrier to migrants with low human capital and perhaps this is the reason why Tarai residents have not have been early adopters of this scheme. Only three migrant covered by the survey was a migrant in South Korea.

5.2.4 In-migration

5.2.4.1 Internal migration

Migrants from other regions in the country, especially from Mountain and Hill locations continue to settle in the Tarai, although the movement is minor compared to the original settlement period. Some migrants have been temporarily residing in the study sites for work purposes as well. Being a municipality with a sizeable market hub, Damak and Dhangadhi have better opportunities compared to many surrounding villages. International organisations like Institute of Migration (IOM) and UNHCR have established a range of support offices in Damak to support local refugee

camps. These organisations provide formal employment to many locals, as well as national and international professionals.

5.2.4.2 Migration from India mostly Bihar

There are an estimated 446,491 Indian migrants in Nepal (UN 2015). Migrants originating in India mostly engage in small entrepreneurships or special skill trade works like brick making, carpentry etc. There is also a seasonal flow of Indian migrants, especially from neighbouring Bihar for work in brick kilns, although such migrants are reported to have declined rapidly (Deshingkar & Farrington 2009). None of the households covered by the questionnaire survey fall into this category, perhaps because the sample did not include urbanised areas of Damak and Dhangadhi municipalities.

5.2.4.3 Hosting of refugees

Damak hosts 20,705 refugees from Bhutan in three camps set up by UNHCR (UNHCR/WFP 2014). As discussed in Chapter 4, the refugee camps and IOM offices provide direct and indirect employment to many households. More than 100,000 refugees from various camps in the Tarai have already been resettled in third countries (UNHCR 2016). Once the remaining refugees are relocated to third countries, the camps will eventually close. The refugees are not officially allowed to get out of the camps, but according to the respondents, they regularly engage in temporary labour in Damak or nearby cities. Since the Bhutanese refugees are of ethnic Nepali origin, they can speak Nepali which means they easily integrate and engage in informal activities. Some refugees have managed to establish families outside the camps, resulting in an estimated 2,000 children with links to the camp (Sanders 2014). Although a precise figure is not available, some of these 'mixed' families could be expected to reside in Damak in the long run.

5.2.5 Patterns of international migration

The history of labour migration can be traced back to the origin of the nation itself in the 17th century when many citizens of the newly formed country had fled to neighbouring regions to avoid paying tax (Gurung 2004). Another pathway of temporary migration commenced after Nepal's treaty with the then British Empire, which generated and continues to supply Nepalis as soldiers. For most outsiders, Nepal was a mystical kingdom up until 1949 when it opened its borders to let visitors in. This isolation meant that much of the country had little influence from major international political events occurring in the region and the society was predominantly reliant on its own resources (Kadga 1992, p. 390). Historically, migration to and from Nepal emerged to reflect specific cultural attributes, with migrants from Bihar and Uttar Pradesh states in India

moving into the Tarai and migrants from Kumaon (a region in mountainous part of North India) and Tibet settling in the Hill and Mountain regions respectively (Subedi 1991, p. 89).

Nepali people have been documented to have migrated to many Asian countries in the 19th and 20th centuries, particularly to Bhutan, Burma, Malaysia (then Malaya), Thailand, Bangladesh (then India) and Tibet. Nepali migrants were involved historically both as merchants in Tibet and Bangkok, and as plantation workers in Malaysia (Kansakar 2003). The census of 1952/52 for instance, recorded 6,621 and 1,849 Nepali out-migrants in Malaya and Burma respectively (Kansakar 2003). Although the exact figures of Nepali migrants before the 1950s are unavailable, the legacy of Nepali workers in South-East Asia since the early 19th century is documented [see (Kansakar 2003) for details]. In Nepal, labour migration has long been a household strategy to maintain livelihood security and reduce economic vulnerability, but in recent decades it has increased in importance. With per capita income of USD730, Nepal is one of the world's least developed countries (The World Bank 2014), and in recent years, the foreign employment industry in Nepal has been established as one of the largest sectors contributing at least a quarter of the nation's GDP (Jones & Basnett 2013).

In recent decades, Nepal has increased its labour exports to international destinations, especially to the Gulf countries. The official estimate is that 6.19 percent of Tarai population are out of country (CBS 2012a) and the majority of them are temporary labour migrants. Among the three ecological regions, the Tarai alone accounts for 50.4 percent of overseas migrants (Ministry of Labour and Employment 2014, p. 26). The Jhapa and Kailali districts, where the study sites are located, have higher absentee rates compared to the national average, as shown in Table 5.2. The Tarai also enjoys a large share of international remittance income, estimated at 57 percent of the Nepali total compared to 34.3 percent for the Hills and 8.7 percent for the Mountains in 2009 (NIDS & NCCR North-South 2010).

Table 5.2 Absent population from Jhapa and Kailali districts compared to National and Tarai figures.

Region	Population	Absentees as % of population	Male %	Female %
Nepal	26,494,504	7.2	87.6	12.3
Tarai	13,318,705	6.2	89.8	10.1
Jhapa	812,650	9.9	85.5	14.5
Kailali	775,709	8.1	80.5	19.5

Source: CBS (2012a).

An important pattern of circular migration to India grew until the 1980s, when destinations in the Gulf States of the Middle East started taking in labour workers following the oil boom of the 1970s. The Nepali Foreign Employment Act – 2042 (1985) was passed by Parliament in October

1985, which paved the way for official pathways for Nepali workers to migrate to Gulf countries and for private companies to mediate their movements. Out-migration of Nepali youths increased particularly rapidly during the ten-year insurgency period from 1996 to 2006, especially from the Hill region. Contemporary data from the DoFE suggests a total of 108 countries accept prospective Nepali migrants around the globe (DoFE 2014, p. 202).

Households having one or more migrants have the added benefit of alternative sources of stable off-farm income, but at the cost of lost labour support at home. Since circular migrants from the Tarai are primarily concerned about remitting the maximum possible amount of their income to the household, Nepali households are essentially earning alternative incomes from each migrant. In other words, increased numbers of migrant members have been shown to increase remittance earnings at the source household – a situation that has parallels in places such as Rwanda and Malaysia (Clay & Vander Haar 1993; Lillard & Willis 1997, p. 130).

The Absentee population from Nepal has been increasing since 1940s when the first such recording at a national level was made. Despite the changes in the methodology to collect absentee data, it is clear that out-migration accelerated in the last decade, with 6.8 percent of absentee population in 2011 compared to just 3.2 percent in 2001 as shown in Table 5.3.

Table 5.3 Trends in absentee population from census data.

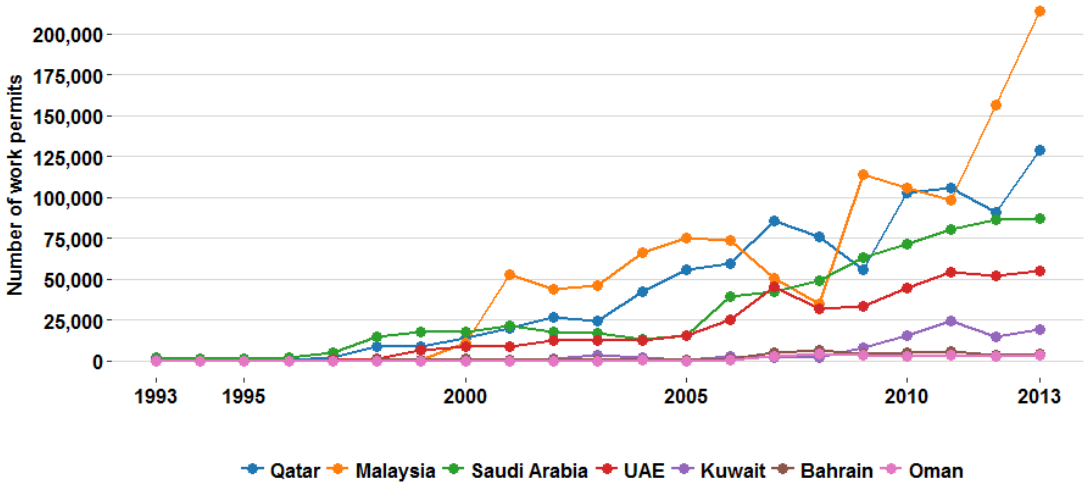
Year	Tarai	Nepal	Total population including absentee	Percent	Male	Female	Remarks
1942	1,221	81,722	6,283,649	1.3	-	-	Census does not include troops working abroad
1952/54	5,292	198,120	8,473,478	2.3			Regions not comparable due to different census districts compared to latter years
1961	16,214	328,470	9,741,466	3.4	-	-	Regions not comparable due to different census districts compared to latter years
1971	-	-	11,561,983	-	-	-	Absentee population not recorded
1981		402,977	15,425,816	2.6	328,448	74,529	
1991		658,290	19,149,387	3.4	548,002	118,288	
2001		762,181	23,913,604	3.2	679,489	82,712	
2011	824,904	1,921,494	28,415,998	6.8	1,684,029	237,400	

Source: Compiled using data from Kansakar (2003), CBS (2012a), and CBS (2002).

Since 1993, Nepali migrants working at international destinations other than India have to obtain work permits through DoFE (Sijapati & Limbu 2012, p. 3). According to data collected by DoFE, there has been a sharp increase in the number of permits allocated to labour migrants since the

late 1990s, in part because of Government support for migrant labourers (Figure 5.1). This period can be attributed to the growth in demand of labourers in the Gulf countries, Malaysia and Brunei. The period also coincides with the internal conflict that occurred in Nepal and an associated time of slow economic development, which generated important push factors for labour migrants.

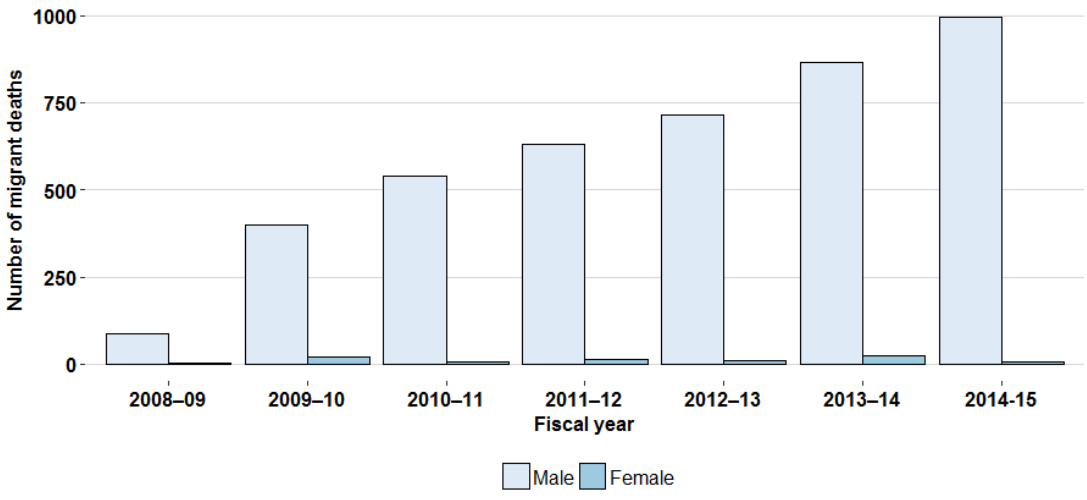
Figure 5.1 Trends in number of work permits issued by DoFE in top seven destination regions—1993-2013.



Source: Constructed from DoFE (2014) data.

In addition to an increase in the number of permits being issued since the mid-2000s, renewal of existing permits has increased (Figure 5.2). Renewal of work permits allows migrants who are nearing completion of their initial contract to return to the same work. From fiscal year 2011/12 to 2015/16, around a third of the permits issued in that same time frame were renewed (Ministry of Labour and Employment 2016, p. 16).

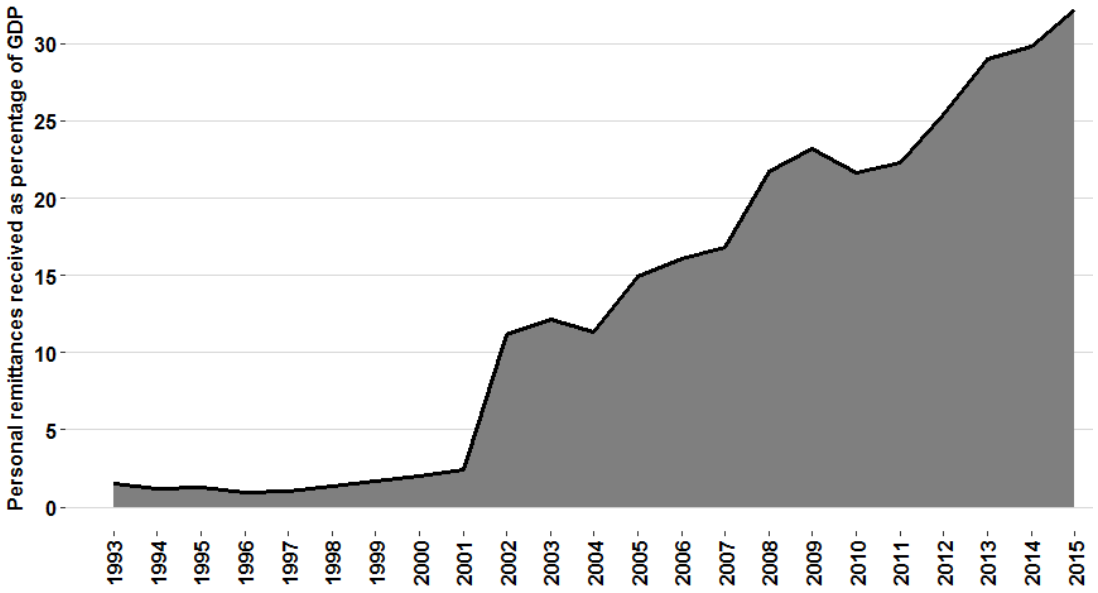
Figure 5.2 Trends in number of labour permits renewed (Fiscal year 2008/09-2014/15). Figures does not include migrants under the Employment Permit System (EPS).



Source: Constructed from Ministry of Labour and Employment (2016, p. 7) data.

Remittances have played a crucial role in supporting the Nepali economy, with contributions of such income to domestic GDP rising since the early 2000s (Figure 5.3). For example, external income accounted for 32.23 percent of GDP in 2015, compared to 14.9 percent a decade before (The World Bank 2016). The role of remittances as a percentage of GDP stagnated at around just over 20 percent in the years 2008-2011 perhaps due to the global financial cricis (GFC), but has steadily increased since then. According to the third NLSS survey of 2010-2011, 56 percent of sample households received remittances, with the average per household figure amounting to NPR80,454 (USD804). The greater proportion (58 percent) of the remittances are still from internal migrants. While the official figures are lower than the actual remittances, due to the fact that migrants use informal pathways to remit earnings back home, these data provide indicators of the importance of labour away from the place of residence in Nepal (Sijapati & Limbu 2012, p. 17).

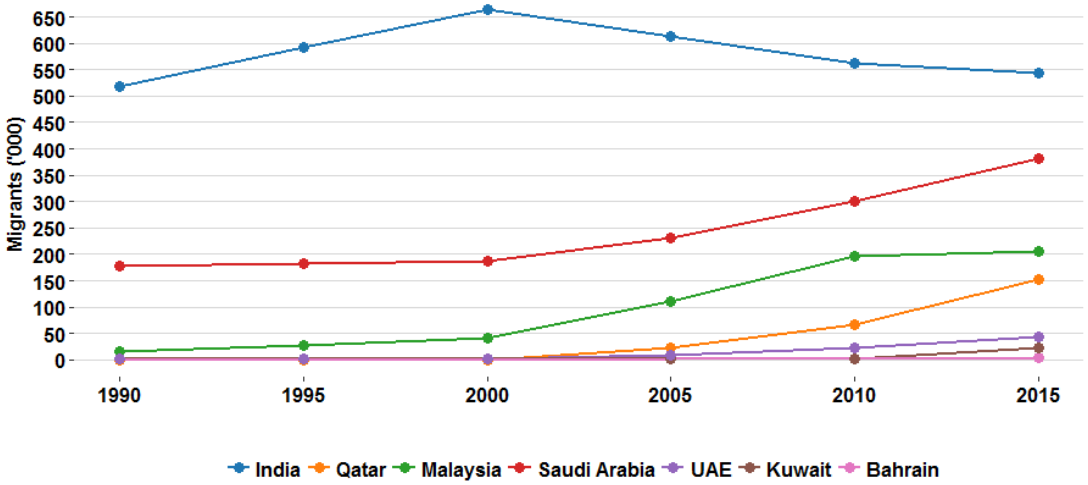
Figure 5.3 Trends in personal remittances received as percentage of GDP in Nepal 1993-2015.



Source: Constructed using data from The World Bank (2016b).

The out-migration data from Nepal is not without problems. Firstly, due to the free movement between India and Nepal, there is no official record of Nepali migrants in India. Secondly, Nepali workers can travel to third countries without permits obtained through private channels. An alternative estimate of the worldwide distribution of Nepali circular migrants to national figures comes from the UN migrants stock dataset (UN 2015), which lists estimates of migrants in every country or region by the source country or region of the migrants. For example, according to this dataset, the rise in the popularity of international destinations like the Gulf countries and Malaysia since the 2000s is clearly evident (Figure 5.4). At the same time, Nepali migrants in India have been declining, especially as a percentage of all international Nepali labour migrants.

Figure 5.4 Trends in number of Nepali migrants in top seven destination regions.



Source: Migrants stock dataset from UN (2015)

Together, the national and UN secondary data reveal a dramatic increase in out-migration from Nepal and the extent of the importance of the circular migration stemming from Nepal. Based on the background provided in this section, the pathways which brought many families to the Tarai will be discussed next.

The Tarai communities have utilised mobility at various stages to supplement their livelihoods. A summary of the various stages of migration seen in the Tarai since the 1950s are presented in Table 5.4. The first modern wave of migration witnessed in the Tarai was the influx of in-migrants mostly from the Hills. The second smaller wave of migration consisted of utilising regional locations. The third and final wave can be conceptualised by the contemporary migration patterns to regional as well as international destinations.

Table 5.4 Key features of the types of migration in relation to the Nepali Tarai region.

	First wave of migration	Second wave	Third wave
Timeline	1950s to 1960s	1960s to 2000s	2000s to present
Major source of migrants	Hills and Mountain regions	Tarai	Tarai
Major destination of migrants	Tarai land	Indian cities	International destinations
Push factors	Harsh living conditions; inability to sustain livelihood based on agriculture	Inability to sustain livelihood from agriculture; lack of in-situ livelihood options	Inability to sustain livelihood from agriculture; lack of in-situ livelihood options
Pull factors	Availability of land; better condition for agriculture	Proximity of destination; ease of travel; similarity in culture and language; availability of low-level work	Demand of cheap labour at international destinations; streamlined process for circular migrants; prospects of high income

The secondary data presented above provides an overview of the various types of migration pathways utilised by the Tarai households. Using the questionnaire survey data, the next section

will look at the characteristics of migrant individuals and their households to explore the role of mobility as a means of livelihood security.

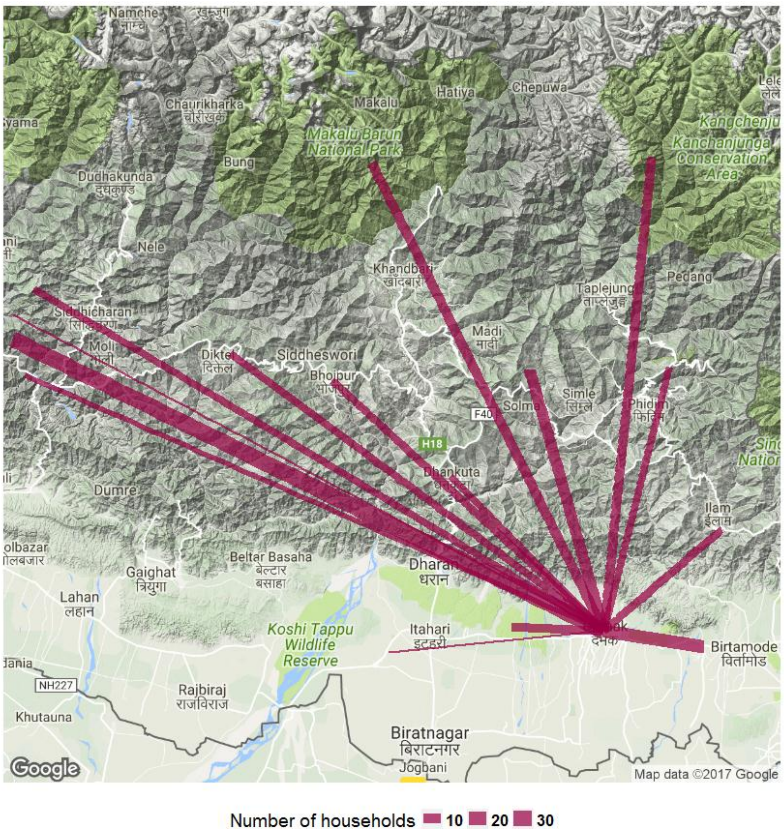
5.3 Migration characteristics

Chapter 4 presented the details on the methods used to generate range of livelihoods by the respondent households at Damak and Dhangadhi municipalities and examined the characteristics of the agricultural workforce in particular. This section portrays the specifics of the migrant members to better understand migration motivations, trends and the role of socio-economic conditions of particular households in relation to the type of attempted migration.

5.3.1 Migratory history of respondents' families

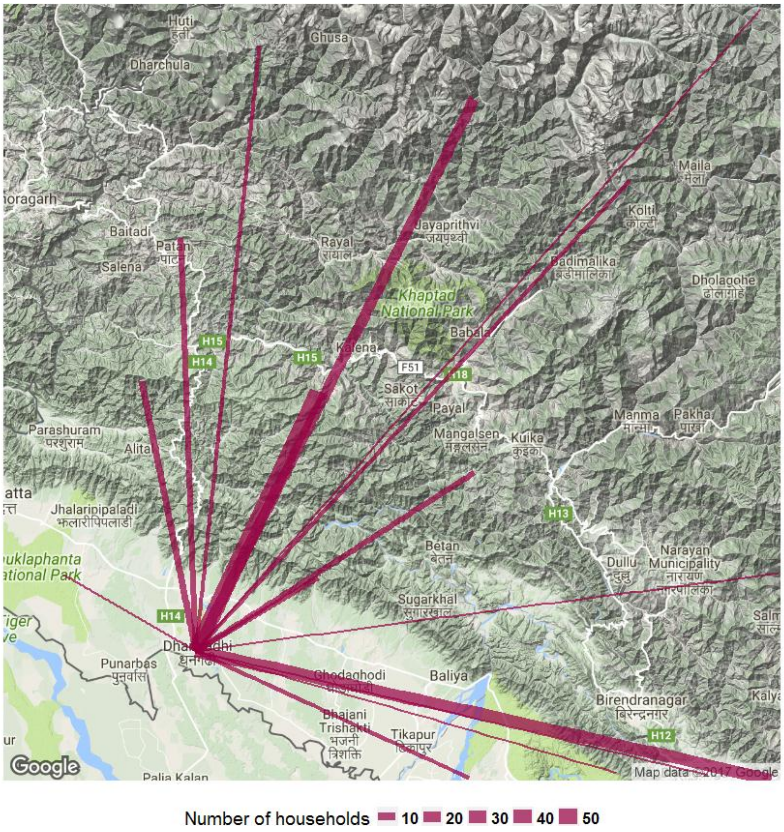
In Damak, only 17 percent of households identified themselves as indigenous to the Tarai i.e. belonging to an ethnic group, which inhabited the landscape before the land was cleared for settlements. The figure was 25 percent for Dhangadhi. In both locations, most households maintain some ties with their place of origin in the Hills to the north (Figure 5.5 and 5.6).

Figure 5.5 Internal migration pattern based on prior residence of surveyed in Damak. Radiating lines originating from Damak show prior residence districts.



Source: Field Survey 2013-14; background map image from Google maps.

Figure 5.6 Internal migration pattern based on prior residence of surveyed in Dhangadhi. Radiating lines originating from Dhangadhi show prior residence districts.



Source: Field Survey 2013-14; background map image from Google maps.

5.3.2 **Reasons for moving to the Tarai**

Many respondents cited the difficulty in maintaining a livelihood in the Hills as the main reason for moving to the Tarai. Phrases like "difficult life", "no prospect of irrigation", "lack of facilities", "difficult to practice agriculture", "inability to provide food for the family", "inability to afford rent", "difficult terrain (to work on)" were used by the respondents to describe the negative aspects of the Hill or Mountain lifestyle. Clearly, the motivations for migration were rooted around the limited land resource and the inability to generate a sustainable livelihood from agriculture. The Tarai then was seen as a place of promise, with the perception of ample land for everyone to practice agriculture. The flat terrain of the Tarai is in sharp contrast to the Hill terrain and promised ease of travel and transport. A 25-year-old female remembered why her parents migrated from the hills:

> *Everyone left the Hills and moved here. We did the same. (Respondent 221)*

Apart from the environmental characteristics of the site of the Hills, particular hazards were also important in driving out-migration to the Tarai. Some of the households were offered land to

relocate to after being affected by a natural hazard event, namely landslides and floods. A 72-year-old male from Dhangadhi said:

> *Flood swept our land [in the Hills]. We requested land [with the government]. We finally moved in 2023 BS [1966/77] after getting approval from the resettlement company. (Respondent 259)*

There was some indication that the support specifically for victims of natural hazards to move to the Tarai has increased in more recent decades and were given land. A 25-year-old male from Damak said:

> *We moved here after the flood of Mangsir 2048 BS [November-December 1991]. We arranged for the move ourselves. There was no help from government. We used money that we received as compensation for my land after it was acquired for airport construction. (Respondent 122)*

The Tarai was described as opposite to the Hills by the respondents, with ease of access to facilities and livelihood opportunities through agriculture. Tarai was described using phrases like "more facilities", "easy life", "better life", "more options for livelihood", "more accessible" and "availability of land". Some even described the reason for moving as following the "trend of the times". The issue of the Tarai providing an escape from the harsh life of Hills is reflected by the following quote, the essence of which was shared by a few respondents—"[We moved] so we could eat rice." Being able to afford rice meals (*bhat*) was considered a sign of self-sufficiency. Less fortunate households would resort to meals from cheaper alternatives like *dhindo* made from maize flour or buckwheat. The prospect of growing rice in the Tarai thus was seen as a sign of opportunity and even prosperity.

Many elderly respondents and interviewees who migrated in the early years after the opening up of the Tarai land reminisced about their initial impressions of the new land. Some recalled the forest being felled in order to clear land for settlements and the problems faced due to isolation and lack of facilities. An older male farmer from Dhangadhi said:

> *The whole area was a forest, trees were everywhere. There was just one road here. My family were one of the first settlers to arrive. I was probably about seven or eight years old then. The trees were fell to make way for settlements. We cleared our own land. Life used to be difficult, we lived in fear from robbers and wild animals. (Person 14)*

A 78-year-old retired serviceman from Dhangadhi remembered the state of the place in the early days of the settlement:

> *The settlement was surrounded by a forest. The market was small ... there was no market at all. The area beyond the cinema hall was dense forest. The settlements were established after clearing the forests. I don't remember the exact year, but I have witnessed the government workers felling the trees and making land for settlements. I was around 15 or 16 at*

> *that time. … Water was different. We used water from well. Mosquitoes were rampant and malaria was widespread. Life was much different. Things were cheap. 2.5 kilogram of rice used to cost just 8 aana (NPR 0.5 or USD0.005). Agriculture was fully manual; we did not have tractors or any machinery. (Person 18)*

Early settlers who were interviewed also shared their experience of getting the official permit to own land and making their move from the Hills to the Tarai. A male farmer in his late 40s from Damak said:

> *This whole place was a jungle. No houses at all. We build the houses on cleared land. The government took the prime timber while the rest was burned down [to clear land] for settlement. Families who came later were not given formal land certificates although the land they are using have been surveyed by officials. I first came here in Shrawan of 2034 BS (July-August 1977) from Doti. I went back after obtaining temporary permit from the resettlement company. I returned a year later and build this house. I still have some land in Doti. I still have some relatives in Doti. (Person 10)*

Many families followed the paths of those who qualified for the initial resettlement programs and came to settle on their own. Not all families who made the move to the Tarai received land promptly. Especially those people who made the move later had to purchase the land or stay in public or unoccupied land. A male farmer from Dhangadhi, in his 50s, remembered the early years after his arrival:

> *When we arrived here, the land was being distributed. The market then was very small; this area was surrounded by forests. At first, we were not allowed to settle in this location but we requested the officials and the nearby land owners to let us stay. This area was officially surveyed for land allocation in 2057 BS (2000) but we have not received our land certificates yet. (Person 13)*

The contribution of environmental factors in the movement of Nepalis from the Hills and the Mountains to the Tarai is evident from the migratory history of the settlers from the study sites. Some households had to make the move after being faced with natural hazards. Many families moved because of inadequate prospects for their agricultural based livelihoods. On the destination side, the Tarai landscape was transferred to host the settlers. Social networks also played a role in the internal migration from the Hills and Mountains to the lower regions of the country in the Tarai. Many respondents cited having relatives or other contacts they knew as the primary reason to migrate. An older male farmer from Damak said:

> *Life was full of sorrow in the Hills. I felt it easier here. Firewood was plenty then. I used to be very active in agriculture. … I came in 2024 BS to follow my friend who was already here. In 2027 BS (1970), we were allocated 4 bigha (2.709 ha) of land like everyone else here. Many of those families are still here. Even this place is named Dhankute tole (locality) [after the Hill district of Dhankuta from which many of this locality hail from]. (Person 9)*

That issue of the importance of established streams and social networks resonates strongly throughout the migration literature.

5.3.3 Personal and family characteristics of circular migrants

The migrants are predominately male—91 percent from Damak and 96 percent from Dhangadhi as shown in able 5.5. This trend is reflective of the national figures that indicate that almost 90 percent of the absentee population from Nepal was male in 2011. This data also indicates that while international destinations are popular, most migrants from Dhangadhi still choose India, perhaps a reflection of the differences in socio-economic conditions. Compared to Dhangadhi, Damak is more connected to the capital city and has overall better socio-economic status, which facilitates more effective forms of livelihood, including migration opportunities.

Table 5.5 The destination of male and female migrants by study areas.

	Damak			Dhangadhi		
Destination region	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
India	3	0	3	97	4	101
Internal	4	1	5	17	1	18
Gulf Countries	53	7	60	5	0	5
South East Asia	32	2	34	7	0	7
Other	6	0	6	1	0	1
Total	98	10	108	127	5	132
Percentage	91%	9%	100%	96%	4%	100%

Field Survey: 2013-14

The gender imbalance is also reflected in the number of work permits issued by DoFE, outlined previously in Section 5.2.5. The tradition of males migrating for work relates back to a core element of the Nepali culture with the expectation that sons, especially the eldest, will provide for the family. The historic penchant of Nepalis to migrate abroad have been detailed my many researchers including, Messerschmidt (1976), Dahal et al. (1977), and Kansakar (2003). That strong cultural attribute may be part of the reason why Nepali men of certain ethnicities have migrated historically—to India as part of the British Army and more recently to a range of destinations. Although the many indigenous groups of the Tarai could not apply for the army, they migrated to India for other work. Such societal expectations on males are seen in other cultures as well—e.g. Matthews and Nee (2000) in China. Female members of households are traditionally expected to engage in household chores and work in settings which do not involve long distance travel. Even in the case of circular migrants to regional centres in India, the spouse

of the male migrant usually stays behind to support the family. A 40-year-old farmer and entrepreneur from Damak said:

> *When we ask for households to donate labour for river taming works, many just send women and children because there are no young men in the house. Some families who managed to earn remittances have moved to the cities. Only the uneducated and unemployed remain. (Person 8)*

Only 2.5 percent and 9.8 percent of migrant households in Damak and Dhangadhi respectively had either migrated with their spouse or planned to do so as shown in Table 5.7.

Table 5.6 Migrants' plan for their spouse to join them at the destination at study sites.

	Damak % (n=142)	Dhangadhi % (n=153)
No plan to take spouse	97.2	90.2
Have taken or plan to take spouse	2.8	9.8

Source: Field Survey 2013-14.

However, in recent years, there has been an increase in female circular migrants to international destinations in the Gulf countries and South-East Asia. Recruiters of migrant workers are actively seeking couples who can migrate together and promise jobs for both. Although both males and females can now choose to become a migrant worker in any allowed destination, such movements have not always been possible. In fact, Nepali females were banned by local law from working in the Gulf countries from 1998 to 2000. Then again, in 2003, females were barred from domestic work but allowed to travel for formal sector jobs. The current law does not allow for Nepali women under thirty to work in the Gulf countries. Prospective female migrants still find ways to work around these rules either by changing their date of birth, or by departing indirectly from India.

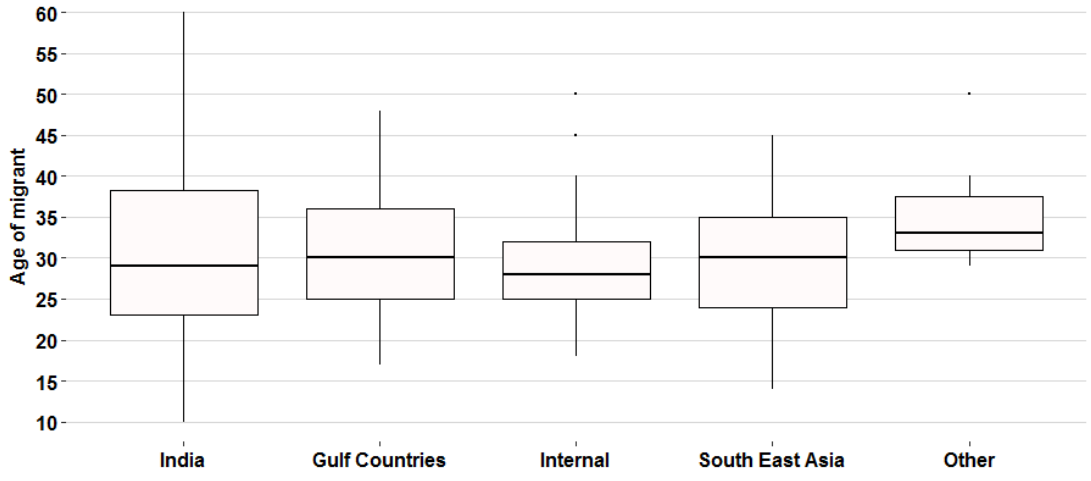
Information on migration opportunities are also shared through social networks. Many prospective migrants get information on work conditions, expected salaries and the application process by word of mouth. Most recruitment however is done by recruitment agencies who reach the villagers through local print media and radio. The number of migrants will to continue to rise, as more youths are aspiring to be migrants and the effort to recruit Nepali labourers has intensified: local media like newspapers and FM radio in Damak and Dhangadhi, can be flooded with advertisements calling for prospective migrants to show up at recruiting interviews. Transcripts of selected radio advertisements are presented here to illustrate the recruitment techniques.

> A reputed company in Malaysia is seeking one hundred security guards, police and ex-army personnel can apply now. Applicants should be able to read, speak and comprehend English language. Pre-interviews are being conducted. Those interested, please contact immediately. (Advertisement aired on December 2013)

> Dubai stationed … motor parts manufacturing company under British management has vacancy: salary SAR 1,050 per month and daily 3 hour of over time [work] totalling monthly SAR 1,500. 80 production helpers sought. Final interviews are planned for Poush 6 [21 December] at Ithari. Those with a SLC degree, basic English speaking skill and up to 35 years of age, please contact today. (Advertisement aired on December 2013)
>
> A golden opportunity with attractive salary in Qatar! A very reputed company in Qatar, ... is seeking Nepali workers as finishing carpenter, setting carpenter, aluminium fitter, steel fixers and mason positions. Interested Nepali workers, please contact immediately along with documents. Interviews are being conducted. For details, contact ... (Advertisement aired on December 2013)
>
> A manufacturing company in Malaysia is seeking 50 production operators with a salary of MYR1,500 (USD450) for 11 hour/26 days work. Similarly, a very renowned computer parts company in Malaysia, ... company is seeking some production operators. Also, a very popular cleaning company in Dubai ... company is seeking indoor cleaners; both husband and wife can go together for cleaning jobs paying up to NPR30,000 (USD300) per month. There are also indoor and outdoor cleaners in various positions in Qatar. The salary is NPR 25,000 (USD250) and upwards per month. Additionally, there is a huge demand for workers in trade occupations— carpenter, mason, steel fixtures, scaffolder and welders so those interested in foreign employment please contact this company soon. Remember that interviews for jobs at ... company manufacturing spare parts for airplanes will be conducted on Poush 4 (19 December), Thursday. And interviews for cleaning company in Malaysia will be conducted by company representatives on Poush 2 (17 December) Tuesday at this company's office. Those interested in applying please contact soon. Contact ... (Advertisement aired on December 2013)

Most migrants to India and other destinations are in the age group 25-35 years as shown in Figure 5.7, with the median age being 30 for males and 25 for females.

Figure 5.7 Migrant of respondent households by age and destination region.

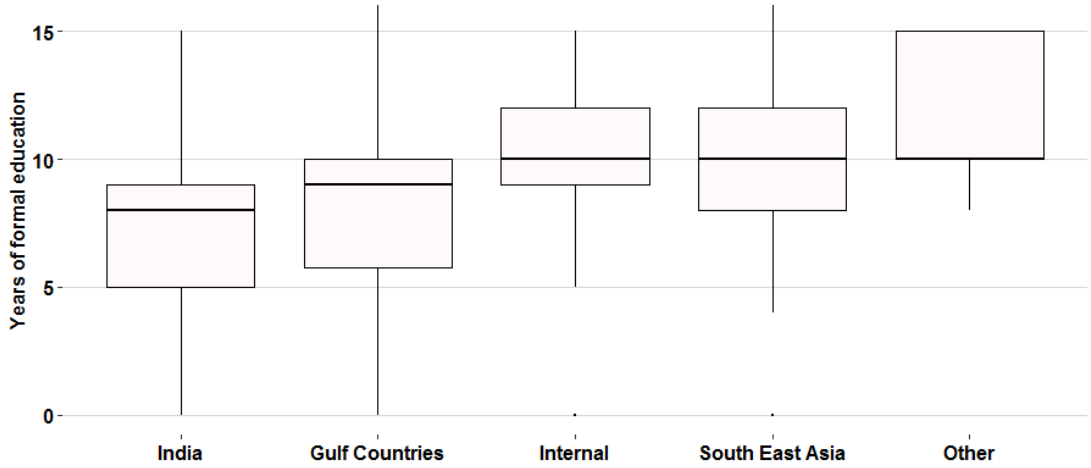


Source: Field Survey 2013-14.

Most migrants from the study sites have low human capital as indicated by their level of education. Nevertheless, the survey data revealed differences in migrants' level of formal education attained and their choice of destination (Figure 5.8). In particular, internal migrants and migrants to South East Asia (mainly Malaysia), had higher education on average compared to migrants to India and the Gulf nations. Migrants to India had the lowest education levels, which might be expected as there is no formal requirements to work there. The difference between the education levels of internal migrants, and migrants to India and the Gulf countries is also indicative of the high requirements of available jobs within Nepal.

In line with many case studies of Nepali migrants (Gartaula & Niehof 2013; Graner 2010; Graner & Seddon 2004), the lack of employment opportunities, especially for those with a university degree emerges as a strong motivation for emigration from the Tarai. Many households who send migrants have exhausted other ways to increase income from agricultural production and other locally available work. A common narrative among the youths with a bachelor's degree was that they could not find work in nearby cities. For a household, especially those sending a migrant to far-off destinations, there is often an important decision to make regarding who to send and who will manage the farm and livestock. This phenomenon is changing however, as households are increasingly sending multiple members for migration, and more couples are migrating together to bring in lucrative remittances.

Figure 5.8 Education levels of migrants from respondent households by destination regions.



Source: Field Survey 2013-14.

5.3.4 Motivations for out-migration

The most common answers when asked why the family member left the household for circular migration was "to earn money" and "lack of local employment". Migration has been a means to supplement household income for the Tarai residents since the early days of the settlement and

for many households across Nepal even earlier than that. What is different now though is the choice of destinations and the way they are migrating. The shift in migration patterns from India and other regional centres to the Middle East and Malaysia has been studied in relation to remittances received [e.g. Graner (2010), Graner and Seddon (2004)]. The Tarai families, by sending one or more members for migration, continue practicing agriculture and livestock rearing, particular for larger families with larger holdings.

Return migrants reiterated that the reason for migration was obvious. The desire to support family, the earning differentials, and the lack of local opportunities as reflected in their stories. A 40-year old return migrant from Damak said:

> *I migrated in order to make money, of course! My brother was already there and helped me with the process and arranged the documents for me. I still had to pay NPR40,000 (USD400) to the agent to arrange my flight ticket. Most of my peers have migrated to Malaysia to work as security guards. They usually migrate after finishing school (grade 10) or plus two (grade 12). The clear reason is lack of work here. Youth with [bachelors] degree have also gone abroad because they could not find employment here. Around twenty to twenty-five youths from my told are working abroad. Even the women are going... Lebanon and Kuwait are popular destinations for women. (Person 5)*

Another migrant, also from Damak, a 33-year old male said:

> *Migrants are on the rise because the agricultural productivity has declined and maintaining livelihood has been difficult. Secondly, prices of daily commodities have gone up. A bag of salt now costs NPR100 (USD1) during this election time. I remember it used to cost only NPR5 (USD0.05) a few years back. If there are opportunities here, there is no need to leave. We simply do not have the right skills. Our education system is not able to prepare us for the world. This becomes evident when we are abroad as we find it hard to adjust to working conditions there compared to youths from other nations. … Youths should be encouraged to invest and work here. They should be able to access loan at low costs. I still think there is opportunities in agriculture here. If there were opportunities for a decent livelihood here, I would not think of going abroad. I have returned after few years of work and I am still thinking of going back again. From my ward, almost all youths have gone to either Saudi [Arabia], Dubai or Qatar. … In some ways, migration is good for the nation. But it's a sure loss for the family. Most people do make money and invest here. Some Nepalis have managed to secure respected positions and make very good money. … Prior to working as a migrant in Qatar, I used to work as a tour guide. The guide work was good but my livelihood came under threat during the insurgency period. The Maoist [rebels] would ask for donations at key points along the tour route and it was difficult to earn a living so I decided to apply for overseas work. I saw an advertisement in the paper and applied. It was a bit of luck ... it took just 25 days for my visa to be processed. I had to leave in a hurry. (Person 3)*

An older male carpenter from Dhangadhi said:

> *I work as a carpenter. I have also worked in India for short durations. When I went to India for work, I take my whole family with me. ... I still have (extended) family in the Hills. We had to leave because there was no means of livelihood. It was not easy here either. We faced a lot of discrimination (as dalits[7]). (Person 16)*

Similarly, a 40-year-old farmer and entrepreneur from Damak expressed:

> *We have a lot of manpower here but have not been able to utilise them. From this very town, there are about one hundred youths currently working in India for a mere NPR5,000-6,000 (USD50-60) per month. … The main reason of youths leaving the village is unemployment. Currently, it is very difficult to find even three young males from a tole (locality). (Person 8)*

Respondents cited the lack of opportunities for income as the main reason for opting for circular migration. Some revealed that they were following their friends or relatives who were already working overseas. Seeing peers return from overseas work and knowing about the remittances they are able to send have been a strong motivation for youths who struggle making an earning in the village.

The internal conflict started by the Maoist faction of the Communist Party of Nepal was also cited as a reason for migrants to resort to circular migration. The armed conflict began in 1996 and continued for a decade taking a toll on more than 16,000 lives on both sides of the conflict (Agence France-Presse 2009). The conflict also negatively affected the economy of the nation, especially the tourism industry (Bhattarai et al. 2005). Interestingly, a few respondents said that the migration decision was due to not being able to finish school. Migrants usually require very little education in order to qualify for overseas work. Migration to international destinations have age restrictions, and therefore prospective migrants who are not old enough to qualify for migration to these distant destinations have the option of working in India, or faking their age in their identity documents.

Migrant networks provide essential information for understanding both internal and international migration phenomenon (Hugo 2012a, p. 47). The field survey was used to seek information on how the migrant members of the household had organised the moves. With the exception of India, most international destinations utilised by the migrants from Damak and Dhangadhi have little cultural similarity with Nepal. Social customs in Gulf countries which are based on Islamic traditions, are in fact very different from the culture of South Asia. Despite differences in culture, language, religion and customs, migrants are keen on circular migration in the hope of generating remittances. Some migrants have contacts at the destination who can guide them on what to expect upon their arrival—12.7 percent in Damak and 18.3 percent in Dhangadhi. Most migrants

[7] A member of the lower cast in the traditional South Asian caste system.

however reported that they had no contacts at the destination prior to making the journey as shown in Table 5.7.

Table 5.7 Migrants' connection at the destination at study sites.

	Damak % (n=142)	Dhangadhi % (n=153)
No relatives or contacts at destination	87.3	81.7
Have relatives or contacts at destination	12.7	18.3

Source: Field Survey 2013-14.

At this point it must be noted that although the migrants start off from Nepal moving through formal channels, at the destination they may, by virtue of circumstance, become informal or irregular migrants as a few of the field survey respondents revealed. A male return migrant in his early 30s from Damak, who plans to migrate again, said:

> *I used to make about NPR6,000 to 7,000 (USD60 to 70) per month as a tractor driver here. Clearly, that income was enough for my family. I saw my friends go abroad and make a lot of money, buy land, build house and so on. A friend explained to me that there was no opportunity here and asked me to migrate with them ... I followed his advice. We were contracted to work in cleaning but upon arrival in Malaysia, we were given work in a plastic [goods] factory. Work was very demanding but the pay was small. Eventually, I decided to leave the company and work illegally. Finally, I was able to save some money and send back home. Had I continued to work with the original company, I would have only saved NPR57,000 (USD570) in two years. My loan back home was NPR150,000 (USD1,500) already, and additional interest of 5 percent per month. There was no way that I could pay back the loan without resorting to illegal work. I had too risk being caught because not paying back the loan would mean that my family would be harassed by the money lender. I was very worried about my family's welfare. I'm back here but have already arranged to work in Saudi Arabia. This time, I am more careful. I have acquired all details from my agent and from my friends working there. I hope it will be better this time. (Person 6)*

5.3.5 Financing migration

Sending off a member to migrate, especially to international destinations, comes at a significant up-front cost to the household. The cost of obtaining a passport, visa and flight tickets alone can run into hundreds of thousands of rupees, many times more than the annual income of most families. For that reason, meeting the initial cost for circular migration is an investment by the household that often requires selling of assets or borrowing money. Among the migrant households, 30 percent in Damak and 12 percent in Dhangadhi reported taking a loan for the sole purpose of sending off a migrant member as shown in Table 5.8.

Table 5.8 Migrant households' experience with loan at study sites.

	Damak % (n=142)	Dhangadhi % (n=153)
No loan for sending migrant member	69.7	88.2
Have taken loan for sending migrant member	30.3	11.8

Source: Field Survey 2013-14.

The locals shared their experiences of arranging necessary finances to send off a member to migrant for the first time. A 70-year-old farmer and craftsman from Damak said:

> *I had to borrow NPR130,000 (USD1,300) to send my youngest son to Qatar. He returned home just after three months because he failed the medical test. The labour agent here faked his medical certificates so he was able to leave. But, three months later, he was declared unfit upon a medical check-up and was sent back with just NPR15,000 (USD150). I was left with the burden to pay back the loan amounting to NPR130,000 (USD1,300). He has since worked with me in farming and crafting musical instruments. (Person 1)*

Similarly, male tea-estate worker in his late 30s from Damak said:

> *Both of my sons also used to help me with bagan (tea estate) work but now they are working overseas. They are working in Dubai and Qatar. They are not highly educated, so they work as labourers. They have been away for six months and eight months but we have already managed to clear all the debts. We borrowed a total of NPR190,000 (USD1,900) to send them overseas. (Person 2)*

When the migrant member is away, the remaining household members continue to work in agriculture and other local activities. Typically, it is the older household members, females and children who stay behind. The return migrants who took part in the survey or interview shared their experience of circular migration and their thoughts on migrating again. Most of the return migrants want to continue overseas work despite the hardships pertaining to the nature of the work and their lives overseas. The cohort of prospective migrants' choice of destination was clear, they preferred destinations in South East Asia compared to the Middle East or India. The traditional migration route to cities in India was, however, well established and still continues, albeit prospective migrants overwhelmingly prefer other international destinations. Nevertheless, India is still the only accessible place for the poorest and least educated households.

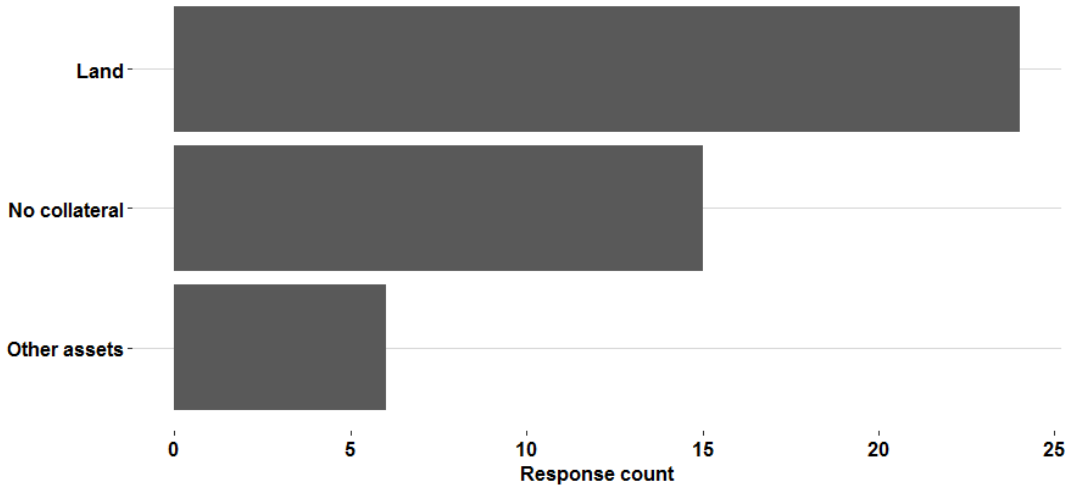
The process of migrating for work has also become easier as the networks and actions have been normalised. Going to work in far-off international destinations has become a norm for the youths. Even the migration to countries in the Middle East and to Malaysia have now been established via regular routes—a common feature of sending locations described as “cumulative causation” (Massey et al. 1993, p. 451). Cumulative causation describes the macroeconomic actions happening with the growth of employment options influencing migration, which results in

further growth of employment options, which again encourages more migration, and so on (Massey 1990, p. 15).

One particular concern for future agricultural practices is the change in distribution of land as a result of households receiving remittances. Households with migrants abroad generally have more income than those who do not, and are at a better position to invest in land and other fixed assets but may no longer engage in actual farming or livestock rearing activities. Indeed, as evident from survey respondents, for many households, traditional farming practices will change dramatically with the influence of migration, particularly when land ownership is transferred to the next generation.

Migrant families often borrow money to cover the upfront costs associated with migration. Many poor households are sometimes unable to access banking services as they do not have formal land entitlement documents or property equivalent to the collateral demanded by the bank as shown in Figure 5.9. In the absence of formal ways to procure loans, households resort to borrowing from relatives, friends, neighbours and local lenders. Such borrowing may also involve providing some collateral but the agreement generally is more accommodating to poorer households' particular situations involving low-value properties which may not qualify as a collateral for a loan from financial institutions. Usually, this form of borrowing from a local lender involves exorbitantly high interest rates.

Figure 5.9 Type of collateral for loan taken by respondent households with migrants.

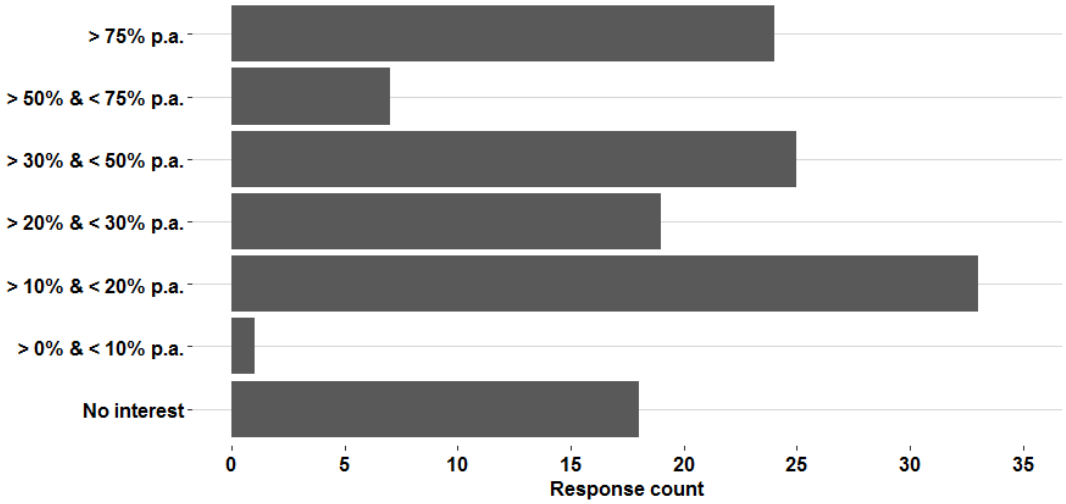


Source: Field Survey 2013-14.

Lenders typically charge interest monthly at rates ranging from 0.5 percent to 5 percent per month or the equivalent of 6.17 percent to 79.59 percent per annum (Figure 5.10). Although the amount of loan taken for migration may not be large, the high interest rates add significant financial and psychological burdens on both the migrant and the remaining household members.

Therefore, repaying the interest and principal is the foremost priority of migrant households. In rare, but not completely unavoidable circumstances when the migrant is unable to send remittances in the immediate months after departure, households have to take extreme measures like taking another loan or selling off land in order to clear the original loan. Families with at least one migrant member were found to be significantly more likely to have taken a loan in Damak as revealed by chi-square tests—χ^2 (1, N = 151) = 3.7875, p = 0.05]. A similar trend was observed in Dhangadhi but the result was not significant—χ^2 (1, N = 151) = 1.836, p = 0.18.

Figure 5.10 Interest rate for loan taken by respondent households with a migrant.



Source: Field Survey 2013-14.

Migration does have many costs besides the fiscal cost associated with travel and the potential for lost local income. Some of the other costs are the psychological cost of being away from family and the anxiety while adapting to live in a different setting; the opportunity cost of lost resources in preparation; and the cost of searching and applying for jobs (Massey 1990). Having migrants in a household has many consequences as they are forced to be separated from their family for extended period of time, sometime years. Especially in close knit communities like those of the Tarai, both the migrant member and the household back home are deprived of emotional and psychological support. There is also a social stigma for females whose male partners are working abroad, which adds to the stress of managing the household for years on their own or with the help of relatives.

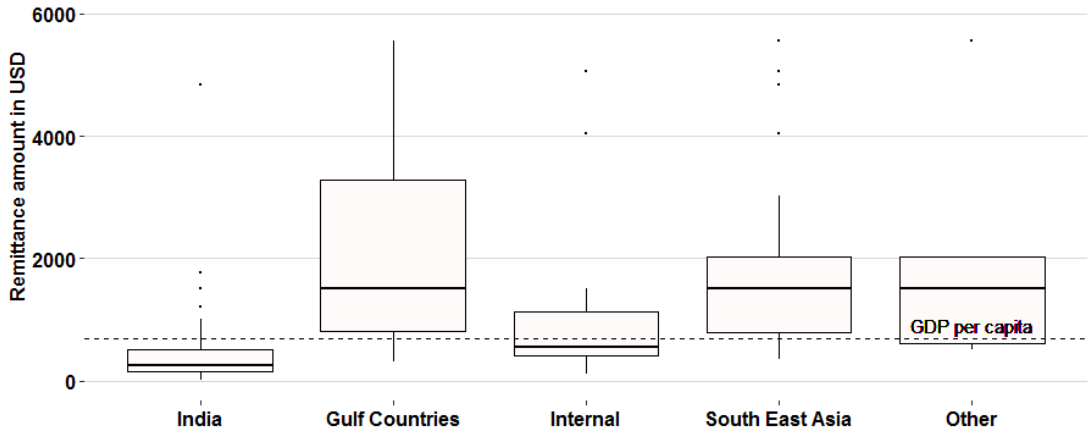
5.3.6 Remittances by migrants' destination

Remittances received by households provide an important income source for households, as well as contributing to the national economy. In the cases of Damak and Dhangadhi, the survey found that much of the earnings from migrants to India are sent via informal mechanisms referred to in South Asia as *hundi*—an informal system of transferring money to trusted agents at the source,

who will instruct agents at the destination to deliver cash to the intended receiver. Another commonly used informal transfer system occurs through returnees who carry cash back home not only earned by themselves, but from other migrant friends and colleagues, so that they can deliver it to the respective families at the destination.

Remittances provide crucial income for families back home without which many households wouldn't be able to provide necessities. Each household with migrants that reported receiving remittance money received on average NPR171,656.1 (USD1,717) in the twelve months prior to the survey. Remittance income reported by respondents was also found to vary significantly by migrant's destination. Figure 5.11 shows that among the destination groups, remittances received from India were the lowest whereas remittances from Gulf countries and South-East Asia were significantly higher. Median remittances from internal migrants was also significantly higher than from India. The vast income differentials partly explain both the rise in popularity of international destinations among prospective migrants, and also in part, the rapid urbanisation of the Kathmandu Valley.

Figure 5.11 Remittance received in the previous year by migrants' household by destination regions. Dotted line shows GDP for 2014 per capita at USD690 for comparison.



Source: Field Survey 2013-14; GDP data from World Bank

Remittances are sometimes paid in kind rather than cash. It is common for migrants to send goods via migrant friends who are returning home. Respondents of the survey, stated receiving electronic goods, like television sets and mobile phones from migrants. Particularly, when migrants return home, it is common for them to bring goods for family and relatives.

The income from remittances is also dependent on the personal and cultural traits of the migrants, and their ties to the family back home. Although relatively little is known of migrant behaviour and cultural tendencies to remit amongst Nepali migrants, due to the culture of close ties among family members, remittance can be expected to grow with the increase in income. It is

possible to anticipate that the pattern of remitting the maximum possible amount might change as earnings for migrants cross a certain threshold. Examples of such changes in migrant behaviour have been documented in Kenya, where remittances stagnated at a certain income threshold and for India, it even declined (Roberts & Morris 2003).

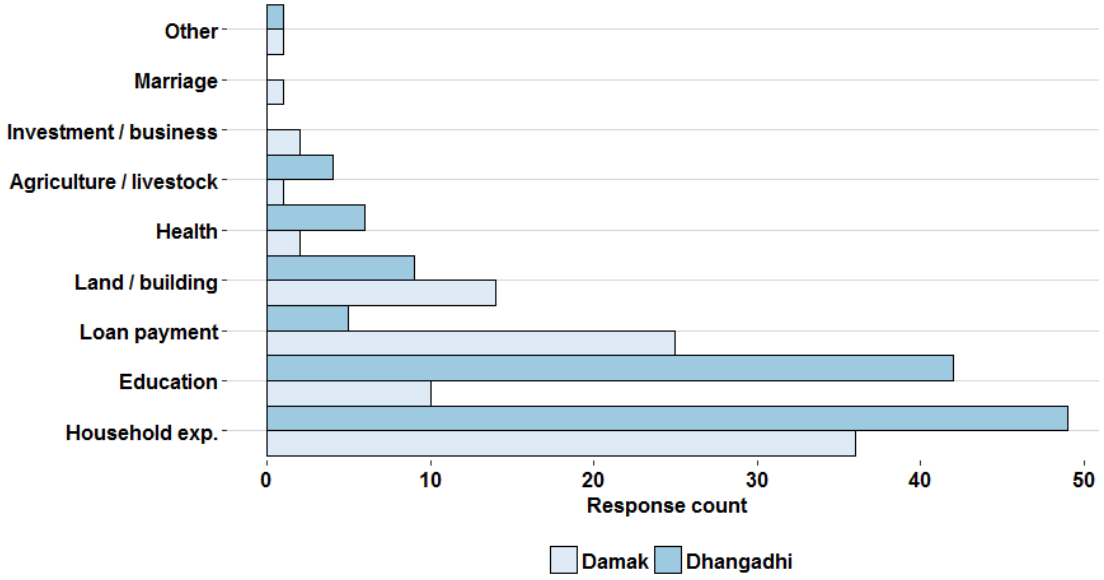
Many Nepali migrants time their return home for October-November so that they can celebrate *Dashain*, *Tihar* and *Chhath*, three of the biggest festivals in the region. During the fieldwork from September 2013 to March 2014, many households had return migrants, especially from India. One of the field surveys at a Dhangadhi household was temporarily interrupted when the household heads greeted their migrant son returning home from India. Loaded on the bullock cart on which the migrant arrived were several pieces of luggage, presumably, items brought for the family members and relatives. The return brought instant joy to the family.

The survey found that remittances received by Tarai households are used for a range of expenses by the household. Primarily, such income is used for covering basic needs such as household expenses, education, loan repayments and real estate. A 40-year-old male farmer and entrepreneur from Damak said:

> *Most migrants upon returning invest in building a house. This is not the proper use of the capital in my opinion. They should invest only minimal amount on building and invest the rest in businesses. (Person 4)*

Only a small number of households reported using remittance money for investment initiatives that would generate further financial capital or improve agricultural production, and use of remittance for basic household expenses was found to be prominent at both study sites as shown in Figure 5.12.

Figure 5.12 Use of remittance earnings by household at study sites (multiple response).



Source: Field Survey 2013-14.

Many respondents also used remittances to procure fixed assets such as land or buildings. Plate 5.1 shows new buildings being constructed alongside old ones in Damak and Dhangadhi.

Plate 5.1 New building construction works employing reinforced concrete systems in Damak (left) and Dhangadhi (right).

Source: Field Survey 2013-14.

5.4 Implications of changing migration pathways

In deciding destinations, return migrants and prospective migrants from Damak and Dhangadhi are looking to maximise earnings to support their household. This often results in changing destinations for return migrants. Malaysia has been established as the most popular destination followed by the Gulf Countries of Qatar and UAE, which is reflective of the overall national trend in choices of migrant destinations. A 34-year-old male prospective migrant from Dhangadhi said:

> *I have yet to pass all my plus two (grade 12) exams. I don't have any fixed plans yet. I might stay here, or go abroad [to work]. It's not fixed... But I'll never go work in India. [laughs] I'd rather stay here than go work in India. I have exams in Chaitra (March-April). My friends have gone to work in India*

> *as well. My younger brother just got a job with the Nepal Army. He's all set. I have not decided what to do yet. (Person 22)*

A 70-year-old female farmer from Dhangadhi shared the plans of her family:

> *Our family has always worked here in agriculture and small businesses. But one of my son now is planning to apply for Korea. (Respondent 320)*

There are many dimensions to the natural environment which can directly or indirectly influence a household's decision to send off a migrant. In this study, the factors related to access to natural resources and land use changes have been considered. As discussed in Chapter 4, exploiting natural resources, mostly from common pool sources, is central to the Tarai lifestyle. Unsurprisingly, many households reported procuring firewood from venders instead of spending time to collect it themselves. Purchasing firewood however is costly and many poor farmers are forced to resort to 'stealing' firewood from protected forests. In the case of Dhangadhi wards immediately adjacent to the international border, many farmers reported taking the risk to venture into the nearby Indian forest to fetch firewood—a practice which is illegal and if caught leads to a large fine.

Intensification or extensification of agriculture (or lack thereof), can also play a part in migration decision-making as those activities can determine if the household needs any supplementary income from off-farm sources. Similarly, loss of agricultural land through selling, division of property or disasters like flood can impact the volume of agriculture output and impact household income, thus influencing the need for external income sources. Loss of grazing land for livestock can put Tarai farmers at risk of reduced income as they have to take the herd further for grazing or put extra effort to carry fodder from a distant place.

Many migrants extend their stay upon finishing their initial contract either by changing their employer or extending their contract. After the first term of work, migrants have a better idea of working overseas and can make informed decisions when making the next move. According to official statistics from fiscal year 2011/12 to 2014/15, a third of migrants with labour permits from Nepal were found to renew their permit (Ministry of Labour and Employment 2016). That record increase in circular migration from Nepal had a significant impact on the daily lives of the Tarai residents. A large number of households now rely on remittances to meet their basic livelihood expenses. As a result, more households have access to amenities like education and health. Remittances have contributed significantly towards reducing poverty among many households, by giving them a stable off-farm income source. The decline in poverty, may mean that more households might move away from direct dependence on natural resources like firewood, or even agriculture. Benefits can also be expected from the increase in human capital, with improved health and education of household members.

Remittance income is not without risks. Firstly, the international labour market is prone to economic, market and political conditions at destination, and some respondents reported poor working conditions. Secondly, the injection of foreign income causes local prices to rise and the loss in competitiveness for some local businesses. Overall, the migration seen in the Tarai is a voluntary migration with the purpose of supplementing income for the household. As such, migration requires an initial investment to provide for the cost of travel and other associated fees, it has been shown that the families with more access to resources tend to migrate earlier and more effectively (Warner et al. 2009). In the context of the Tarai, most household have to borrow money to be able to afford to send off the first migrant. In almost all cases, the migrant returned every 2-3 years and the family back home continued their farm based livelihood. This trend is reflected in other areas of Nepal, as well, as presented by Adhikari (2001) and Aubriot (2010).

In the absence of opportunities to make a stable income in-situ, migration has become a de facto pathway for securing livelihoods. Households receiving remittances have higher resilience to external shocks on local livelihoods. This has been evident in the case of Koshi River flood-victims where remittances received from circular migrants were crucial in rebuilding (Banerjee et al. 2011). The devastating earthquake that hit Nepal in April 2015 quickly shaped migration flows. In the weeks and months after the quake which resulted in 8,710 fatalities[8], and labour out-migration increased (Sijapati 2015). Remittances received by Nepalis grew in 2015 at a higher rate than other South Asian countries due to the rise in post-quake remittances (Ratha et al. 2016). In the post-quake period, Nepali migrants to some developed countries received some relief due to differential treatment that aided travel for those with affected family members. For instance, Canada offered faster and more flexible processing of visas for quake affected Nepalis (Government of Canada 2015). Similarly, the United States of America (USA) offered temporary protected status to Nepalis residing in the country even on expired visas (Advancing Justice - LA 2015). At the same time, the post-quake scenario also highlighted the difficulties faced by source countries in rebuilding and reconciliation, as many migrants could not return home to support their families in a crucial time due to their work commitments, unfair work arrangements, and possibly due to a lack of funds.

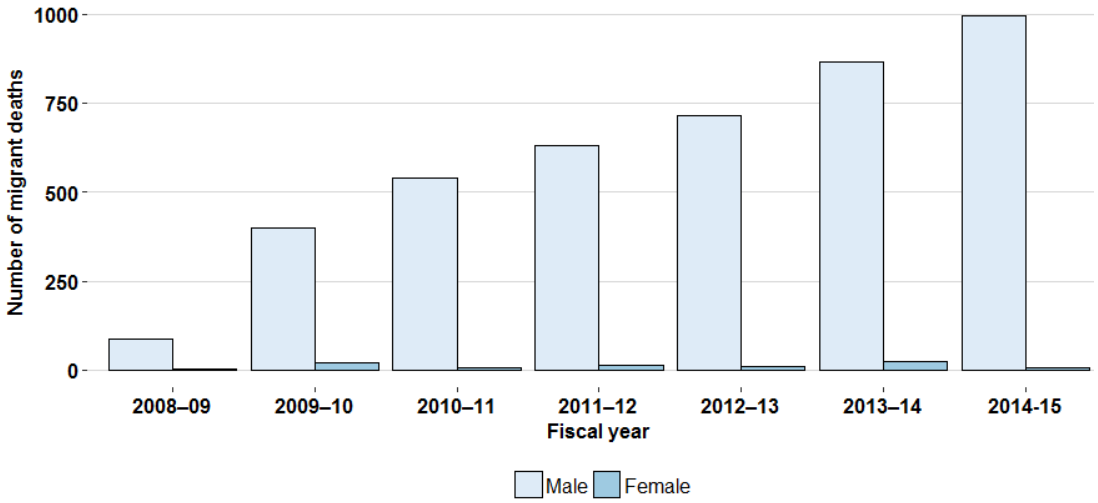
The income differentials between households with migrants and households without them suggests the increased likelihood of more households adopting circular migration in the future, especially to international destinations. Not all households however are in the position to send off

[8] Ministry of Home Affairs (MoHA)/National Emergency Operation Centre (NEOC) official figures for casualties and damages last updated on 5 June 2015.

a member to migrate. Households without at least one youth with a certain level of skill who is willing to migrate are unable to tap into the remittance sources. These households are at a risk as they continue to rely on existing in-situ livelihoods and in the absence of an external source of income, are prone to agricultural risks, especially to shocks from inter-annual variations in rainfall.

Migration also has a consequence on the socio-cultural aspects, both at the destination and at the source. The physical absence of household members for prolonged times causes shift in the internal labour dynamics of households. The division of household tasks among the remaining members can lead to increased pressure for the elderly and female members. Furthermore, the poor treatment of Nepali workers abroad, especially in the Gulf countries, highlights the safety concerns for migrants (International Labour Organisation 2016; Ministry of Labour and Employment 2014). With a rising number of Nepali out-migrants, the rate at which Nepali migrants are dying overseas has also risen (Figure 5.13).

Figure 5.13 Trends in death of Nepali migrants abroad 2008-09 to 2014-15.



Source: Constructed using data from International Labour Organisation (2016).

The trends in renewal of permits (see section 5.5) suggests that the vast majority of migrants are likely to be away from home for longer periods of time. As their contribution to the household income through remittances continues, they are not able to participate in traditional livelihood opportunities resulting in changes, particularly in labour-intensive agriculture. In fact, such changes are already occurring: respondents referred to hiring labour for agricultural work instead of exploiting communal means like labour sharing and neglecting some production opportunities. Other important aspects in relation to circular migration of Nepalis include feminisation of labour, governance structures, social networks, historical inclinations to migrate and shifts in culture. Although such factors have been mentioned in the discussion, they are not dealt in detail in this

thesis. Such micro-factors have been covered in recent literature such as—Bhandari (2004), Thieme (2010), Gartaula et al. (2012), Sijapati and Limbu (2012), and Sijapati et al. (2015),.

According to the 2011 census, 65 percent of Nepalis with SLC (grade 10) and above qualification were males (CBS 2012d, p. 27). Since the literacy rate for women is lower compared to men, their employment opportunities in the formal sector is limited. This also implies that if they opt for foreign employment, they are more likely to engage in low-skill work and be exposed to higher risks of exploitation.

5.4.1 Theoretical implications for migration theories from the Tarai case

The findings of this research are mostly in line with the available literature. There are however some key contradictions with the established theories, perhaps due to the unique nature of the cases pursued here. The findings are first compared with the principles of migration with the influence of climate change as outlined by Findlay (2011), discussed in Chapter 2, and with the principles outlined in other environment-led migration scholarships.

Agreeing with the principles, there is clear evidence from the Tarai that the short-distance moves are mostly utilised by the poorest, while those who can afford to do so have transitioned to long-distance destinations. Once the most popular destination among the Nepali migrants, India, has seen a decrease in number of in-migrants from Nepal despite rising Nepali out-migrants in general. Regarding the principle that longer distance moves will most likely be in the vicinity and follow long established destinations, the case of Tarai seems to be different. In fact, most migrants are opting for long distance moves to international destinations with no or few cultural ties. Moreover, the migrants themselves are relatively poor and almost all of them have no experience of extensive travel in their region, let alone international travel. In fact, Circular migration stemming from the Tarai shows that long distance international movements are not entirely out of reach for the poor. In fact, it is the poorer section of the society that is utilising these moves as they are unable to engage in local jobs. For most Tarai circular migrants working in international destinations, their first move involves for the first-time they travel to the capital city (being the host to the only international airport in the nation); the first time to be on an airplane; and the first-time overseas. First time migrants naturally find it difficult to comprehend the process getting through the airport control and often require assistance from other travellers in filling and signing of departure forms (Observation, various dates). And yet, they embark on journeys that take them to destinations for which they know very little, if anything, about.

By far, the clearest indication from the Tarai cases is the complexity of migration drivers and the arduous task of detecting the role of environmental factors. This is in line with the “multiple

causality" principle suggesting a range of drivers influences the complexity of migration choices. Although the environmental stresses observed in the Tarai can at times be directly and indirectly linked to the trends in out migration, the specific effect on livelihood options including migration needs to be disentangled from multiple drivers of change.

Following up further on principles introduced for environment-led migrations discussed in Chapter 2, people from poorer communities if they move, will often resort to irregular or illegal forms of migration. This does not seem to be the case in the Tarai if we consider that those with higher education do not migrate as much, and circular migration is entirely in the reach of the poorer communities. The poorest still follow traditional destinations to India, which does not require documentation, but the majority of the circular migrants go through formal channels. Understanding this shift in migrant destinations is vital information for policy and development planning, especially for the source country of Nepal. Grasping the relationship between the impact of environmental change on the agricultural sector and the subsequent migration streams arising from stressed livelihoods could also help in estimating the distribution of migrant flows (Findlay 2011). This may allow for better methods to assist migration linkages to secure livelihoods for communities, including those who are unable to send off a migrant member. The findings reveal that although migration stands as a promising tool for adaptation to socio-ecological change, the poorest members of the community and those with low human capital are more likely to be unable to access the types of mobility pathways that yield effective returns. Providing in-situ livelihood options remains essential, especially for the poorer sections of the community. It has been argued that the migration to India cannot be attributed to the expansion of global capitalism (Bruslé 2008), but the changing destination choices do favour international growth hubs, suggesting that the migrants are tapping into an emerging global migration industry. The popularity of international destinations begins to challenge the theories that imply that most movements by the poor will be within national boundaries, and is perhaps reflecting a new form of transnationalism in a global era (Findlay 2011).

The findings reveal that circular migration can result in long distance, international movements, and that such movements are sometimes utilised by the poorer sections of the society. In other words, pressures on local livelihood options from environmental and other socio-economic change drivers do not necessarily result in internal and short-term moves, but can involve long-distance circular migration in cases where such movements are accessible. Destination countries should continue to explore ways to improve migration policies both to meet the need of labour shortages, and also to facilitate positive development outcomes for source countries (Hugo 2012b).

5.5 Conclusion

As described in Chapters 4 and 5, agriculture and circular migration has become complementary livelihood activities for many Tarai households. The case agrees with many of the findings from recent migration literature. Firstly, Tarai residents themselves have a history of migrating, making them more likely to opt for foreign employment. For example, this agrees with the notion that those with a history of migration are more likely to move as a result of environmental change as outlined by Kniveton et al. (2008). In the Tarai (and in the whole of Nepal), migrating for employment has been established in the culture for some time. So much so, that migrating abroad and providing for the family is an established norm for able-bodied males (Aubriot 2010; Sharma 2013). These poor workers are not a part of a global cosmopolitan elite by any means, but they do form an increasingly important component of the transnational community. Secondly, it is theorised that better off and educated households primarily exploit international destinations (Findlay 2011; Massey et al. 1993), which is reflected in the differences in destination choices in the two study sites.

The early settlement days in the Tarai saw mass in-migration resulting in inevitable resource depletion. However, the migrants were able to utilise the land in order to exploit agriculture and livestock rearing. The Tarai at present faces further problems from broader socio-economic issues as discussed in Chapter 4 and from global environmental change, a topic which will be further discussed in Chapter 6, which further threaten to the resilience of the Tarai socio-ecosystem. The Tarai communities have always utilised mobility to balance the resilience with some success. Migration, especially in recent decades is playing a crucial role in managing the resilience of livelihoods in in the Tarai, and could become more important to adapt to the external driver of global climate change.

6. An assessment of global climate change impacts in the Tarai

6.1 Introduction

In previous chapters, the important elements of Tarai livelihoods have been introduced with the latter focus on the exploitation of temporary migration. Those livelihood systems are being altered by the external driver of climate change and projections suggest increased impacts in the future. This chapter looks at the patterns of changes in local climate in the Tarai from secondary data, compares those changes with the perceptions of locals and discusses the livelihood implications. The current coping and adaptation measures currently practiced by the locals to respond to climate change impacts are highlighted. Firstly, an overview of the changes in regional climate from the prevailing literature is provided. This is followed by the statistical analysis of trends in temperature and rainfall in the study sites using the indices defined by the Expert Team on Climate Change Detection and Indices (ETCCDI). Next, the findings from primary data on locals' perceptions of environmental change in the study sites are discussed. Descriptive statistics and chi-square (χ^2) tests were performed to examine the relationships between the perceptions and actual changes detected from statistical analysis. In addition, qualitative information using narratives of experiences shared by locals are provided to describe the perception of change as witnessed by locals. Some adaptation measures observed in the study sites are discussed as examples of current actions to deal with climate variability and change, as well as broader environmental issues. Overall, changes in climate are poised to further affect the already fragile balance between the Tarai communities and their surrounding environments in non-linear ways. Consequently, the risks to the quality of local environmental systems and the associated in-situ livelihoods of the people are being amplified. It is possible to anticipate that environmental risks are going to be more problematic in the future, changing the ways that migration or ex-situ adaptation methods will be exploited.

6.2 Humans, climate and the environment

The climate of a place refers to the general weather conditions observed over a long time-frame, usually three decades or more. Climate differs from “weather” which refers to the immediate condition of meteorological elements over a short time frame of a few days to weeks. Since the climate of a place is based on statistical analysis of the records, it is an abstraction of average conditions and is often detached from everyday experiences of people residing at the place. Human life has always been influenced to some degree by the changing climate and the immediate environment. On the other hand, humans have modified the local and global climates through their actions. This interaction between humans and natural systems is central to the

conceptualisation of climate. For Tarai residents, the climate is perceived through relationships with the seasons and climatic hazards, through the lens of their livelihoods and culture. Environmental resources like forests, rivers and other water sources also have significant cultural meanings in Tarai culture, such that many cultural sites like shrines and temples are situated in areas where key environmental resources are found (Plate 6.1). Resources such as the forest and water sources are idolised and revered, especially by the Tharu communities, the original settlers of the Tarai prior to 1950s (Müller-Böker 1991, p. 112). Natural resources have important ceremonial roles in the local culture: river banks are cremation locations among Hindus; funeral pyres utilise firewood from local forests; bathing rituals in rivers are carried out during festivals such as the *Chhath* celebrated on the 6th day of the month of *Kartik* (October-November). Extracts from indigenous plants are also commonly used to treat a variety of illnesses in humans and livestock by Tarai communities (Dangol & Gurung 1991). The Tarai forest also provides raw materials for building traditional constructions and essential edible items (Müller-Böker 1991, p. 108). Climate is also often tied to the local religious belief—certain events like the changing of the seasons, drought periods, solstices etc. are marked in cultural calendars and celebrated. For example, the onset of rainfall, the beginning of planting season, and harvest times are marked with important festive celebrations. Hence, a change in local weather patterns can be expected to be recorded in the cultural memory.

Plate 6.1 Left: A shrine belonging to the indigenous Dhimal community surrounded by trees (Damak). Right: Students at a secondary school in Dhangadhi gathered to celebrate Shreepanchami festival on the fifth day of spring 20 Magh 2070 BS (4 Feb 2014).

Source: Field Survey 2013-14.

"Climate variability" refers to the changes in climate that are within the normal range of extremes for a certain place as indicated by temperature, precipitation, and frequency of occurrences.

> Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability). (IPCC 2013, p. 1051)

The climate of a place varies over seasons and over years as opposed to weather which varies daily or over shorter durations. Any changes in weather conditions are easier to perceive due to the short time span of such changes. Climate change on the other hand is harder to perceive—although a particularly different season is likely to be noticed. For example, interviewees and respondents of the survey recalled previous seasons to provide evidence of their assessment of climate variability. The actual perception of climate by humans occurs over relatively short time frames—4-5 years instead of decades. Incidents of impacts from short-term variability on current climate are more likely to be ingrained in people's memory. Therefore, many respondents also described their perceptions of changing climate in reference to their experiences of extreme events. To complement these observations, climate variability can be measured by comparing the deviations of climate indicators such as temperature and precipitation compared to long-term average values. For this research, a three-decade window of daily records is used to compute climate variability.

"Climate change" refers to a certain and consistent change in the mean state of the climate or its variability.

> Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. (IPCC 2013, p. 1450)

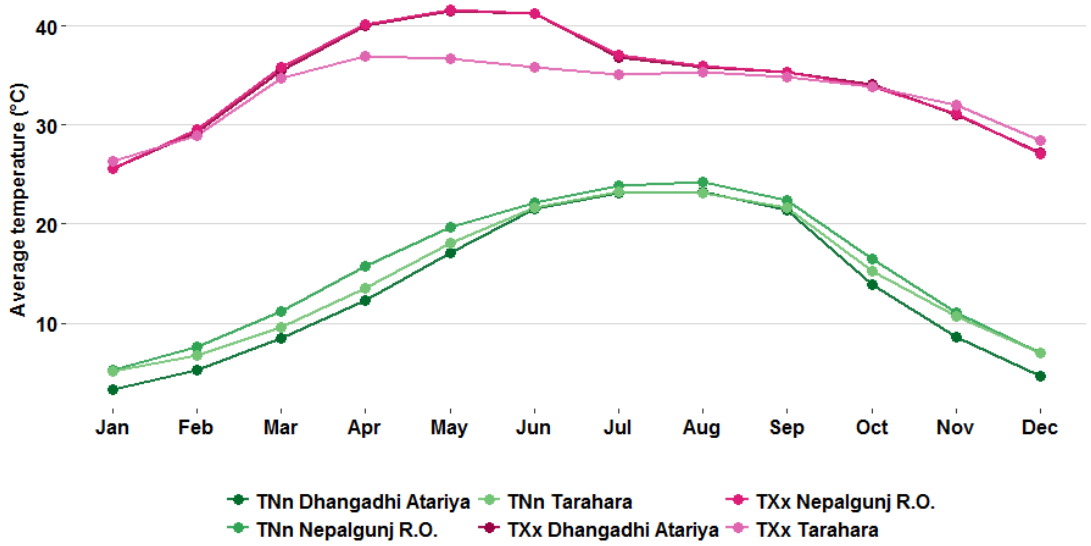
It is fundamental to describe the variation in temperature and rainfall before discussing the perception of locals regarding impacts from such climatic changes to their livelihoods. Changes in climate are detected in terms of deviations in climatic indicators observed through analysis of long-term records. Evaluating climate change at local and regional scales is essential for understanding localised impacts and for adaptation planning.

6.3 Physical aspects of the Tarai climate

Rainfall distribution in Nepal can be categorised into four distinct seasons—Pre-monsoon for the months of March to May, Monsoon for the months of June to September, Post-monsoon for the month of October, and Winter for the months of November to February (Nayava 1974 cited in Nayava 1980). The general classification of annual cycles into four seasons closely resembles the above categorisation except for November, which is classified as Post-monsoon instead of winter. For seasonal analysis, the general definition of seasons as indicated by calendar months is followed here, i.e. 1) Pre-monsoon for the months of March to May, 2) Monsoon for the months of June to September, 3) Post-monsoon for the months of October and November, and 4) Winter

for the months of December to February. The climate of the Nepali Tarai is characterised by heavy monsoonal rainfall and marked summer—winter differences, but has significant spatial variations. Figure 6.1 illustrates the pronounced differences in summer months on the monthly maximum value of daily maximum temperatures averaged from the 1980-2013 period. Broadly speaking, the daily minimum temperatures are similar across the region, whereas western Tarai experiences more extreme heat during the summer. The summer minimum temperatures peak around July-August with a similar pattern across the three stations. The winter minimum temperatures are markedly lower at Dhangadhi, albeit by a small amount.

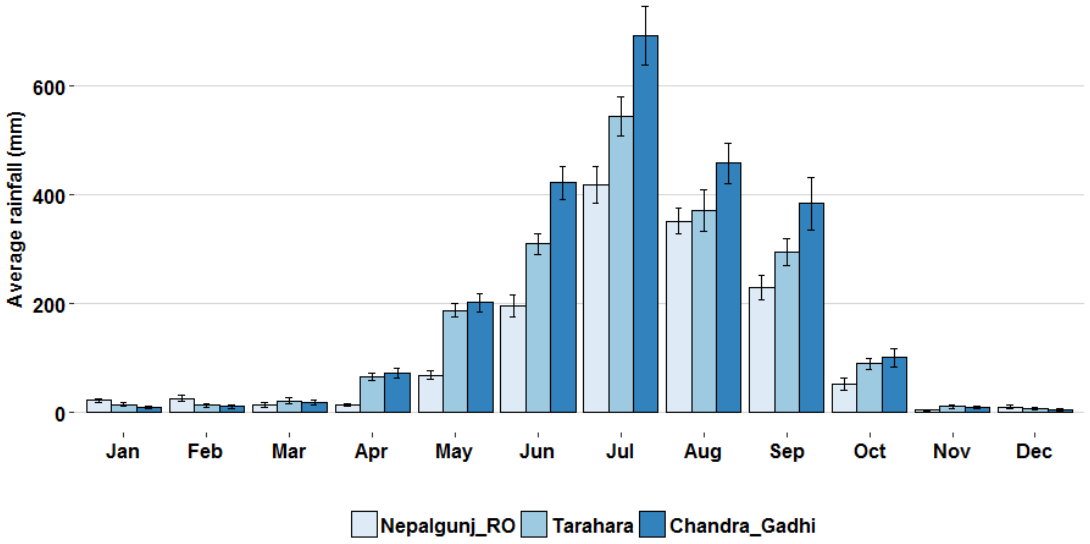
Figure 6.1 Long-term average of monthly maximum value of daily minimum temperature (TXx) and monthly minimum value of daily minimum temperatures (TNn) at three stations.



Source: Constructed from unpublished DHM records.

At the two ends of the Nepali Tarai, Tarahara and Chandra Gadhi stations receive significantly more rainfall than the Nepalgunj station during monsoon and pre-monsoon months (Figure 6.2). The Indian monsoon enters the country from the east and generally reaches the western Tarai a few days later. During winter months however, the Nepalgunj station on the west receives more rainfall.

Figure 6.2 Long-term average of monthly total rainfall at three stations in the Tarai.



Source: Constructed from unpublished DHM records.

Trend analysis of long-term recorded temperatures in the region have revealed a general warming in the region, with conflicting reports regarding rainfall. Further rainfall and temperature characteristics and trends are discussed in detail in latter sections of this chapter. The climate and the local environment are only a part of the Tarai socio-ecological system. Direct effects of the environment are mediated by the socio-economic situations of the subject and can translate into different outcomes at community, household and individual levels.

6.4 Integrating climate data with local perceptions

In recent decades, large scale gridded reanalysis data have increasingly become essential sources for the analysis of temperature and precipitation, especially in areas with few ground based measurement stations. However, such estimates are partly based on interpolation of ground data, and the density of in-situ ground stations impacts the accuracy of the gridded data. For instance, for South Asia, the Asian Precipitation-Highly Resolved Observational Data Integration Towards Evaluation of Water Resources (APHRODITE) dataset is one of the most detailed reanalysis available at a resolution of 0.5˚ × 0.5˚ grids is based on 5,000 to 12,000 ground stations over Asian landmass (Yatagai et al. 2012), but the quality of the data would be impacted by the paucity of ground measurements as in the case of the Nepali Tarai. Data from satellite observations are also commonly used for climate data analysis, but are not free from uncertainties due to the imperfect correlation between remotely detected data and actual rainfall received on the ground; gaps in frequency of detection; and other atmospheric effects on rainfall (Bitew & Gebremichael 2011). Comparison of rainfall from reanalysis datasets to ground

observations have revealed that they do not often overlap but are still invaluable for large scale analyses (Diro et al. 2009; Jury 2009; Tong et al. 2014).

In a limited data scenario, it is helpful to integrate available physical data with public perception and response options. Gaining people's perception helps hone in on exact issues at the local level. Such an exercise can also highlight the impacts that have already been experienced and the manner which multiple factors mediate the ultimate impact based on household characteristics. Documenting perceptions from locals is an essential aspect of adaptation planning. Primary experiences gained from locals provide insights into how climate change and variability are embedded into their customs and livelihood actions (Hulme 2012; Vedwan & Rhoades 2001). For that reason, in this research the physical climate change data derived from local secondary data and peer-reviewed research are combined with primary data on local perceptions and experiences to triangulate understanding of the impacts and response capabilities.

Using perceptions to compare with the results of climate data analysis however is not without caveats. When there is a mismatch between the perceptions and the data, the reasons can be convoluted and demand further exploration (Opitz-Stapleton & MacClune 2012). In this chapter, the perceptions from locals are discussed and evaluated in relation to the overall socio-ecological context of the study sites. Besides serving as a comparison to physical evidence on climate change, qualitative data from perceptions have also served to provide insights into social understandings of the environment.

6.5 Climate variability and change in the region

Global climate change will have variable impacts across Nepal. Although much of Nepal is impacted by the same Indian monsoonal system, there are distinctions in climate between the three ecological zones. Much of the high Mountains remain snow-covered throughout the year whereas in some districts in the Tarai, summer temperatures rise to over 40°C. Analysis of long term trends reveal that the global climate is changing at an accelerated rate in the late 20th and early 21st century compared to the past millennium (Hartmann et al. 2013). Anthropogenic activities which cause changes to atmospheric concentrations of greenhouse gases (GHGs) have proven to be responsible for much of the unprecedented changes (Hartmann et al. 2013). Direct impacts of environmental change are being experienced globally through increased incidents of heat waves, droughts, increased extreme rainfall events and rapid melting of glacial ice (Christensen et al. 2013). There are also numerous indirect impacts of environmental change on societies in terms of risks to health, well-being and livelihood security. The complexities of global climate systems mean that not all regions experience the same changes. Moreover, the impact is

mediated by the socio-economic status of the community. Hence, broad claims of quantifying climate change often mask the underlying spatial variability in countries such as Nepal. At the same time, communities across the world are responding to local and regional effects of climate change in different ways. The Himalayan region in particular has been regarded as having higher than average global rates of warming (Shrestha et al. 1999b; Shrestha et al. 2012) and understandably, much of the research on climate change in Nepal has been concentrated on the High Mountains. In contrast, there is a dearth of research exploring the complexities of environmental change in the Tarai region of Nepal.

Climate change is one of the foremost important challenges of modern times. There is an overwhelming consensus among scientists that the climate is changing globally and the change will prevail in the foreseeable future due to the inertia of responses to increased GHGs in the atmosphere and further inputs from anthropogenic GHG emissions (Christensen et al. 2007; Christensen et al. 2013; Hartmann et al. 2013). Climate change is also expected to alter the pattern of weather related events such as storms, droughts, extreme rainfall and heat waves in many places. Globally, average rainfall is reported to have increased, however, certain areas like the tropics for instance, have exhibited no significant change in rainfall (Hartmann et al. 2013). Christensen et al. (2013) report an increasing trend of mean precipitation and extreme rainfall events for the monsoonal Asia region. A review of the regional climate research reveals significant spatial inconsistencies. Zhang and Zhou (2011) identify significant decreases in monsoon precipitation in much of the northern hemisphere between 1901-2001, while Jain et al. (2013) suggest that precipitation patterns lack any trends for North-East India over the period of 1871 to 2008. Duncan et al. (2013) claim evidence of decreasing precipitation extremes in Nepal, however, for the Tarai, they suggest no clear precipitation trend. Analysis of monsoon rainfall from India and Pakistan also reveal no significant long-term trend (Kale 2012, p. 1116). All of this suggests significant uncertainty regarding the exposure of the Tarai to rainfall changes.

The meaning of the term “climate change” within any local context may be different to the actual observed changes in weather patterns, as highlighted by Marino & Schweitzer (2009) in the case of Alaska. In this research, rather than asking directly about climate change, the household questionnaires aimed to analyse community experiences of climate and how people think it has evolved and influenced their livelihoods over the years. Many studies have shown that communities with a heavy dependence on natural resources, and farmers in particular, are aware of changes and variability in climate and use traditional knowledge to minimise the impact on their livelihoods e.g. Vedwan and Rhoades (2001); Chaudhary and Bawa (2011) and Bardsley and Wiseman (2012). Yet, local perception of changing climates, and environmental conditions more

broadly, do not always reflect reality (Carr 2005a; Mbow et al. 2008). What constitutes an "environmental problem" itself is relative (Meze-Hausken 2000b) and adaptation response actions are based on cultural and personal conceptualisations of the threat (Hulme 2008a). Data gathered from engaging with locals can be vital in augmenting climate analysis studies and can enhance the resolution of climate projections (Macchi et al. 2014, p. 2). Thus, perceptions of climate change can play a crucial role in filling gaps in scientific records, as is the case of the Tarai. In this case, primary data gathered through interviews, questionnaire survey and field visitations is used in conjunction with the long-term physical climatic records to paint a picture of the challenges to Tarai livelihoods.

The warming trend over high altitude areas, particularly in the high latitude and the mid-latitude mountains in Asia, far exceeds global averages, and even faster rates of change are projected for the future (Nogués-Bravo et al. 2007). The inter-annual variability of temperatures in the Swiss Alps was also found to be higher than global averages (Beniston et al. 1997). Similar higher than average rising temperatures in the Himalayas have been documented by many studies (Chaulagain 2006; Diodato et al. 2012; Lemke et al. 2007; Sheikh et al. 2015; Shrestha et al. 1999b). As with rainfall, most rainfall studies in Nepal are inclined towards the Himalayan region [e.g. Armstrong (2010), Prasad et al. (2009), Song et al. (2015), Sveinbjörnsson and Björnsson (2011), Wang et al. (2013), Wiltshire (2013); Xu et al. (2007), and Zhang et al. (2015)], with only the occasional study focusing on the Tarai region—e.g. Bhatta and Aggarwal (2015), Devkota (2014), Manandhar et al. (2011) , Paudel et al. (2014), Shrestha et al. (2000), and Shrestha et al. (1999b). Additionally, much research uses mean values to compute trends. It could be argued, however, that the exploration of extreme events such as drought days and heat wave periods require the analysis of daily data (Alexander et al. 2006). Very few studies have explored trends in climatic extremes for the Tarai with an exception being work by Duncan et al. (2013). For that reason changes in climate extremes have been analysed here using standard climatic indices.

6.6 Quantifying climate change

This section outlines the findings from analysis of climatic data and discusses the trend statistics. The livelihood implications of these findings will be discussed in the next section in relation with the local perception data.

6.6.1 Rainfall characteristics at study sites

According to long-term daily data, most of the Tarai's rainfall occurs during the monsoon season, with around 80-85 percent of yearly rainfall experienced from June to September (see Table 6.1; Figures 6.3 & 6.4). At each of the three stations, there is a huge inter-annual variation in the

amount of rainfall received in each of the three stations (Table 6.2). For instance, Nepalgunj Regional Office station receives an annual total averaging 1,413 mm (*s* = 345 mm), but in 1994 it received only 867 mm, while in 1981 it received 2,173 mm.

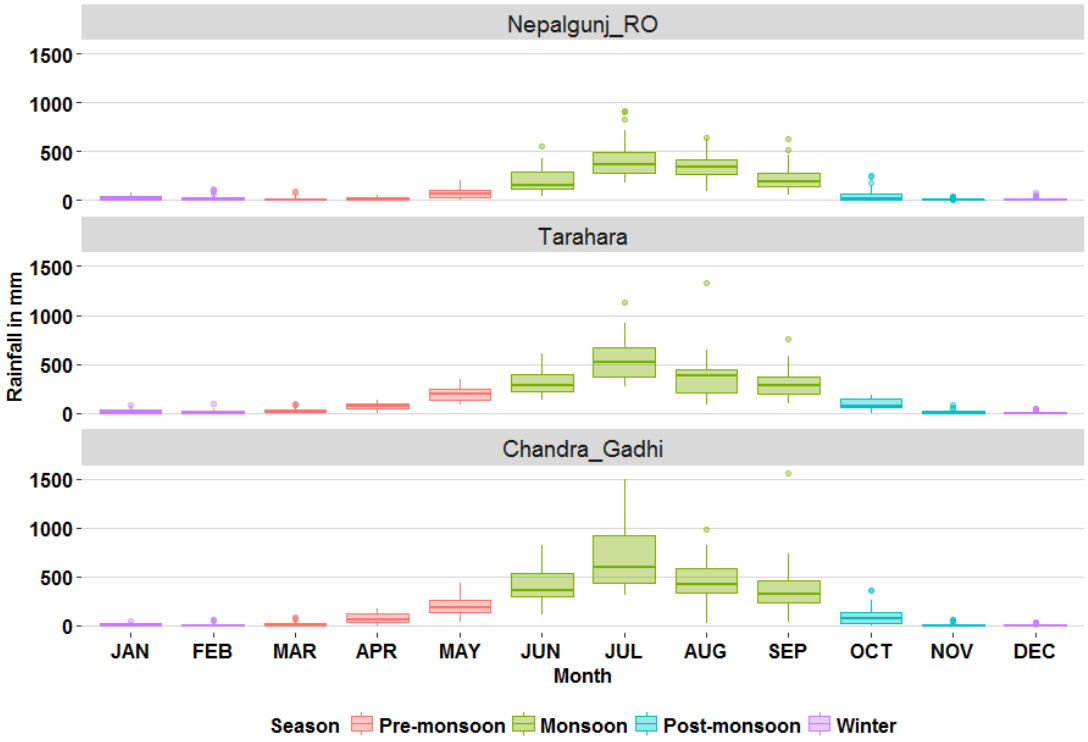
Table 6.1 Summary of rainfall characteristics at three stations in the Tarai.

Station	Annual total			Monsoon total				Winter total				Daily maximum
	Mean	Min	Max	Mean	Min	Max	% of annual mean	Mean	Min	Max	% of annual mean	
Nepalgunj Regional Office	1,413	867	2,173	1,198	707	1,969	84.81	64	0	153	4.53	280
Tarahara	1,938	1,264	2,820	1,522	916	2,428	78.55	48	0	188	2.46	378
Chandra Gadhi	2,391	1,495	3,591	1,959	1,121	3,156	81.91	37	0	106	1.54	381

Source: Constructed from unpublished DHM data.

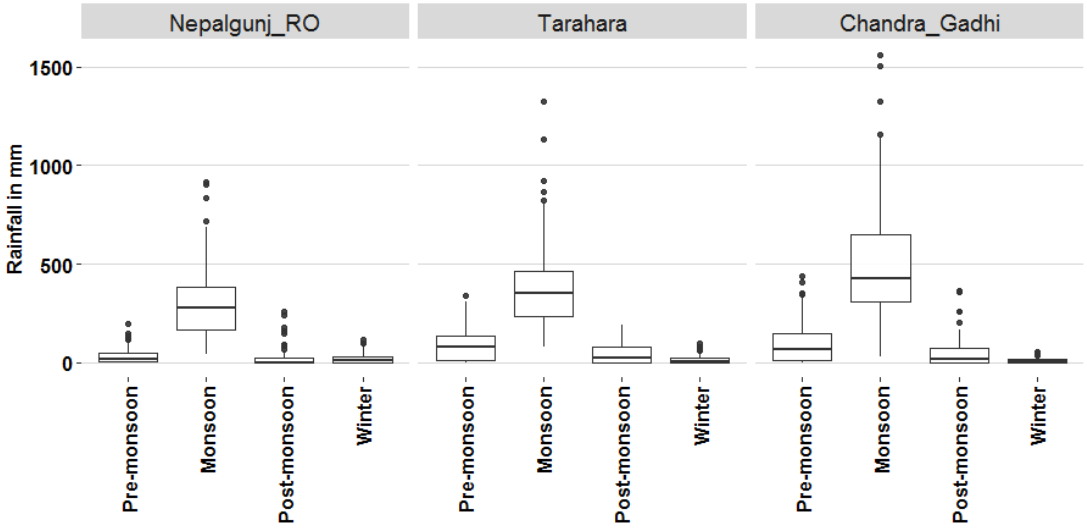
Out of the three Tarai stations, Chandra Gadhi station receives the highest average annual rainfall. However, Nepalgunj Regional Office station receives more rainfall during winter months than the eastern stations. There is a large inter-annual variation in winter months, with each station receiving virtually no rainfall at all during some winter seasons. For example, in 2008 Nepalgunj Regional Office received no effective rainfall.

Figure 6.3 Variation in monthly total rainfall across three Tarai stations.



Source: Constructed from unpublished DHM data

Figure 6.4 Variation in total seasonal rainfall across three Tarai stations.



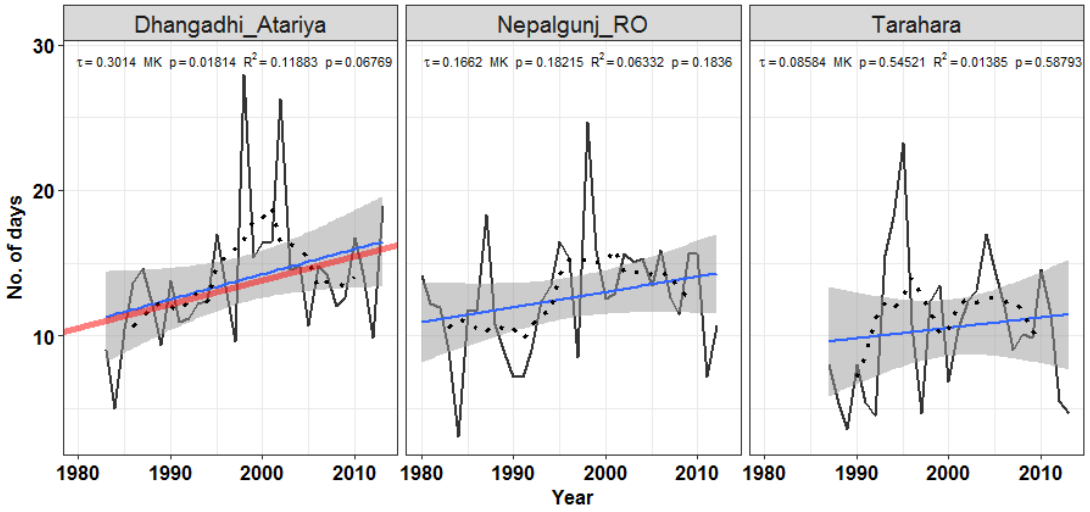
Source: Constructed from unpublished DHM data.

According to the data, pre-monsoon and monsoon rainfall are significantly higher in the eastern Tarai. The median pre-monsoon rainfall in Tarahara and Chandragadhi are more than double the median for Nepalgunj. The difference is not very significant during post-monsoon although the median for Nepalgunj is still lower than Tarahara or Chandragadhi. This extra rainfall provides farmers in western Tarai with a unique window for winter crops.

6.6.2 Trends in heat extremes

The changes in heat extremes are indicated by the TXx, TXn, TN90p, TX90p, SU25 and TR20 indices. The monthly maximum values for daily maximum temperature (TXx) show an increasing trend for Dhangadhi and Nepalgunj stations, but are decreasing in Tarahara. However, the rates of such changes are minimal and the increases are not statistically significant. On the other hand, monthly minimum values of daily maximum temperature (TXn) at all three stations are decreasing, although only the decline for Tarahara is statistically significant (MK p=0.0691). The analysis of the 90th percentiles of warm nights (TN90p) shows an increasing trend (Figure 6.5), but only the increase at Dhangadhi is significant with an increase of 5.9 warm nights per decade (MK p=0.0181). In the case of the 90th percentiles of warm days (TX90p), no significant trends are observed. The results of the analysis of both warm and cool days and nights suggests that the warming in night-time temperatures has to date been greater than for daytime temperatures in the eastern and western Tarai. The trends however are not consistent across the three stations.

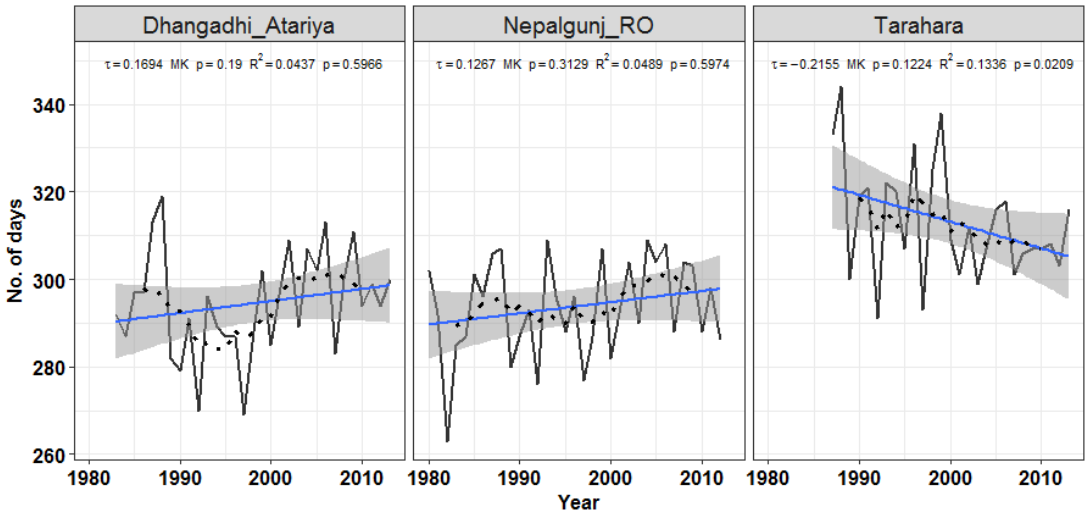
Figure 6.5 Temporal evolution and trends for 90th percentile for warm nights (TN90p) at three stations in the Nepali Tarai.



Source: Constructed from unpublished DHM data.
Note: Dotted black lines represent seven year moving average. Thin blue straight line represents linear regression trend. The shaded region represents a 95 percent confidence interval for the linear model. Thick red straight lines, which are only shown when MK trend is significant, represent trends based on Theil-Sen slope estimates.

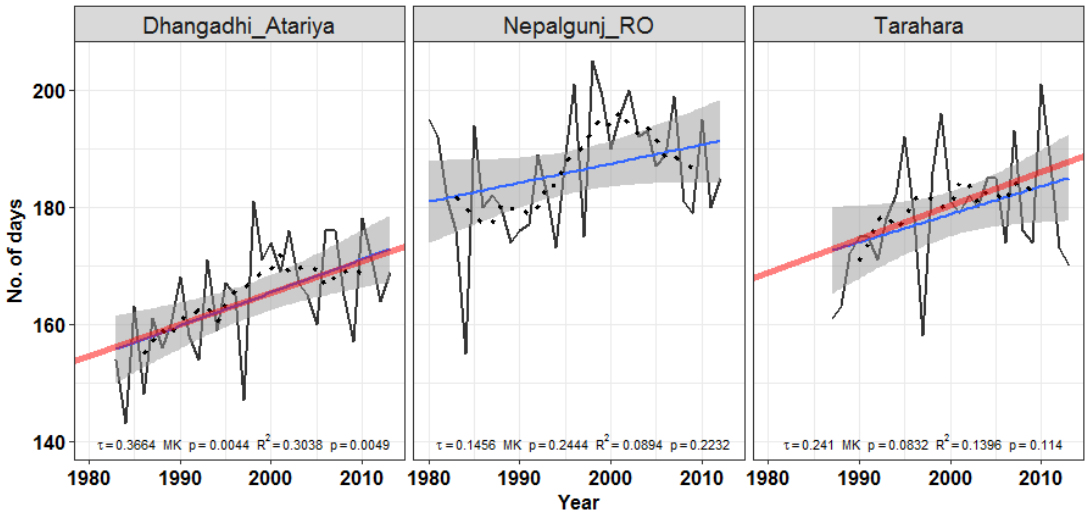
The changes in the number of summer days, defined by the number of annual days with maximum temperatures reaching 25°C or higher (SU25), vary between the stations with no significant trends (Figure 6.6). On the other hand, the tropical nights, which are indicated by the days with daily minimum temperatures over 20°C (TR20) have increased in all locations (Figure 6.7). The finding shows a clear decrease in summer nights in the east, whereas tropical nights are increasing at a similar rate of 5.3 to 5.7 days per decade at two stations, but changes in Nepalgunj are not statistically significant. This translates into an increase of more than two weeks of warmer nights over three-decades which might be expected to be noticed by people experiencing the climate during this period.

Figure 6.6 Temporal Evolution and Trends for summer nights (SU25) at three stations in the Nepali Tarai



Source: Constructed from unpublished DHM data.

Figure 6.7 Temporal Evolution and Trends for Tropical Nights (TR20) at three stations in the Nepali Tarai



Source: Constructed from unpublished DHM data.

6.6.3 Trends in cold extremes

The changes in cold extremes are indicated by the TNx, TNn, TN10p and TX10p indices. The monthly maximum values of daily minimum temperatures (TNx) have increased at all stations, however only the increases for Tarahara (MK *p*=0.0338) are statistically significant. Monthly minimum values of daily minimum temperatures (TNn) have also increased significantly at all locations, with the highest rate of increase at Dhangadhi (0.0357°C per year). These rates of increase in temperature are analogous with the globally averaged trend of 0.024 to 0.0267 °C per

year from 1879 to 2012 as summarised by Hartmann et al. (2013). Trends of the 10th percentile of cool days (TX10p) and cool nights (TN10p) show that only the 10th percentiles of cool nights are significantly decreasing, with the rates of decrease generally similar for Dhangadhi: -2.7 percent (10.0 nights) per decade (MK *p=0.0002*) and Tarahara: -2.2 percent (8.0 nights) per decade (MK *p=0.0285*). The decrease in the number of cool nights at Nepalgunj is lower than other stations (-1 percent or -3.7 days per decade) and is not significant.

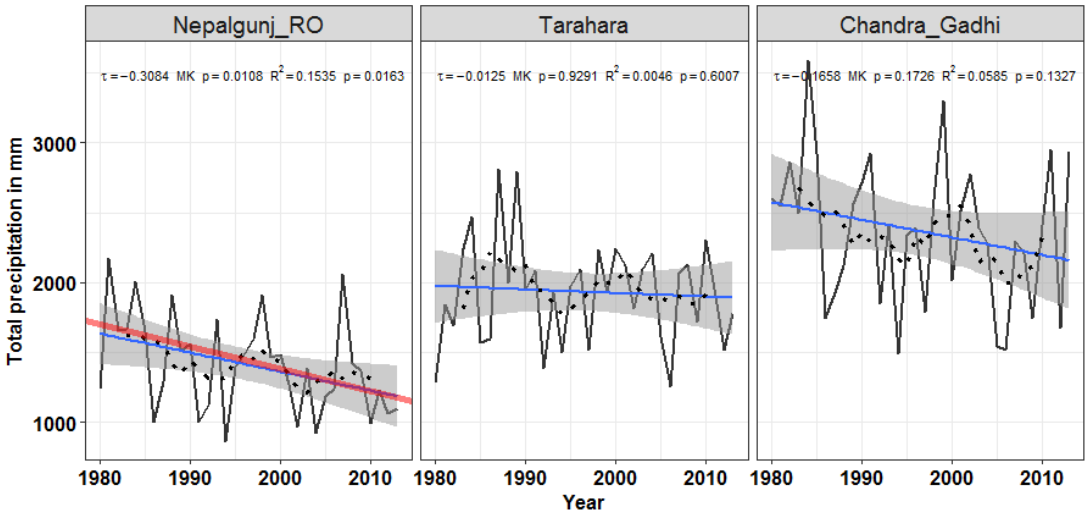
6.6.4 Trends in temperature variability extremes

The variability in daily temperature extremes are measured by the daily temperature range (DTR) which records the absolute difference between the extremes as indicated by daily maximum and minimum temperatures in a 24-hour period. The analysis of DTR shows a decreasing trend of -0.0166°C per year (MK p=0.0526) at Dhangadhi, by -0.0107°C per year (MK p=0.0526) at Nepalgunj and by -0.0316°C per year (MK p=0.0001) at Tarahara. Once again, the trend in daily temperature suggests that the minimum temperatures in the Tarai are increasing more rapidly than the maximum temperatures, thereby narrowing the DTR. A smaller DTR means that a person is exposed to less variable temperatures in a 24-hour period. The values, although significant, are very small and the actual impact on day-to-day life may not be detectable.

6.6.5 Trends in rainfall volume

The changes in precipitation patterns as indicated by RX1day, RX5day, SDII and PRECPTOT are not as pronounced as the trends seen in temperature extremes. The monthly maximum single day precipitation (RX1day) shows significant decreases (MK *p*=0.0325) only at Nepalgunj. In contrast, the monthly maximum five-day precipitation (RX5day) trend is only significant at Chandra Gadhi (MK *p*=0.0289), again, with a small magnitude. The Simple Daily Intensity Index (SDII), which is a sign of the relationship between annual total precipitation and the number of rainy days, reveals a decreasing trend. The annual total precipitation (PRCPTOT) shows a significant decrease at Nepalgunj with 55.9 mm per year (MK *p*=0.0108), but other two stations do not exhibit any significant trends (Figure 6.8). This suggests that while there is no significant change in total rainfall volume in eastern stations, the rainfall is being experienced in fewer days annually suggesting intensified rainfall and a contraction of the duration of the monsoon which is vital to Tarai's agriculture and associated livelihoods. In Nepalgunj, the decline in total rainfall volume is considerable and demands further exploration in terms of trends in days with rainfall and season-specific trends.

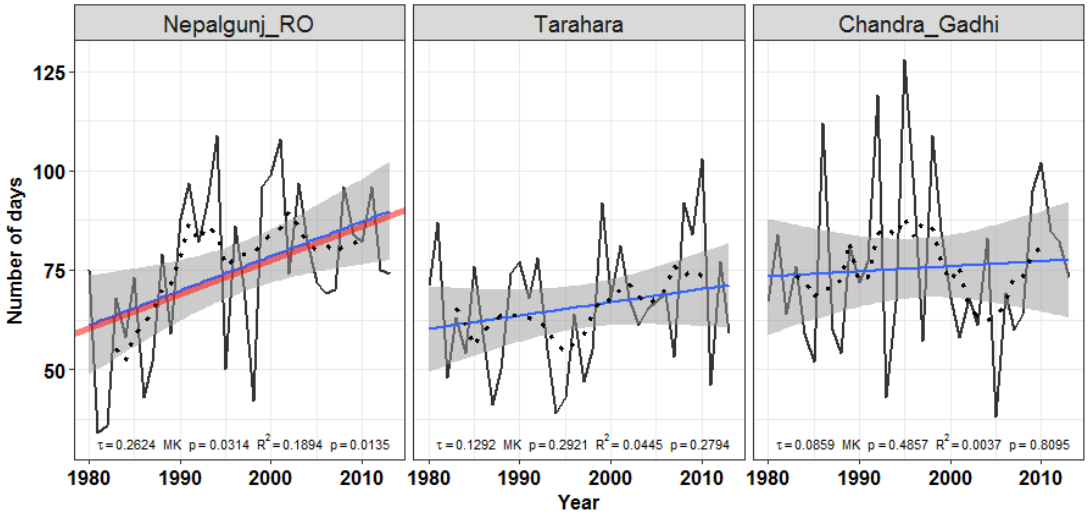
Figure 6.8 Temporal evolution of PRCPTOT in three Tarai stations



Source: Constructed from unpublished DHM data.

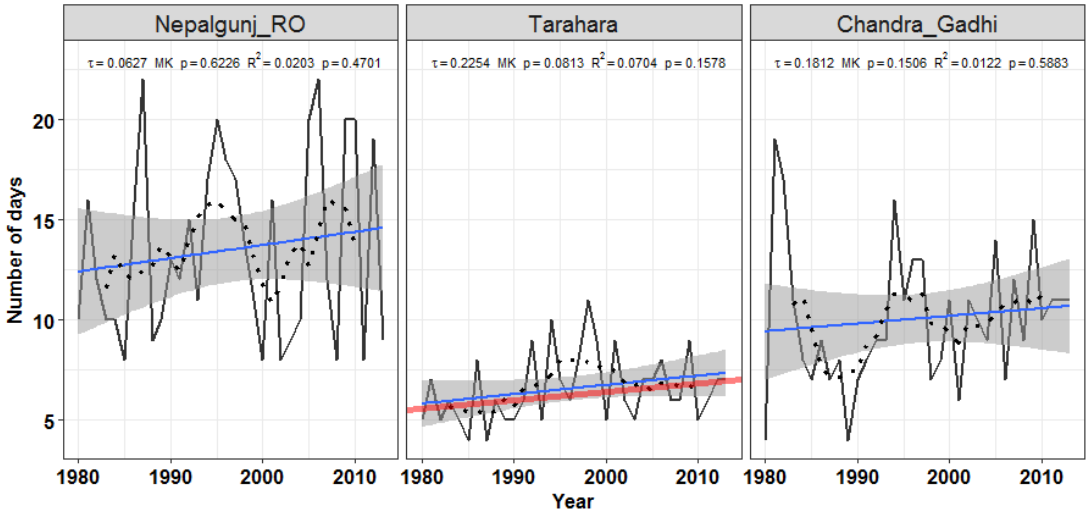
Consecutive dry days (CDD) in the Nepali Tarai have increased over time, with higher numbers of consecutive dry days towards the west of the region (Figure 6.9). At Nepalgunj, the rate of increase of CDD is 8.5 days per decade (MK *p*=0.0314), while increasing but insignificant trends have been experienced at Tarahara and Chandra Gadhi. While CDD have increased at all stations, consecutive wet days (CWD) have decreased for all of the sampled stations with a higher magnitude in the east, but none of the changes in CWD are statistically significant. Consecutive dry days for monsoon (CDDm) show an increasing trend across all three station (Figure 6.10). The increase of CDDm at Tarahara is still small, at 0.4 days per decade (MK *p*=0.0813). The increase in CDD and the decrease in CWD indicate an increase in periods of rainfall deficits in the Nepali Tarai especially in the eastern Tarai, with significant implications for paddy production. The analyses of Very Wet Days, 95th percentile (R95p) and Extremely Wet Days, 99th percentile (R99p) all indicate no significant trends, although all exhibit decreasing trends.

Figure 6.9 Temporal Evolution of Consecutive Dry Days (CDD) at different Stations of Nepali Tarai.



Source: Constructed from unpublished DHM data.

Figure 6.10 Temporal evolution of consecutive dry days during monsoon (CDDm) at three stations in the Tarai.



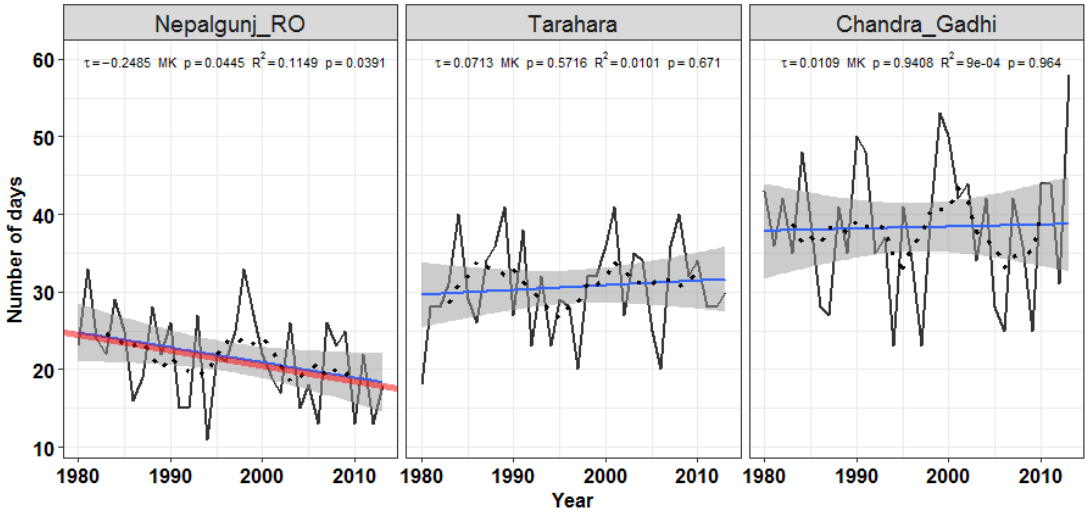
Source: Constructed from unpublished DHM data.

6.6.6 Trends in Extreme Rainfall Events

In this study, extreme rainfall events with four different thresholds were analysed. The number of rainy days with rainfall of 10 mm and above (R10) is decreasing at Nepalgunj and at Chandra Gadhi, but increasing at Tarahara. Nevertheless, none of these changes were significant statistically. The trends in days with 20 mm and above rainfall (R20), 50mm and above rainfall (R50), and days with 100 mm and above rainfall (R100) do not exhibit any uniform trends (Figure 6.11 and 6.12). Only some cases, such as R50 at Chandra Gadhi, which is decreasing at 0.1818

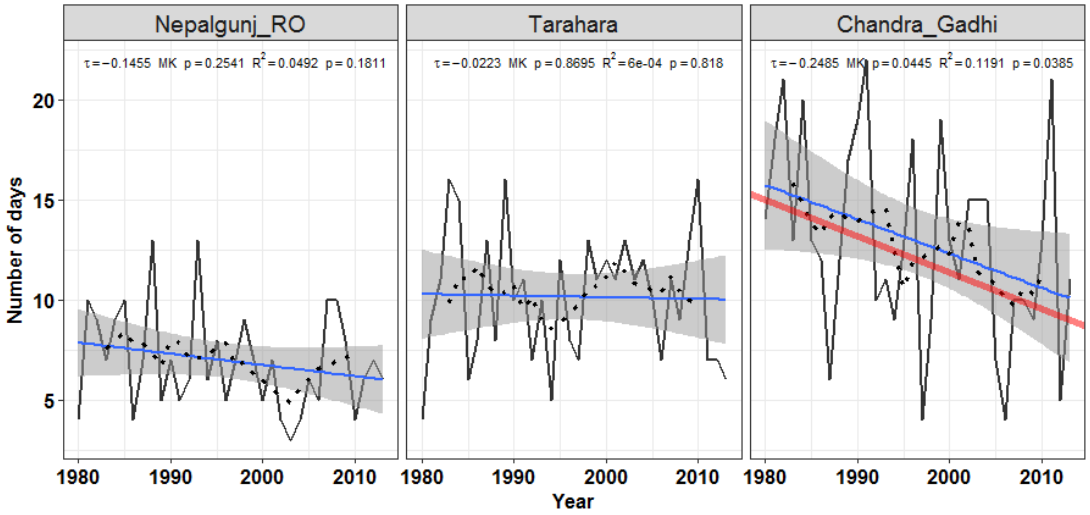
mm yr^{-1} (MK p=0.0445), and R20 at Nepalgunj, which is decreasing at 0.2000 mm yr^{-1} (MK p=0.0445), appear statistically significant (See Appendix H for details for all stations).

Figure 6.11 Temporal evolution of R20.



Source: Constructed from unpublished DHM data.

Figure 6.12 Temporal Evolution of Very Heavy Precipitation Days (R50) at different Stations of Nepali Tarai (1980-2013).



Source: Constructed from unpublished DHM data.

6.6.7 Analysis of dry spells

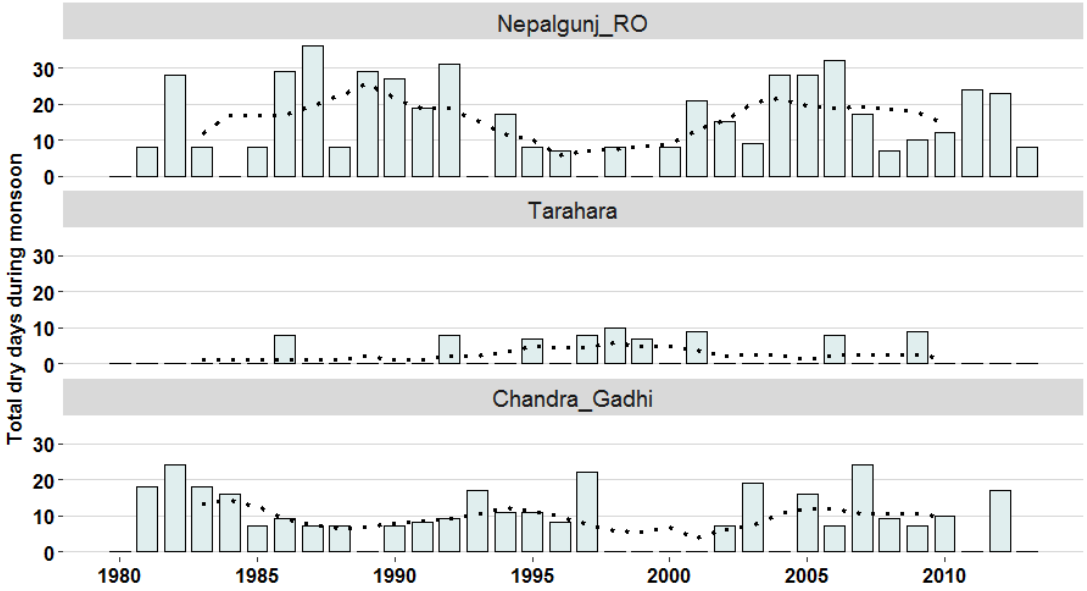
While the ETCCDI defined indices such as CWD and CDD give some indication of rainfall quantity, or lack thereof, the analysis of dry spells during the monsoon is arguably a better measure of the impact on agriculture, and especially paddy production. In this section, temporal trends in total dry spell days and number of dry spells per monsoon are analysed. Generally, a dry spell is a certain number of consecutive days without rainfall during a period when rainfall is

crucial for crop germination or growth. Based on the germination and growth pattern of the most popular crop, paddy, a dry spell in the Tarai can be defined as at least seven consecutive days of no rainfall after the commencement of monsoon in the next thirty days (Karmacharya 2010). A "no rainfall day" or "dry day" is defined as a day with less than 0.85 mm of rain. If it drizzles but the amount of rainfall detected is below 0.85 mm, then the day is classified as a dry day. If, in the thirty days after a successful onset of monsoon, there is no occurrence of a single dry spell then the period is classified as a successful plantation period.

The onset of the Indian monsoon depends on various factors besides rainfall amounts (Devkota 1984), and the calculation of the exact onset dates is complicated. There are however, simplified ways to confirm monsoon onset dates using only total rainfall records. For this purpose, the definition of the onset of monsoon is taken as any rainy day that occurs after 1 June with total rainfall in three consecutive days exceeding 30 mm (see Karmacharya (2010) and Upadhyay (2010) for a more detailed explanation). Again, the threshold for a day to be counted as a rainy day is 0.85 mm. There are other variations of this method using different thresholds which give slightly different results. However, for this study, the thresholds of 30 mm for a three-day rainfall and 0.85 mm as a minimum indication of rainfall have been used throughout.

Analysis of total number of dry days during the monsoon does not reveal any significant trends (Figure 6.13). As discussed earlier, generally, the eastern Tarai receives more rainfall than the western Tarai. Moreover, the eastern Tarai also has more rain-days compared to the western Tarai: there are sixty-three and sixty-eight wet days in Chandra Gadhi and Tarahara respectively, compared to forty-seven wet days during the four months of monsoon in Nepalgunj. Nepalgunj regularly has a larger number of dry days during the monsoon. This suggests that Nepalgunj farmers are more in need of irrigation for paddy plots compared to the eastern Tarai, especially when taking into account the significant decline in total volume of rainfall in Nepalgunj as revealed by trends in PRCPTOT and R20 indices (Sections 6.6.5 and 6.6.6).

Figure 6.13 Temporal evolution of total number of dry days during monsoon at three stations in the Nepali Tarai. Dotted line represents 7-year moving average.



Source: Constructed from unpublished DHM data. Dotted lines show seven year moving average.

A closer scrutiny of good rainfall days and dry-spell occurrences was also carried out for all monsoon months in the dataset. Analysis of total dry-spell days and number of dry-spell occurrences were carried out for the three stations which had long-term rainfall data. Figure 6.14 shows temporal monsoon rainfall patterns along with monsoon onset days, good plantation periods, and dry spell days for years 2010-2013 for three stations. The illustration shows that in Chandra Gadhi did not have a successful plantation day in 2011 as there was a 9-day dry-spell within the first day of monsoon, which was 13th of June. Similarly, Nepalgunj did not have successful plantation days in years 2011 and 2012. Detailed figures for the three station with three decades of rainfall records are presented in Appendix G. Monsoon onset days and dry spell days are only shown for years on which they occur. There are some distinct variations in the three stations. Tarahara, which has the highest monsoonal rainfall, has not experienced a single year without a successful plantation period. Data from Nepalgunj Regional Office, on the other hand, reveals that twelve of the previous thirty-four years were without a successful plantation period.

Figure 6.14 Daily rainfall, monsoon onset day, dry-spell days and successful plantation days for three stations in the Tarai (2010-2013).

Source: Constructed from unpublished DHM data.
Note: Daily rainfall amount shown as blue vertical bars, the monsoon onset date for each year marked by a green vertical bar, a green shaded period after the onset of monsoon represents a successful plantation period (if there is one), and a red shaded region for marking dry spells of seven days or longer.

The analysis of monsoon rainfall reaffirms the findings from the analysis for rainfall using ETCCDI defined indices—that there is huge inter-annual rainfall variability across the Tarai. Additionally, it reiterates the finding that the western station at Nepalgunj experiences drier monsoons than the east, and arguably generating more uncertainties for agricultural production.

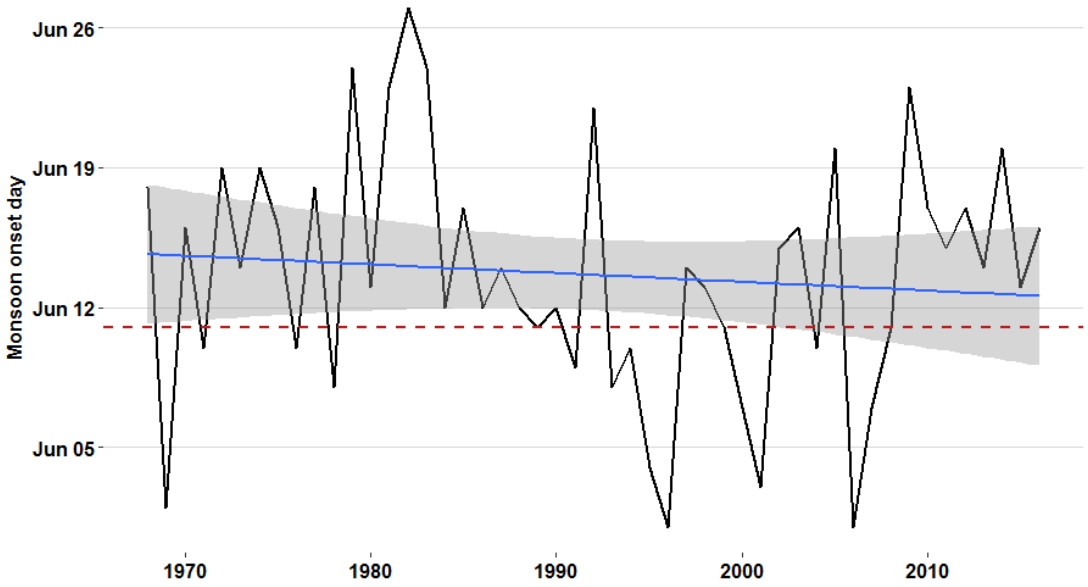
6.6.8 East-west variation

This research is not able to fully quantify spatial variations in the trends in climate extremes across the Tarai, mainly due to the limited number of stations with adequate data. The absence of mountainous relief in the lower Tarai could be expected to result in a climate with less spatial variability compared to the Hills and Mountains of Nepal. Yet, this can be only said for the lower Tarai as the Tarai districts include areas at the foothills of the mid-Hills, which have a dramatic shift in rainfall and temperature patterns. The spatial variation in monsoon is documented in the literature—Barros and Lang (2003); Devkota (1984); Karmacharya et al. (2015); Kripalani et al. (2007); May (2004); Zhang and Zhou (2011) for example. There is about a week of delay in monsoon rainfall between western Tarai and eastern Tarai. The monsoon first approaches Nepal from the east with a modal onset date of 10 June and extends towards the west reaching the western districts after about a week (Hannah et al. 2005, p. 20).

6.6.9 Variations in onset of monsoon

To detect any trends in the onset of monsoon itself, the official monsoon dates provided by DHM were analysed. The official monsoon dates indicate the date on which monsoon enters the country from the east. The analysis of official monsoon onset dates from 1968 to 2016 does not show a significant temporal trend as shown in Figure 6.15. There is substantial inter-annual variation observed: on some days, the onset is as early as 31 May and on some years the onset occurs as late as 26 June. The mean onset date stands at 14 June (s = 6.12 days). Many farmers reported mistimed rainfall which impacts production either via the lack of rain when it is required or from damage to the crops when no rainfall is needed. The analysis of past rainfall data does not suggest a clearly shifting monsoon pattern, but is reflective of the high inter-annual variability. This intrinsic variability can catch farmers off-guard when it comes to predicting cropping dates based on their personal observations. This risk could be partially overcome by providing improved weather predictions that are understandable to the farmers, so that farmers don't have to rely on luck but base their crucial actions on informed decisions.

Figure 6.15 Temporal evolution of official monsoon onset dates for Nepal (1968-2016).



Source: DHM
Note: Blue line represents linear model trend. Shaded grey region represents a 95 percent confidence interval for the linear modal. Dotted red line represent the official modal onset date.

6.6.10 Trends in temperature extremes

Although there is a lack of extensive climate records for the Tarai, there have been a number of studies of trends in climate variables for the region using data from the past three decades and from interpolated gridded data. An analysis of maximum temperature dynamics in Nepal over the period from 1977 to 1994 reveals an increase in the daily maximum temperature by 0.059°C per

year and 0.041°C per year for all Nepal and the Tarai respectively (Shrestha et al. 1999b). Another analysis by Chaulagain (2006) reported an increasing trend for mean temperature at 0.04°C per year for the period of 1971 to 2000 for central Tarai (Rampur station). Another study for the same station shows an increase of 0.036°C per year (Qi et al. 2013), and a more recent study using data from remotely sensed imagery, found an average increase of 0.06°C per year in Nepal (Shrestha et al. 2012). For the most part, these results are consistent and the temperature increases are higher than the global average increases for similar time-periods. The values resemble the increase found here in TNn which is significant at all locations, with the highest rate of 0.0357°C per year at Dhangadhi.

This study found increasing monthly maximum values for daily maximum temperatures (TXx), the 90th percentile of warm nights (TN90p) and the tropical nights (TR20). The monthly minimum value of daily maximum temperature (TXn) is decreasing and the 90th percentile of warm days (TX90p) does not exhibit any significant trend. However, there is notable variation across the stations.

Generally consistent with the findings from Nepal and India (Christensen et al. 2007), this study found significant increases in monthly maximum values of daily minimum temperature (TNx) and monthly minimum values of daily minimum temperature (TNn), while the tenth percentile of cool days (TX10p) and cool nights (TN10p) have significantly reduced. The increase in minimum temperatures and decreasing cool days and nights suggests a warming climate at the study sites.

The greater increases in minimum temperature extremes than increases in maximum temperature extremes are leading to a narrowing DTR in all three stations. No local literature could be located to compare to these DTR findings. The IPCC's (2007) AR4 report highlighted that minimum daily temperatures increased faster since the 1950s than the maximum daily temperatures, although the IPCC's more recent AR5 reports generally reports unchanged DTR since 1997 in a global context (Hartmann et al. 2013, p. 188). Contrary to that global scenario, the Nepali Tarai has experienced a clear decreasing trend in DTR over the last thirty years.

6.6.11 Trends in rainfall extremes

The monthly maximum single day precipitation (RX1day) in Nepalgunj and monthly maximum five-day precipitation (RX5day) at Chandragadhi have increased, while numbers of rainy days (SDII) have decreased except at Rampur. In addition, consecutive dry days (CDD) have increased over time while consecutive wet days (CWD) have decreased. In contrast, there is no clear pattern in trends of extreme rainfall events in the three stations with only a few indices (e.g. R50 at Chandra Gadhi and R20 at Nepalgunj) revealing statistically significant trends. Annual

total precipitation also does not reveal a clear trend which suggests that to date there is limited evidence of changes in the amount of rainfall. What is vitally important for the timing and realisation of paddy production is that the normal amount of growing season rainfall is being experienced in fewer days. At the same time, consecutive dry days have increased at all stations, and consecutive wet days have decreased, although the results are not statistically significant. These results are supportive of trends towards variable short-strong and long-weak monsoons. The increase in CDD and decrease in CWD indicates increased periods of rainfall deficits in the Nepali Tarai with serious implications for farmers depending on rainfall. Such a finding is particularly important for rice nurseries dependent on the sufficiency of water for germination of rice grains and transplanting. The case of western Tarai as represented by Nepalgunj station in this study, presents an important picture of decreasing rainfall and increasing dry days which together could have direct implications for agriculture and connected livelihoods.

6.6.12 Impact from extreme rainfall

Incidents of floods are common in the study sites. Some 69 percent of respondents in Damak and 84 percent respondents in Dhangadhi had experienced at least once incident of flood in the last five years. Although a common occurrence, floods in recent years have not resulted in many fatalities in the study sites. According to DesInventar (2013) data on fatalities from flood incidents, there were two deaths in the entire Jhapa district and three deaths in Kailali district in 2011. None of the respondents reported knowing of any flood-caused fatalities in the surveyed sites in the last five years. The damage from floods to the crops and livestock on the other hand is a major concern for the farmers as reflected in their responses to the survey. A 32-year-old female farmer from Dhangadhi said:

> *The 2040 BS (1983) flood brought about 3 feet (91 cm) of water. We sought refuge on top of trees. The flood swept away our plot. The entire paddy crop was destroyed. (Respondent 245)*

Another farmer, a 48-year-old male, from Damak shared his experience of flood:

> *Flood damaged my house and some equipment. The flood came during night-time. I also lost some of my livestock. (Respondent 51)*

Similarly, a 72-year-old male farmer from Damak said:

> *The main damage [from floods] is to crops. Flood water washes away fertile soil. (Respondent 59)*

The study sites, Damak and Dhangadhi are two of the municipalities with some of the highest incidents of floods recorded in the Tarai, as outlined in Chapter 3.

Although consistent trends in rainfall were not found from the analysis, Nepalgunj station has seen a significant decrease in the volume of rainfall as well as an increase in dry days. The mistimed nature of recent rainfall has been documented in other regional areas as well—e.g. Manandhar et al. (2011). This can be partly explained by the erratic nature of rainfall patterns that have been observed in the past three decades. However, the analysis of rainfall data reveals no significant evidence of a shift in monsoon arrival dates in the Tarai.

6.6.13 Water availability

Access to water is universal in the Tarai as even poorer households have access to at least a shared pump very close to their dwelling. The term 'drought' in the context of the Tarai applies to the lack of rainfall that results in the drying of rain-fed fields when water is required, which has adverse consequences for crop yield. Due to the ease of availability of alternative sources of water like underground water and water from rivers, farmers can in theory, rescue the crops from such incidents. In practice, however, the cost of pumping and restrictions on the availability of electricity and fuel provides barriers that many small farmers cannot overcome.

Although the Tarai is blessed with ample water, the quality of water available from shallow sources is not consistent and in some cases, far from potable. Arsenic contaminants in the underground water has been a significant health issue in the Tarai (Pokhrel et al. 2009; Shrestha et al. 2003). The amount of arsenic concentration, however, shows spatial and temporal variability and needs to be monitored regularly to ensure harmful levels are not exceeded. The GoN uses a threshold of 50 parts per billion (ppb) arsenic content to deem the water harmful for consumption. According to official 2011 data, only 0.05 percent of hand tube-wells in Jhapa district were found to have levels of arsenic above the threshold. This figure was much higher in Kailali however, standing at 3.37 percent (Table 6.2).

Table 6.2 Arsenic levels in water samples in Jhapa and Kailali districts.

District	0-10 ppb	0-10 ppb percentage	>11-50 ppb	>11-50 ppb percentage	>50 ppb	>50 ppb percentage	Total
Jhapa	113,077	99.34%	699	0.61%	53	0.05%	113,829
Kailali	74,357	88.30%	7,009	8.32%	2,839	3.37%	84,205

Source: CBS (2013a)

6.7 Comparing physical evidence with local perception

When collecting data during the household surveys and interviews with locals, the mention of the term "climate change" was consciously avoided. The aim was to generate an understanding of the respondents' experience of climatic and environmental indicators in relation to their daily livelihood activities. During the course of the survey, the term was cited by only a very few of the

respondents and by two interviewees during the survey. Climate change or *jalbayu pariwartan* (जलवायू परिवर्तन) in the local vernacular, was mentioned as a consequence of increased air pollution and environmental degradation. A 40-year-old farmer and entrepreneur from Damak said:

> *Weather pattern has changed a lot. Fruits used to grow better in the past. Crop harvest has also declined. I think the decline can be attributed to pollution and change in weather. … Rainfall has also declined. We have destroyed our forests. Forest areas are declining day by day. Local forests have been destroyed by illegal loggers. (Person 4)*

The majority of the respondents however, presented their experience with the changing patterns in climate without referencing climate change, global warming or pollution. This is understandable in the context of rural areas in Nepal as there is limited mention of environmental issues in the local media, with only 51 percent of Jhapa residents and 46 percent of Kailali residents having access to radio as shown in Table 6.3 (CBS 2012d, pp. 33-34). Despite efforts to inform the public on the topics of the environment via radio programs, the reach of such programs have been limited in other parts of the country (Shrestha et al. 2014), and the same can arguably be applied to the Tarai which has lower percentages of households with amenities like television and computers. In other words, the farmers who face the brunt of environmental change in the study sites are largely unaware of the long-term impacts and the global nature of climate change. This lack of understanding is reflected in their responses reasoning that the negative impacts were acts of god and there was nothing farmers could do about it.

> *We cannot prevent drought. It happens because of god's will. (Respondent 41)*
>
> *Nothing can be done [about the floods]. (Respondent 53, 55, 203)*
>
> *Flood happens every year. There is no way to prevent it. (Respondent 56)*

Their interface with such change, as and when it occurs, coping and adaptation responses involves specific impacts using the knowledge and resources they have access to.

Table 6.3 Access to common household amenities in Jhapa and Kailali districts.

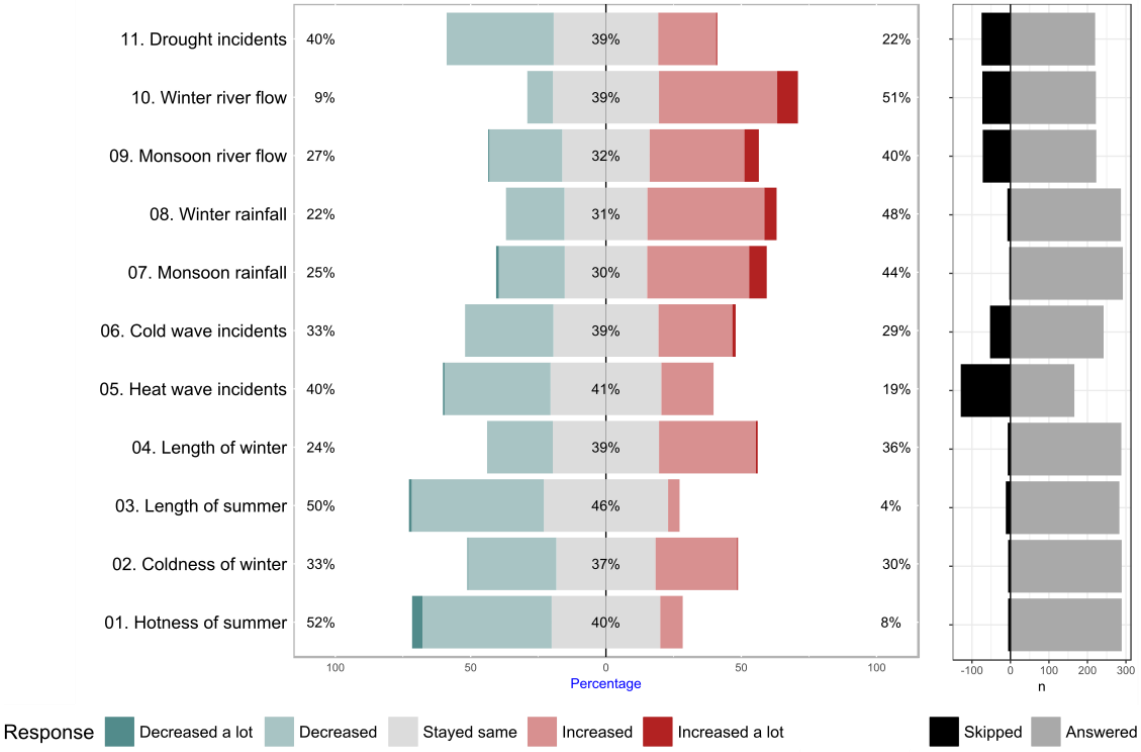
	Jhapa district	Jhapa percentage	Kailali district	Kailali percentage
Households with radio	94,656	51	66,010	46
Households with television	115,555	63	46,500	33
Households with mobile phone	135,825	74	93,658	66
Total households	184,384	100	142,413	100

Source: CBS (2012d, pp. 33-34).

6.7.1 Perception of change in climatic indicators

Many respondents mentioned that the rainfall in recent years was getting more 'untimely'. Farmers' understanding of the local climate pattern is not only from personal experience of the climate in daily life but also from associated impacts to agricultural activities and harvest outputs. From a farmer's perspective, 'ideal weather' is based on the required conditions for planting, growing and harvesting of crops and the description surrounding weather is based around the deviation from those ideal conditions. Both inter-annual and intra-annual changes in rainfall will have significant impacts on the cropping process and harvest outputs. The timing, quantity and the frequency of rainfall determines the labour demand and ultimately, the success of the harvest. If the interval between rainfall events is long, the paddy will not grow to its full potential. Figure 6.16 shows Likert scale responses from the survey on eleven climate related variables; variables 1-6 relate to perception of temperatures, variables 7-11 are related to rainfall and water availability indicators, which are discussed further below.

Figure 6.16 Responses on impacts from eleven climate related variables in Damak and Dhangadhi.



Source: Field Survey 2013-14.

6.7.2 Perceptions on temperature trends

As discussed in earlier sections, analysis of temperature extremes reveals a general rising trend in night-time temperatures and overall warmer nights. Trends in rising daytime extremes is not consistent across the stations. Interestingly, 51 percent of respondents reported summer being

less hot and only 8 percent stated that summers were getting hotter. Similarly, 49 percent revealed that summer days were in decline with only four percent stating an increase in summer days. The responses regarding winter temperatures were more mixed: 32 percent observed decreasing cold temperatures, 31 percent reported increasing winter temperatures and 37 percent perceived there to be no change. The perception of temperatures is dependent on many personal variables and it is difficult to make any direct comparisons based on the survey responses alone. Interviews with farmers and responses to open-ended survey questions gives a more meaningful picture of how the judgement on temperature trends are made.

Some respondents reported that although the extreme temperatures have probably stayed the same, they feel less impact as the living standards have improved and there are means to protect against extreme heat or extreme frost. The magnitude of the change itself is small and the actual impact may not be noticeable from day-to-day experiences. There was no report of any extensive damage to crops from increased heat. Damage to winter vegetables from frosts was reported by many respondents but there was no indication of increasing incidents. Respondents acknowledge both positive and negative experiences of perceived changes in temperature.

> *It is nice that it's not as cold as before. It means we don't need a heater and that many clothes. (Respondent 81)*
>
> *If the winter is too cold, wheat does not grow as well. (Respondent 241)*
>
> *[Warmer temperatures] has been good for winter crops like wheat, mustard, pulses, bitter melon, and okra. (Respondent 253)*
>
> *In the past, it used to be cold for three months. Now, we have two months of cold weather. Summer used to last for three months. Now, summer is longer ... it lasts four months. (Respondent 275)*
>
> *It has gotten warmer. Winter used to bring dew early in the morning. There is less dew now ... good for winter crops like vegetables, chick peas, mustard, and cauliflower. (Respondent 255)*

6.7.3 Perceptions on rainfall and water availability trends

As revealed from the analysis, rainfall in a particular year can vary by a broad margin from the average patterns. Average rainfall values and patterns may not be very useful when planning for agriculture if there is enormous variability, and this adds to the challenge for Tarai farmers in their attempt to maximise agricultural output. Keeping track of rainfall is a key role of being a farmer in the Tarai. Farmers described the current trend in rainfall as untimely and does not synchronise with the seasons. Respondents used terms like "बेमौसमी" (out of season), "कुबेला" (mistimed), and "बेसाईत" (inauspicious or inappropriate timing) to describe rainfall patterns in recent years. Among the respondents, there was no consensus on any trend in the overall amount of rainfall, but most farmers reported that the changing rainfall pattern was problematic for both monsoon

and winter crops. Rainfall during harvest time can be detrimental to the crops as it can cause grains to fall and in some cases can even rot the grain. Farmers also described rainfall as arriving later in the monsoon resulting in damage to crops during harvest times. There is no significant shift in the arrival of the monsoon but the high inter-annual variability of almost four weeks can take a farmer by surprise in their anxious wait for the arrival of the first monsoon rain. The respondents overwhelmingly reported increased rainfall during both winter, monsoon and rising levels of water in rivers during both winter and the monsoon. Responses were probably biased by the exceptionally wet monsoon just months prior to the survey. Despite this, they were eager to share their experiences of rainfall patterns. A 52-year-old female farmer from Dhangadhi said:

> *Rainfall has become erratic. It does not rain when required. (Respondent 208)*

Similarly, a 66-year-old female farmer from Dhangadhi expressed her experience with changes in rainfall patterns as follows:

> *The rainfall pattern has changed. We are forced to rely on underground water for agriculture. We are disadvantaged because we don't own water pumps. (Respondent 231)*

A 64-year-old farmer from Damak remembered the time when rainfall used to be more regular:

> *The winter rain in the month of Magh (December-January) used to be good for agriculture. It used to always rain on Shreepanchami day (the fifth day of spring). (Respondent 113)*

Some respondents were specific in explaining that the overall quantity of rainfall had not changed but the timing has been different. A 78-year-old male farmer from Dhangadhi said:

> *The total rainfall amount has not changed, but the rain arrives late these days. That is not good for crops. I rely on my diesel pump to pump water from a 65 foot (20 m) deep bore well. (Respondent 277)*

Paddy harvest is most reliant on rainfall during the transplanting and growing seasons. In case of a failure in rainfall, irrigation can supplement the water required. Respondents were eager to share their irrigation woes by explaining the difficulty of ensuring proper irrigation given the added costs and manpower required. A female farmer in her 40s from Dhangadhi said:

> *Rainfall used to be consistent in the past. It doesn't rain at the correct time these days. We have resorted to pumped water. ... We rent pump when we need irrigation. We pay NPR160 (USD1.6) per hour. It's for an electric pump. (Person 17)*

Similar difficulty was reflected by survey many survey respondents from both sites:

> *Irrigation from pumped water is expensive. The cost of electricity is NPR 8 (UDS 0.08) per unit (kWh). (Respondent 215)*

> *There is less water in canals and rivers. We need to stay up all night to ensure water from the canal reaches our fields. (Respondent 30)*
>
> *It is costly to irrigate fields. Irrigation is no way as effective as rain water. Less rainfall makes crops prone to diseases. (Respondent 22)*

The perception of the effectiveness, or the lack thereof, of pumped water was virtually clear—farmers widely believed that groundwater is not as effective as rainfall.

> *Rainfall is the best. Pumped water contains no vitamins (nutrients). (Respondent 226)*
>
> *The [underground] water is corrosive. It is not as effective as rainfall. (Respondent 109)*
>
> *Harvest from fields using pumped water is less [compared to rain-fed fields]. (Respondent 92)*
>
> *It is better than no rain. (Respondent 228)*
>
> *Using pumped water to irrigate is the same as using rainwater. (Respondent 213)*

A comment by Respondent 49, a 51-year-old farmer from Damak, is particularly interesting as they compared the utility of water from different sources to different forms of milk—*"Rainwater is the most effective. Rainwater is like pure milk; river water is like yogurt; and pumped water is like buttermilk".*

Extreme rainfall during the transplanting season can damage paddy seedlings and extreme rainfall during harvest time can rot the paddy on site. Excess water, and even the flooding of the field for a few days, is not harmful during the growing phase for paddy. Flood becomes a problem for paddy only when the plant has already fruited and is ready for harvest. Dry spells and droughts on the other hand are much harder to manage for farmers. About 53 percent of the respondents reported that they had experienced drought in the past 5-7 years. This is consistent with the analysis of monsoon rainfall as dry-spells are common, especially in the western Tarai. In 2004 for instance, there was no successful plantation period after the onset of monsoon on 18 June and there were three dry-spell periods of eight, ten and ten days respectively as indicated by rainfall records from Nepalgunj. An older male farmer from Damak recounted his experiences of flood:

> *The river expands immensely during monsoon. It creates a huge distress for us. Every monsoon, the river overflows and floods our fields. This year was particularly bad. We use bamboo spurs to divert the river. Bamboo spurs have proved to be very effective at protecting lands. We prepare bamboo nets and place them along the banks to form barriers. We have been doing this for years to protect our farmlands. I have witnessed floods here since my first arrival in 2040 BS (1983). … Families with resources have moved to higher areas. We cannot move due to our economic condition. Of course, we desire to move to a safer place, but it can't be realised. … I plant paddy,*

> *mustard, potatoes and the like. I plant only one batch of paddy per year. Two batches are possible but there's no guarantee of irrigation. I plant other crops like mustard after harvesting paddy. Output from agriculture has definitely increased. In the past, it was difficult to produce 10-15 man (373-560 kg) of paddy from a bigha (0.7 ha) of land. Now we get almost double of that. The reason for the increase I think is that the soil has improved over time. (Person 7)*

In Damak, the respondents who worked for, or had a household member working in the tea plantation company, reported that their livelihoods were at risk during dry years as tea production was low. Interviewees and respondents acknowledged their perceived changes in rainfall with remarks like the following from a male tea-estate worker in his late 30s from Damak:

> *Water level in the rivers have risen in the last few years. I have lived here for twenty years; from my experience, the river has become fiercer in recent years. Monsoonal rainfall has also increased. The water has remained the same in winter however. The shape of river has changed, but the amount of water flowing during winter is the same. The river has widened and the area of sandy banks has increased. (Person 2)*

A 61-year-old male farmer from Damak remembered his harvest from 2056 BS (1990):

> *"… we received virtually no rainfall. … the paddy field was dry and the harvest was nil" (Respondent 43).*

The lost harvest that year was reported by a few other farmers as well. Many farmers also complained about shifting rainfall patterns. A 54-year-old male from Damak expressed:

> *We experienced drought around a decade ago. There was no rain during monsoon. [Paddy] leaves turned yellow. We shared water from a canal for irrigation. (Person 135)*

Some farmers reported planting paddy as late as Bhadra (August-September). There were also reports that farmers had to resort to a second plantation after the first batch failed due to lack of rain. The lack of rainfall is especially harsh for winter crops – vegetables, oilseeds etc. In Dhangadhi, Ward 12, one farmer reported that they had to leave their land fallow that winter as there was no means to irrigate in the absence of sufficient rainfall. A 57-year-old male farmer from Damak said:

> *The harvest was nil on one particular [drought-affected] year. That year, we left the lands on elevated areas fallow. These days, the fields can be easily irrigated with pumped water. This certainly works for paddy but the underground water level has declined. (Respondent 131)*

Another farmer, a 26-year-old female from Dhangadhi shared his experience of the ongoing dry winter:

> *We had to leave the field fallow this winter. [points to an empty plot of land]. This has never happened before. (Respondent 235)*

Reduced rainfall can also have significant impacts on livestock, mainly through reduced fodder. Not all Wards have access to grazing land—livestock, mostly remain in sheds, and are only released to freely roam around only when the harvests have been collected. This is primarily to prevent livestock from consuming or damaging the harvest. Wards close to a river or forest have access to open grazing lands. These lands are often over-grazed and there is simply not enough area for the cattle to roam freely. For those without access to such open spaces, the only option is to keep the cattle in a shed at all times. This requires the fodder to be delivered to the cattle every day. In the Dhangadhi wards close to the international border, many farmers reported taking their cattle across the border to graze forested land. This is illegal and there's a risk of a large penalty if the cattle is caught by a ranger. Despite this obvious risk, farmers continue to herd their cattle to India as there are hardly any options for grazing them locally. Some respondents reported paying annually for the use of the grazing land but most farmers were utilising such lands at their own risk. A 35-year-old female farmer said:

> *There's no land here for grazing. We take our cattle to the nearby Indian land for grazing. We pay INR200 (NPR320, USD3.2) per year for the land. (Respondent 209)*

Modern Tarai farmers now have access to fertilisers, insecticides, and improved varieties of crops which are more suited to the area. Many farmers reported that the yield from improved or hybrid varieties increases yield by 25-100 percent. Table 6.4 summarises farmers' views of respondents on tends in agricultural production.

Table 6.4 Respondents' views on trends in crop yield.

Question (Questionnaire variable C22)	Acknowledging positive yield trend	Acknowledging negative yield trend
Change in yield in the last five to seven years	Traditional rice varieties do not cope well. Hybrid varieties are better and produce double the output.	Output has declined due to lack of quality fertiliser.
	We use more chemical fertilisers these days. We also have access to water from deep boring for irrigation.	Farming needs more effort and money these days. Fertiliser has become very expensive.
	Output has increased in recent years as I plant paddy twice a year.	Harvest has definitely declined. For the first time this year, I had to buy hay for my cattle because of low harvest.
	In the past, we used to throw paddy seeds to plant, but now farming has improved a lot. We use imported fertiliser and harvest have been improving.	Rainfall has become very untimely.

Source: Field Survey 2013-14.

Access to irrigation water when rainfall is insufficient can increase yields. Farmers who can afford to install private bore holes and water pumps enjoy the benefits of watering the farms even if there is no rainfall or the communal sources, such as canals are not functioning. Poorer farmers

who cannot afford such mechanisms have to rely on communal systems or rainfall. Farmers in both study sites in some cases can pay to water their fields but this can be expensive: payments have to be made to the bore-hole owner, the pump owner and the distribution pipe owner. Additionally, the farmer must pay for electricity or fuel, both of which are under short supply and have restricted access. During the field work, Damak and Dhangadhi had roughly twelve hours of electricity per day. Farmers with access to electric water pumps thus have to plan irrigation times according to the electricity schedule, which might mean they have to stay up all night on some days. Access to fuel like diesel and petrol is also not easy: they are relatively expensive and there are frequent shortages. During the winter of 2013-14, some farmers from Damak and Dhangadhi showed land, which had been left fallow, claiming that without rainfall or irrigation, the harvest would not be profitable. If such dry winter events were to continue or increase, it could be expected that more farmers will decide to leave their land fallow forcing the household to seek alternative income sources. The general consensus regarding drought incidents was that they had declined however, forty percent said such incidents had decreased while twenty-two percent said the opposite. There were no significant differences in perception of the eleven variables in regards to gender of the respondent and respondent's household migrant status. The next section will discuss some of the implications of the impacts of climate variability and change, especially in relation to agriculture—the main in-situ livelihood option in the Tarai.

6.8 Implications of climate variability and change on Tarai's agriculture

As discussed in Chapter 4, there has been a steady increase in the amount of grain production in Nepal. In 2011, the country produced more grain than was required for national consumption (CBS 2013b), and most come from the Tarai. Much of Tarai's agriculture is fuelled by manual labour, and is heavily reliant on rainfall. As mentioned earlier, the monsoon season brings the region 1,200-2,000 mm of rainfall on average over the four months. For crops like paddy, this rain is essential as the fields require puddling during the transplantation phase. The fertile soil of the Tarai is favourable for a variety of crops. In fact, most farmers practice continuous cropping, and farms are usually left fallow only for a short amount of time after each harvest.

Due to this reliance on agricultural practices that are sensitive to climate variability, significant impacts are possible upon a huge section of the Nepali population from relatively minor changes in climate. Already, Bapuji Rao et al. (2014) have reported remarkable losses in Indian agricultural production in regions similar to those in the Tarai due only to a 0.28°C 10 per year rise in seasonal mean winter temperatures. Those impacts include important reductions in rice production due to increased mean minimum temperatures during the paddy growing season. The implications of similar yield losses could have significant direct impacts on the Tarai due to a

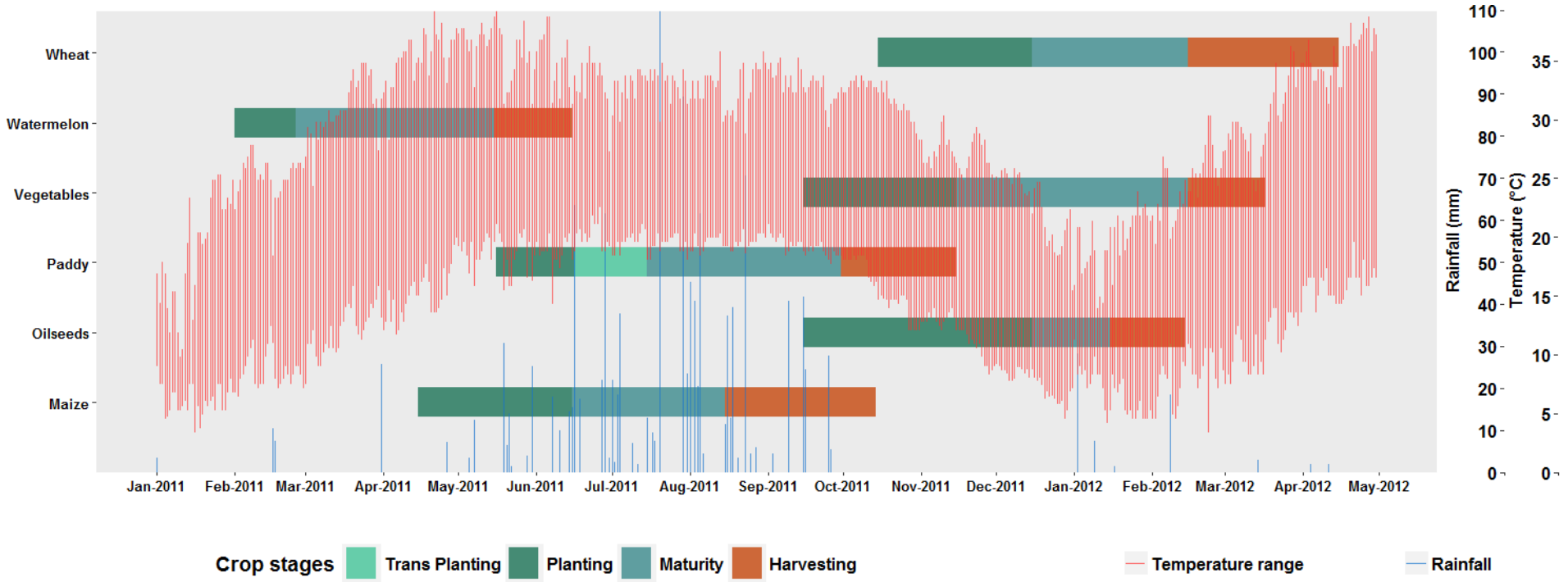
combination of factors, including: its dependence on agricultural production; the high density of a relatively poor population; and limited agricultural modernisation, including irrigation infrastructure. Some 85 percent of Nepal's agricultural lands are concentrated in the Tarai as of 2005/06 (Centre for Engineering Research and Development 2007), but only a little over fifty-three percent of the Nepal's farmlands are irrigated (CBS 2013b), thus the remaining farmlands rely heavily on the increasingly unpredictable monsoonal rainfall. The impact from change in rainfall patterns could be devastating to a Tarai farmer as the majority of agriculture in Nepal is supported by limited interventions to manage water (Manandhar et al. 2013). So, while greater heat extremes and any changes to rainfall patterns would have direct implications for the agro-ecosystems of the Tarai, with improved knowledge of the rates and forms of regional climate change, adaptation recommendations could be detailed and made specific to peoples' situations.

6.8.1 Implications of climate change on major crops

A cropping calendar describes the schedule of growing seasons for various crops from the timing of land preparation, to crop maintenance and harvest. For farmers, such a schedule is useful for planning, for procuring inputs like seeds and fertilisers, and arranging additional help for labour intensive activities. For the Tarai farmers, such schedules are already ingrained in their daily activities acquired as part of local / indigenous knowledge and experience. For researchers, a cropping calendar also provides an overall picture of agricultural activities spread throughout the year and allows comparisons of activities with the prevailing climatic patterns. During the field-work, information regarding schedules of various crops in the Tarai were collected through interviews with experienced farmers in both Damak and Dhangadhi sites. Figure 6.17 shows the cropping calendar for major crops and plants in the Tarai along with daily rainfall and temperature range based on January 2011-May 2012 records – the period roughly coinciding with the twelve months prior to the field survey dates.

Paddy is the most widely farmed crop in the region followed by wheat and oilseeds. Taking advantage of the monsoonal rain, which commences around early July, the paddy seeds germinate and are transplanted after the onset of monsoon. Paddy fields are supposed to be waterlogged for the early maturity phase. Wheat is planted during winter when there is less rainfall, often weeks after the paddy is harvested. The planting is done on dry ploughed land by broadcast seeding—scattering by hand. Ploughing of land used to be done by hand, but now most farmers use tractors. Farmers usually pay a tractor owner to plough their field. Farms are irrigated using water from any available sources such as canals, pumped river water, pumped underground water, or even by water fetched manually from a nearby source.

Figure 6.17 Cropping calendar for selected crops in the Tarai (January 2011-May 2012) showing daily rainfall (blue) and daily average temperatures (magenta).



Source: Constructed using climate data from unpublished DHM records, and crop calendar data collected from Field Survey 2013-14.

Not every impact from a changing climate is negative. The impact of climate change on paddy production occurs on three fronts – changes in rainfall, change in temperature and change in carbon dioxide (CO_2) levels. Increased atmospheric levels of CO_2 have been found to have a net positive impact on paddy (and most plants in general), however, higher temperatures will be harmful overall (Ainsworth 2008; Erda et al. 2005). With the clear warming trends observed in the Tarai, it is important to focus on rice varieties that could withstand further increases in daytime and night time temperatures. Paddy farmers have to constantly stand guard over the field to ensure the field has adequate water. Excess water needs to be channelled away from the farm. In case of low rainfall periods, farmers often have to negotiate water allocations among neighbouring plots. Additionally, in case of dry-spell days, farmers with means may resort to irrigate their fields with water pumped into the fields.

Harvesting of the crops is done manually. Farmers reported that harvesting used to be mostly managed by family members but now paid labour is increasingly being used. Thrashing of paddy and wheat are now mostly being done mechanically, Plate 6.2 shown thrashing being carried out using a mechanical thrasher in Dhangadhi. Smaller wheat farmers reported traditional methods of thrashing like bullock-assisted method. Case studies in other sites in Nepal have reported shifting cropping patterns being adopted by farmers—e.g. Manandhar et al. (2011); Shrestha and Nepal (2016). Some respondents from the survey mentioned that in certain years, they had to delay planting or even had to replant after the first attempt failed. The delay was, however, for only certain years and a definite shift in traditional cropping patterns was not observed.

Plate 6.2 Thrashing machine being used for processing paddy harvest in Damak.

Source: Field Survey 2013-14.

It has been found in experimental settings that rainfall alone will be unable to provide enough water to compensate for increases in evaporation losses in paddy fields in the case of

Kathmandu (Aryal 2012). Excessive temperatures also increase evaporation rates of soil moisture and evapotranspiration rates. Heat stress in wheat during the growing season have been found to reduce yields by a factor of half in Australia (Asseng et al. 2011). While the temperatures in the Tarai during the wheat planting season (winter) does not reach heat stress levels (maximum temperature exceeding 35°C), a greater concern is from higher moisture levels in the soil in the post-anthesis stage which decreases yields in wheat crops (Devkota 1993, p. 218). Winters are relatively dry in the Tarai which provides the right conditions for wheat to flower and develop fully. Increased winter rainfall as a result of unusually late monsoon, or increased variability thus could cause significant wheat yield loss.

The faster increases in minimum temperature extremes and slower increases in maximum temperature extremes are leading to narrowing DTR at all stations. Globally, the DTR is said to have been generally stable since 1997 (Hartmann et al. 2013, p. 188). Therefore, the finding that the Nepali Tarai has experienced a clear decreasing trend in DTR over the last thirty years is an important one for understanding how tropical systems in a vital basin for global food supplies is responding to climate change. That constraint in DTR in association with higher temperatures could have a negative impact on much paddy production in tropical areas (Ainsworth 2008; Erda et al. 2005). Therefore, the results here infer that with the warming trends observed in the Tarai, it might become more important to focus on rice varieties that can withstand increased temperatures or retain diversity within systems to help manage the variable conditions.

Being the basis of livelihoods for the majority of the Tarai households, impacts on agriculture due to environmental change were noticed by most respondents and there have been many efforts to reduce negative change but local capacities to adapt are limited. The measures discussed below are probably not only associated specifically with climate change but rather, overall threats brought by climate variability and other uncertainties. Important adaptive actions include planting improved varieties of crops, adjusting plantation dates, investing in irrigation, protecting farmlands from floods, planting high-value crops, and planting close to river.

Farmers in the Tarai are interested in maximising their yields. Modernisation of agriculture however has been slow, with minimal mechanisation and uncertainties surrounding the supply of seeds, fertilisers and irrigation. Despite the challenges, the current state of affairs of Tarai agriculture is a significant improvement from early settlement days. According to the farmers who were among the first settlers, farming initially was very primitive and the yields were much lower. A 70-year-old male farmer from Dhangadhi said:

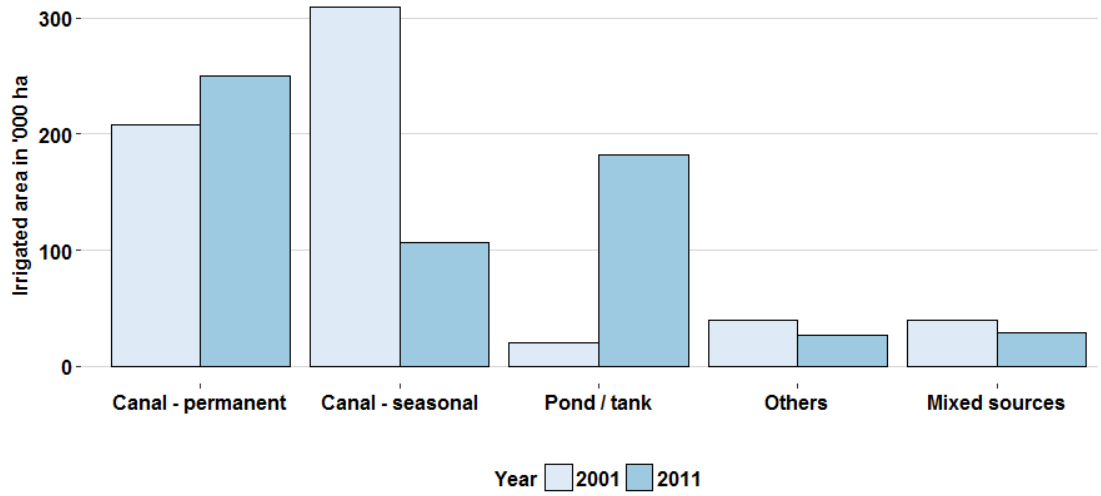
> *In the early days, we used to throw the seeds on tilled field for paddy. Now we prepare the seedlings and transplant them with care. … In my opinion, harvest has improved by three times. (Respondent 252)*

Farmers can now choose amongst a variety of high-yield crops suited to the Tarai climate which can withstand common pests. Official data on crop output shows a gradual increase in national grain production in the last five decades (CBS 2013b). Along with access to improved varieties, farmers have access to better fertilisers and means of controlling pests and weeds. The reliance on chemical fertiliser however adds a significant input cost to farmers. Respondents also noted that prolonged periods of shortages are common. During a shortage period, farmers are forced to procure fertilisers from a distant source or resort to black markets; in either case this results in added costs. Moreover, fertilisers from the black market are known to have been tainted and relatively ineffective, resulting in a double loss for the farmer. Despite the availability of means to increase outputs, some farmers blamed chemical fertilisers among other broader problems for declines in output. A farmer and entrepreneur aged around 40 from Damak said:

> *Output from agriculture has actually decreased in recent years. The reason is the use of chemical fertilisers. Chemical fertilisers are harmful for the soil. I think we should opt for more organic farming but no one has tried it here. Crops and trees are more susceptible to diseases these days. Most farmers have little or no education and need guidance from the government. I haven't seen any such support. Flood events also negatively impact agricultural output. Floods damage crops and covers the fields with sand. (Person 4)*

Data on shifting patterns of irrigation reveal that the water availability for irrigation is already under stress. According to official statistics on irrigation usage, there is a significant increase in the demand for non-traditional sources of irrigation as shown in Figure 6.18. Compared to 2001, the area of farms utilising seasonal canals for irrigation have declined by 65.5 percent, whereas areas utilising tube wells and bores, or pond and tanks have increased by 84.0 percent and 794.6 percent respectively (CBS 2014c, p. 128). This jump in the use of underground water and stored water signals a diversifying of irrigation sources to include non-seasonal and non-rainfall related sources. The use of alternative sources is partly attributable to the increase in the area of irrigated farmland itself by 18.9 percent, from 2001 to 2011 (CBS 2014c, p. 128). This shift also highlights the Tarai's potential to generate agricultural outputs in the future.

Figure 6.18 Area irrigated by source of water in the Tarai—2001-2011 comparison.



Source: Constructed from CBS (2014c, p. 128) data.

The excessive cost of irrigation due to high energy costs and unreliable supply remains the prime concern for poor farmers in the wider region (Shah et al. 2006, p. 307). In the study area in both Damak and Dhangadhi, there is little permanent infrastructure built for irrigation. The few remaining canals built decades ago have not been repaired. Plate 6.3 shown the conditions of canals at the study sites. For the most part, farmers rely on trenches to transfer water from rivers and streams onto their fields. The water is shared between the fields through which it flows. As the water flows further from the source, the amount available decreases. This means that in the case of a dry-spell, the shared water may not be enough for everyone, especially in the fields furthest from the source.

Plate 6.3 Concrete structures for channelling water to fields at Damak (left) and Dhangadhi (right). Much of the canal infrastructures have not been updated for decades and are mediocre.

Source: Field Survey 2013-14.

Livestock can be impacted by climate change in multiple ways. Reasons such as, weather conditions that make animals uncomfortable, impact from diseases, impact from water and grazing land availability can negatively impact efficiency and productivity of livestock (Otenyo

2015). Some of these effects have been already felt by Tarai communities and they have improvised measures to protect the livestock and ensure continued productivity. Some respondents mentioned the impact of cold waves on livestock during winter months. As an adaptive measure, farmers use hot water to mix feeds. During summer, livestock sheds are treated with smoke or anti-mosquito incense. With depleting forest resources, fetching fresh fodder for livestock also becomes more arduous as farmers are forced to travel longer distances to access sufficient amounts. Many farmers candidly admitted having fetched fodder from restricted areas such as conservation sites or private property. Chopped straw forms a substantial component of the cattle feed in the Tarai. Upon harvest, farmers stock straw in piles near their livestock shed. In a year with low harvest, a household's straw supply may not be able to keep up with demand which forces purchasing of straw for fodder mix. Some respondents reported the added burden of having to purchase straw when they were already suffering from low harvest. A 60-year-old female farmer from Damak said:

> *[Due to reduced harvest,] I had to purchase straw to use as fodder. I have never done that in the past. (Respondent 48)*

6.8.2 Measures against natural hazards

The two case study sites were chosen, in part, because of their exposure to floods, which are projected to become more common. Measures to mitigate flood by means of physical barriers as well as bio-engineering are in use. More emphasis has been put on physical barrier measures such as constructing dikes and retaining walls to protect land from being washed away. Bio-engineering measures such as vegetation along river banks have also been tried, especially in recent years. In both Dhangadhi and Damak, ongoing construction work for new dikes were observed, as shown in Plate 6.4. Much of the construction is carried out in stages depending on the municipality's available budget allocation. The demand for retaining walls is higher than what the municipality can support financially, so in many cases, the community have organised themselves to procure materials like stones and bamboo to construct their own dikes and retaining walls.

Plate 6.4 Bamboo piling to protect land from floods in Damak (left). River water eroding agricultural fields in Dhangadhi (right).

Source: Fields Survey 2013-14

Bio-engineering means of flood control have been successful in the Tarai but the popularity of the measure among farmers was found to be low. Most farmers wished the municipality would allocate more funds for construction of more gabion walls and dams to fix the river's course. Many Non-Government Organizations (NGOs) in the Tarai support flood mitigation and relief activities. A female local development practitioner, in her 20s, based in Dhangadhi described the collaboration among local agencies and the community for flood mitigation and relief efforts:

> *First, we design the project and prepare detailed [cost] estimates. The community will contribute towards unskilled labour and locally available materials. Our organisation provides technical help. We also procure non-local materials such as gabion wires, boulders and stones needed for the projects. Generally, the contribution of the locals cover about 30 percent of the costs while we cover the remaining 70 percent. … There are many success stories in the Tarai. Bamboo spurs have proved very effective in the Tarai. Constructing impermeable means to control flood will hold up water upstream and increase the chance of water overflowing from the sides and causing erosion. However, if we use permeable structures like bamboo spurs, there is a reduction of velocity of water as some water can seep through. Bamboo spurs also allow for siltation to occur which is good for flood control. There may still be damage in case of extreme flooding or if the water brings in large debris, but for the most part bamboo works. [...] If the bamboo is exposed to both sun and water regularly, bamboo dams can last 5 to 6 years, maybe up to 7 years. However, if the bamboo stays completely submerged or stays dry the entire time, then it will last a lot longer. It all depends on the exposure. In extreme cases, the bamboo will rot in 4 to 5 years. Replacing such structures is easy. The communities can themselves repair or replace bamboo structures. Bamboo spurs is also cheaper because hard materials like stones are harder to get in the Tarai and they are expensive due to transportation costs. We collaborate with DDC, VDC and other government agencies to execute our projects. (Person 24)*

In Damak, organisations such as Nepal Red Cross, Mercy Corps Nepal, Lutheran World Federation, Rural Reconstruction Nepal engage in flood mitigation and relief efforts that includes construction of physical or biophysical barriers, community education, planning of escape routes, installation of sensors and early warning systems and distribution of relief efforts. Similarly, in Dhangadhi, organisations like Mercy Corps Nepal, Faya Nepal, Lutheran World Federation, Nepal Red Cross work with the community in providing flood mitigation and relief efforts.

As discussed in this chapter and in Chapter 4, rising human and livestock populations in the Tarai have impacted land and forests, and aggravated livelihood by causing shortage of fodder, firewood and other resources. The impact from climate change will further exacerbate the already fragile livelihood situation by impacting upon agricultural outputs and increasing the likelihood of the flood hazard. The rise in circular migration as a means of ex-situ livelihood, discussed in Chapter 5, is arguably linked, in part, to the pressures on the farm-based livelihoods and the lack of capacity to develop agriculture. Furthermore, the potential benefits of modernisation in agriculture are unlikely to be realised in full as more households rely on remittance income and labour availability for agriculture is on a serious decline.

6.9 Conclusion

The changes in the daily extreme temperatures and daily precipitations in the study sites and in the Tarai ecological zone, were discussed in detail. Daily climatic records from four stations in the Tarai were analysed for possible trends using the MK test. Analysis of meteorological data for selected stations in the Tarai reveals a distinct warming trend whereas precipitation lacks any trend.

The research presented here provides insights into farmers' perceptions to changing climates in the Damak and Dhangadi municipalities. It is apparent that the region is experiencing gradual changes in climate as indicated by trends in temperature extremes, rainfall extremes and dry-spell days. Farmers' observation and experiences of local climate offer an important knowledge base to complement the physical data from ground stations and satellite observations. Much of the findings from statistical analysis is consistent with the available literature. Changes in climate were identified by the locals to be a challenge for agriculture, as well as health. The farming community is especially concerned about the changing rainfall patterns which result in reductions in harvest or loss of harvest altogether. Although the lack of rainfall during paddy season causes harvest to be lost, untimely rainfall post-monsoon damages the harvest-ready paddy. Excess rainfall during winter damages crops like wheat which needs relatively dry soil for growth.

Changes in climate are affecting farming practices in the Tarai, limiting livelihood opportunities for many small land holding farmers and influencing families to seek alternative livelihood options. These stressors are in addition to the socio-economic and political challenges that the Tarai have been facing since the early settlement days. The final chapter describes the nexus of the three issues—livelihood, migration and environmental change raised here and puts those issues in the context of key theory and outlines policy recommendations based on the findings of this study.

7. Conclusion

7.1 Introduction

This thesis has critically examined the pressures from environmental change on rural livelihoods of the Tarai and the ways such pressures translate into livelihood decisions. That analysis included a review of the changing modern patterns of human mobility, including the extent of transnational mobility as a livelihood option. The analysis is based on primary data collected through a questionnaire survey of 298 households at two locations in the Tarai and twenty-three in-depth interviews with locals and development experts. Inputs from secondary data such as daily climate data, census reports, government reports and maps were also used to aid the discussion, especially of climate change impacts. The study is based on case studies from the Damak and Dhangadhi Municipalities in the Nepali Tarai, a region with high dependence on agriculture, and at the same time expecting socio-economic underdevelopment. The two municipalities are also hotspots of flood impacts, as they have experienced one of the highest number of flood incidents from 2004 to 2011. The relevance of migration as a popular household strategy for income, and the relatively small interest in flood mitigation from respondents, suggested the shifting focus of livelihood strategies away from in-situ adaptation. The cases also provide snapshots of broader socio-economic transformations happening in the country, especially the exodus of Nepali male youths as circular migrants to international destinations.

This chapter concludes the thesis by summarising the key findings, reviewing the implications for climate change adaptation and development policies. It assesses the contribution to the environment-migration knowledge base, lists the limitations of the research, and presents possible avenues for future research.

7.2 Synthesis of key findings

This section provides an overview of the results from the discussion chapters and evaluates how the findings reveal interactions between local environmental resources, agricultural pressures, and global climate change and influence livelihood decision-making. It also explains how the research contribute towards answering the research questions outlined in Chapter 1. The key theme of the research is to evaluate environmental change impacts upon agriculture dependent households, and to establish if they lead towards a greater exploitation of off-farm livelihood opportunities, and the direct and indirect linkages towards mobility decisions. The findings indicate that Tarai farmers evaluate environmental risks and livelihood adaptation measures in the context of other risks that surround them, and employ a range of in-situ and ex-situ livelihood

opportunities at the household level, but off-site options are a much greater component than even a decade ago.

Tarai residents are already faced with a myriad of socio-economic problems which limit their livelihood options, and climate change is making these even more severe. Rural residents are exploiting ex-situ measures to better adapt to such changes, helping households avoid poverty traps. Policies should also be aimed at addressing issues in-situ, so that households are not vulnerable in the first place. Additionally, the increasing goal of Tarai migrants to work in international destinations suggests the ongoing inclusion of circular migration as an adaptation policy to mitigate impacts of future climate change in such resource dependent communities. Although migration pathways can help to secure income for the households, there are negative implications for agriculture, which rely on labour intensive practices. The challenged rural systems will pose further risks unless people can be supported to utilise their new financial capital to develop local socio-ecosystems. The following sections examine the findings related to each of the five research questions of this study.

7.2.1 Research questions 1 and 2: To what extent has the climate of the Tarai changed in the last three decades? To what extent have the locals perceived changes to the local environment and climatic patterns?

Chapter 6 presented detailed analysis of the direction and magnitude of global climate change in the Tarai, from the analysis of both biophysical and social perception data. Three decades of daily records relating to temperature and rainfall were analysed to understand the temporal behaviour of these aspects in the study sites, which were also compared with local perceptions of climate change. Biophysical trend analysis of extreme temperature indices show increases in both the maximum and the minimum extremes, and since extreme minimums are rising faster, the daily temperature range has narrowed. Analysis of rainfall related indices did not reveal significant trends, which could be due to the high inter-annual variation. Data also show increasing consecutive dry days and the subsequent decline in consecutive wet days. In contrast, the survey findings suggest that while respondents' perceptions of climatic change varied, consensus prevailed on the fact that summers were becoming shorter and cooler. Most respondents said that rainfall had been increasing, which could not be backed up by biophysical data, but could be explained by the particularly wet monsoon just months prior to the survey. Respondents outlined both positive and negative implications of perceived changes in climate. The significant negative perceptions of climate change were strongly related to respondents' prior experiences with floods in Damak.

7.2.2 Research question 3: To what extent is the Tarai socio-ecological system able to adapt to current and future impacts of climate variability and change?

Due to high rainfall variability, agricultural droughts and floods are a common phenomenon in the Tarai. Around half of the respondents had experienced floods in the past decade. Regarding possible adaptation measures that mitigate flood impacts, the majority of them were not satisfied with government initiatives and they suggested a number of techniques for protecting lives and livelihoods by avoiding or minimising damages from floods. Many such techniques (e.g. bamboo piling, hard barriers along the river bank, construction of dams to control water flow) were already being implemented, albeit with varying degrees of success. Many believed that flood impacts could be avoided by river taming; not surprisingly, such measures were often promised by candidates running for local elections. Only a minority of respondents suggested ideas such as buffer zones along the riverbanks by removing agricultural land from the edges of the river. Farmers have also experienced negative environmental impacts like loss of grazing lands, loss of forests, declining water levels in rivers, declining quality and quantity of ground water, and unpredictable harvests. Most farmers reported practicing some forms of coping and/or adaptation measures in their agricultural activities. However, due to a broad range of problems, ex-situ adaptation options like engaging in non-farm jobs or migrating for work have become common.

7.2.3 Research questions 4 and 5: To what extent are the Tarai farming households able to diversify their livelihood to include off-farm opportunities? To what extent is circular migration helping the Tarai farming households adapt to agricultural pressures?

Chapters 4 and 5 explore the motivation to migrate and the perceptions of the ways that migration has changed in the Tarai, and argue that environmental factors have played a part in modifying and amplifying traditional and new migration pathways. Historically, the Tarai has been an important focus of Nepali migration activities. Before the 1960s the Tarai, which is now home to most of the country's population and provides 60 percent of the nation's grain production, was almost entirely covered with dense forest. Despite the clear importance of the Tarai, National development efforts have been highly centralised.

Almost all the respondents in those households with at least one migrant, cited economic reasons for their household's decision to support a migrant working outside of the village. There is wide-spread realisation that the income that can be generated through local economic activities is not adequate. Many gave a more specific reason for migration pertaining to economic requirements, like providing for the family, their inability to bear medical costs for a family

member, and the failure of local livelihood options. Many migrants mentioned the peer pressure from families, friends and neighbours. Socio-economic factors were found to influence the choice of destination, for while the poorest and the least educated still seek employment in regional centres in India, most migrants aspire for other international destinations. Those having higher education degrees were generally not migrating, perhaps due to the fact that they could find well-paid jobs within Nepal. The fact that the income from remittances was much higher compared to income from the farm, suggests that more farmers will become migrants in the future, which could have implications for the sustainability of agriculture in the region. These changes could be seen as the signs of a transition from the first modern phase towards a much more complex reflexive modernity. Farmers have questioned traditional conservation methods and established livelihood practices, and are seeking alternatives to avoid the risks generated by the first, industrial modernisation. The concept of a second modernity, which posits the society as exposed to a number of simultaneous challenges - globalisation, ecological crisis, underemployment, individualisation etc. – also argues that society must address all these challenges concurrently (Beck 1992; Beck & Lau 2005). The problems of the Tarai thus could be described as a case of transitioning into a second modernity phase, which has been described as the by-product of the success of the first modernity. The Tarai case, however, is that unlike developed country reflexive transitions, the communities adapting to rapid change are relatively poor, uneducated, and disempowered, and the transition to reflexivity is being forced onto them by poverty, globalisation and environmental change.

7.2.4 Research question 6: To what extent is circular migration decision driven by environmental pressures?

This objective was addressed through a synthesis of the three discussion chapters. The most immediate economic impact of floods and other environmental changes was the loss of income, as most farmers rely on the harvest for a considerable portion of their income. In many cases such a loss of income had lead the household to rely on supplementary sources of capital, such as income from livestock, selling of firewood and grain stock and borrowing money. Access to natural resources like grazing grounds, river water and forests has become difficult. As a result many households have already given up on traditional ways of cooking with firewood and grazing livestock. When supplementary income was insufficient, or when a loan could not be repaid, the household tend to support a member to work off-farm either for the short-term or long-term. Thus, in the attempt to minimise risk and diversify earnings, Tarai households are practicing multiple adaptation strategies: while some members continue farming and livestock rearing, they often support young males to become labour migrants to ensure income that is independent of the local

climate and economy. Some farmers stated that they were benefiting from their adaptation activities, particular those who have invested in water pumps or switched to high value vegetable crops, and those households receiving remittances were better off financially than they were previously. Therefore, the environment is driving circular migration, but in an indirect form, where the economic well-being of households cannot be enhanced through local development opportunities.

7.2.5 Implications of findings on understanding the external drivers impacting livelihood systems

Compared to the early settlement days, the Tarai community have made significant progress in the areas of education, healthcare and general wellbeing. Despite the improvements however, the Tarai lags behind the Nepali Hills when it comes to development indicators. The Tarai still faces problems from social inequalities, slow improvements in human capital, and lack of a stable economic or physical environment. The transformation of the Tarai landscapes have eroded environmental health and caused depletion of natural resources. As a result, risks to agriculture-based livelihoods have increased, especially for the poorer sections of the society with little or no land ownership. The uncertainty of harvest has made many Tarai households reliant on supplementary ex-situ income, especially from remittances from household members who migrate to engage in menial work, while the remaining members continue agricultural work on their own lands as well as *adhiya* land, often with some form of communal labour sharing. As examined in Chapter 6, impacts from recurring flash floods still continue to impact many farmers. With increasing inter-annual variations, such incidents are likely to continue and even increase in the future, as revealed from the analysis of climatic records. While the impacts to livelihoods from floods were discussed by many respondents, it was clear that arranging for circular migration to ensure remittance income was of prime concern among many. This signals the ingrained transnational extension of Tarai livelihoods and the increasing roles such global forces play in rural livelihoods, rather than a direct form of environmental migration.

As discussed in the discussion Chapter 4, the inability of the agricultural sector to modernise has meant that the risks of farming have not been minimised. In fact, recent crises in access to fuel and extensive black-outs has arguably made farming riskier and forced households to rely more on ex-situ income. Tarai migrants, have joined their counterparts in Hills and Mountains and also sought to become migrant workers at new international destinations as discussed in Chapter 5. Additionally, as discussed in chapter 6, increased rainfall variability and environmental resource degradation have added a new challenge due to further uncertainties in agricultural risks that

further undermine the socio-economic resilience of communities. Although the link between environmental change and migration is rarely explicit, this added pressure on local agriculture is in part responsible for recent increases in circular migration. The mass exodus of migrants who are usually the household members with the highest human capital has in turn caused fundamental changes in the labour contribution towards agriculture. The lack of able-bodied youths in the household and high up-front costs involved in contemporary agriculture, has started to impact the forms of agriculture, which used to rely on non-cash inputs arranged by shared labour, use of locally available resources and payments made in-kind. This new situation can be expected to induce further risks to the poorer farmers with limited access to financial capital and increase reliance on ex-situ income. Amidst the existing and new threats, the trend in circular out-migration is expected to continue resulting in even greater reliance on remittances. Even with the popularity of new migration destinations, the income inequalities are likely to be reinforced as most of the new destinations with the prospect of higher remittances are not being utilised by the poorest households, as discussed in Chapter 6.

The Tarai has witnessed fundamental changes in the availability of natural resources and labour over the last 50 years. The lives of Tarai residents have been made better as they have access to modern amenities, better education and healthcare. That said, the Tarai still lags behind other regions of the country despite having a huge potential for agriculture and infrastructure development. Agriculture and livestock rearing have been the mainstay of the majority of the Tarai households with vital supplementary income coming from non-farm opportunities. The reliance on off-farm income is increasing due to a number of reasons. Firstly, in the absence of safety nets, income from agriculture is unreliable, and is likely to become increasingly more so, due to climate variability and change. Secondly, the income from new opportunities at international destinations promises a much higher income. This local exodus of individuals has already resulted in labour shortages at the household level, further increasing the input costs of agriculture. Measures to increase agricultural productivity have been few and far between. If this trend continues, it can be expected that the relationship between labour and agricultural practice will change significantly. These case studies confirm the linkage between environmental factors and off-farm employment albeit mediated by other socio-economic conditions.

Given the high inter-annual variability of rainfall and limited fresh water sources, irrigation has become scarce and highly contested. Farmers have to put extra effort into ensuring that their farm stays irrigated. Although extending the reach of irrigation is undoubtedly beneficial to the Tarai farmers, excessive and unregulated extraction of underground water can lead to long-term waning of the water-table and declining water quality (Shah et al. 2006, p. 307). On the other

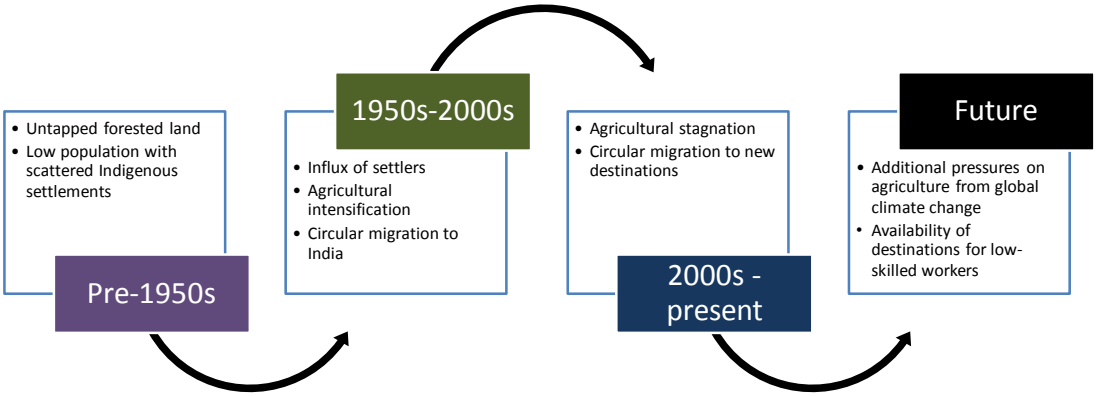
side, floods are an omnipresent danger in the Tarai and flood mitigation efforts have been limited to small scale physical barriers with a few exceptions looking at bio-engineering approaches. While adaptation measures to contain floods have been successful to some extent, most farmers still bear the full risk of crop losses as the popularity of crop insurance remains almost nil. The poor farmers in the study sites are unable to seek financial services support and do not have access to insurance measures that would compensate for the loss of harvests from flood or drought. Although the Crop and Livestock Directives 2012 has paved the way for insurance companies to offer agricultural insurance (Beema Samiti 2014; Ghimire 2013), such services are not widespread. None of the respondents from this survey had accessed such insurance mechanisms. Despite a 75 percent subsidy on crop insurance, the service has not been utilised (The Kathmandu Post 2016). Since the insurance schemes are recent, it could be expected that in future such services will be accessed by more Nepali farmers. The Insurance Board (IB) has also put forward plans to offer weather index-based crop insurance policies aimed at covering against losses incurred as a result of weather conditions (The Himalayan Times 2016).

Since early settlement days, the Tarai landscape has undergone a rapid transformation as evidenced by the extensive deforestation and establishment of agricultural fields. Those interventions have generated major changes in the availability and management of environmental resources. Contemporary changes in the environment, especially from global climate change are adding yet another layer of stress and accelerating transitions of the overall socio-ecological system.

Environmental problems are not the only causes of underdevelopment in the Tarai. Being regarded as a frontier settlement, the Tarai has not received national development attention and the region suffers from rural economies that are problematic in similar regions globally. The long standing socio-political issues like the relationship with the central government, the identity of the Tarai people, imbalances in the cost and prices for agriculture, and unfair share of development funds continue to resurface. The Tarai inherits historical inequalities set about by the then ruling class which resulted in an unfair distribution of land, enforced social inequalities especially for the indigenous inhabitants, and caused destruction of the environment. Although climate change impacts are emerging issues which further exacerbate current situations, a discussion of adaptation on its own is unlikely to resolve any problems if not considered in unison with broader development goals. In particular, development efforts geared towards the rural poor, and households unable to send migrants, appear to be more meaningful targets in increasing community resilience and preparing for anticipated threats.

There are significant differences in destinations and forms of mobility employed by rich and poor households. Poorer and less educated migrants dominate regional destinations requiring short-distance moves, whereas migrants with more economic capital and education opt for international destinations. The relationship however, is not linear as those with highest levels of education are found not to migrate out of the country. In most cases, destinations with high income potential are accessed by migrants with the highest human capital. Return migrants who had previously worked in India revealed that they want to make their next move to alternative international destinations. Similarly, return migrants from Gulf countries noted that they preferred Malaysia for their next destination. It is difficult to predict future movements which will depend on global demand for such labour. In any case, the significance of in-situ and regional opportunities remain as those with low socio-economic or human capital generally stay back or seek employment in closer destinations. Figure 7.1 presents a conceptual diagram summarising the key stages of shifts in the Tarai socio-ecological systems as indicated by environmental pressures and subsequent reliance on ex-situ mechanisms as a form of adaptation and learning.

Figure 7.1 Stages of livelihood-environment interactions in the Tarai.



International circular migration for the Tarai households has emerged as a means to expand their livelihood horizons to supplement agricultural income. Individually, the migrants are responding to local challenges utilising the limited resources available to them. Yet, collectively, they constitute the mass movement of people to procure labour that has become a necessity of the modern world, especially for projects in affluent global cities. In this process, the migrants unwittingly become part of a transnational society where international borders are fluid and people, capital and goods move freely. The migrants are indeed very much a part of "global mobilities", as Sheller and Urry (2003, p. 117) state:

> They result from people acting upon the basis of local information but where these local actions are, through countless iterations, captured, moved, represented, marketed and generalized within multiple global waves often impacting upon distant places and peoples.

The case of the Tarai illustrates the complex non-linear relationships that drive contemporary mobilities. It also shows how individuals with low human capital have become essential transnational actors in a globalised world, and it is not just a cosmopolitan elite who represent that group.

There is no cultural connection to the new destinations for most migrants and the passport they have is one of the few formal government-issued documents they own. Yet, they make this leap of faith, and board a plane to take them halfway across the world to engage in menial labour. As farming households integrating into global migration networks, they have broadened their arsenal of livelihood opportunities. In fact, those transnational networks being utilised by the farming communities are exclusive to the relatively poor, as the Tarai "elites" manage to find work within Nepal and have little need or the incentive to migrate. The study also shows that agricultural and environmental problems can to some extent catalyse transnationalism, because livelihoods are increasingly difficult to secure from in-situ development alone (Bardsley & Hugo 2010).

If the current socio-ecological trends were to continue, more migrants from the Tarai farming households are likely to resort to circular migration to international destinations. This research found an increasing desire for migrants to favour distant international destinations over regional destinations which have dominated past movements. Despite reports of some negative stories, motivations to migrate remain high. Moreover, more females are starting to migrate, defying past trends. Future outflows will be influenced by conditions at the existing and also emerging destinations, so any restrictions on visa extensions, curbing of illegal workers, or raising the bar for entry will affect the capacities of prospective migrant workers to access international opportunities. Additionally, if the demand for workers in current destinations were to decline, the migrants would have to find alternative destinations. The livelihoods of Tarai farmers are intricately tied to the health of world markets and liberal labour regimes. It is difficult to predict future hotspots of labour demand accurately. While the future migrants from the Tarai, and from Nepal, are likely to adapt to emerging trends, a global financial or political crisis affecting the Gulf countries or Malaysia would now seriously jeopardise the livelihoods of farming households in the Tarai. Global concerns like climate change, financial crisis and global demand for cheap labour are now part of the perceived risk for the residents of the Tarai communities. These global risks also shape the manner in which the Tarai farmers adapt locally with modifying agricultural practices or shifting livelihood options.

If the system is unable to respond to the external stresses, then the breakdown of the socio-ecological system may lead to what Wrathall (2012) calls an "undesirable state" where the

possibility of development is lost for the foreseeable future. Nepal is witnessing a transformation in political, social and cultural arenas. Arguably, there has already been a modal shift in the Tarai fuelled by social change. The contribution from agriculture to the nation's GDP has declined as the income from services sector have increased. Most notable is the increase in the remittances' contribution to the nation's earnings. An increasing reliance on remittances and less upon the agricultural economy in the Tarai could shift the whole region towards a state where the drivers of progress are spatially highly separate from the community they serve. Remittances have been found to be closely co-related with the capacity of Nepali households to adapt to stressors (Banerjee et al. 2011). Seddon and Adhikari (1998) have also positioned remittances as the most important driver of rural change even more important than infrastructure development like roads or irrigation facilities.

7.3 Theoretical, methodological and policy contribution

This research provides a socio-ecological framework for analysing livelihood adaptions in response to environmental and non-environmental drivers. The case studies highlight the complex and non-linear relationships between the issues of livelihoods, environmental pressures and human mobility. Using a socio-ecological framework enabled an examination the Tarai communities' management of current and future risks through complex resource management and livelihood diversification strategies. By examining the management of the threats to agricultural systems in the Tarai, the study is able to link the perceived and actual threats from climate variability and changes to migration decision-making, while also exploring how socio-economic conditions of the household mediate the risks.

This research also examined the historic context of the underdevelopment of the Tarai leading up to its current position using the framework of reflexive modernisation. That framework enabled the case of the Tarai to be examined from a range of perspectives, which revealed how the Tarai rural communities are interconnected with the rest of the world and are very much a part of a dynamic transnational community. The framework also revealed how transnationalism interacts with local livelihood issues in complex ways, which may not be promoting agricultural development. It also shows the possibility to anticipate significant systemic risks in such dependence.

The current literature on environmental change – human mobility nexus portrays a complex relationship between the two. While this study did not reveal a direct relationship between environmental change and human mobility in the Tarai, it provides evidence for empirically-based interactions between environmental pressures and migration decision-making at the household

level. In particular, this study links the existing underdevelopment and inequalities faced by the Tarai communities, the increased reliance on ex-situ livelihood opportunities, and current and future threats from climate change to understand how socio-economic factors mediate environmental risks and play a role in migration decision-making.

The analysis of monsoon rainfall in relation to local cropping patterns provides further insights into key pressure points in agriculture. The analytical procedures applied for site selection and sample selection are applicable for other regions as well. The procedures of climate data analysis used here can be applied to any limited data scenario. Overall, the study is able to link the rainfall being experienced in fewer days as an added burden for farming households due to added costs and/or harvest losses, which may in turn be forcing increased reliance on income from a migrant member. This study also provides a framework of integrating analysis of daily climatic data with local perceptions of change to evaluate, and anticipate, pressures on agriculture. Together, it is clear that the use of local perceptions and narratives gathered from interviews enable a deeper understanding of how potential futures could evolve in the Tarai to inform policy.

Historically, the Tarai socio-ecological system has shown resilience and successfully adapted to the changing conditions. However, emerging risks may not be successfully handled due to exceeding the threshold of adaptation causing a short-term disruption in the socio-ecological system (Bardsley & Pech 2012). In the case of the Tarai, there are limited avenues of adaptation in the agriculture sector to intensify and extensify production. The historical context of migration to and from the Tarai seems to have increased the ease of the use of migration as an additional livelihood option for farming households. The failure to provide for the household from agriculture alone has been a factor in migration decision-making at three separate stages for many Tarai households: the first move from the Hills or the Mountains was carried out in response to the difficulty to sustain livelihood from agriculture; the second move of circular migrants to India was to a large extent an attempt to supplement agricultural income, especially for households with little or no land of their own; finally, the contemporary migration to new international destinations can be seen as an extension of the second move that now includes migrants with relatively greater human capital. It must be reiterated that the lack of in-situ livelihood measures are a result of multiple socio-political factors in addition to agricultural and environmental reasons as discussed in Chapters 4 and 5.

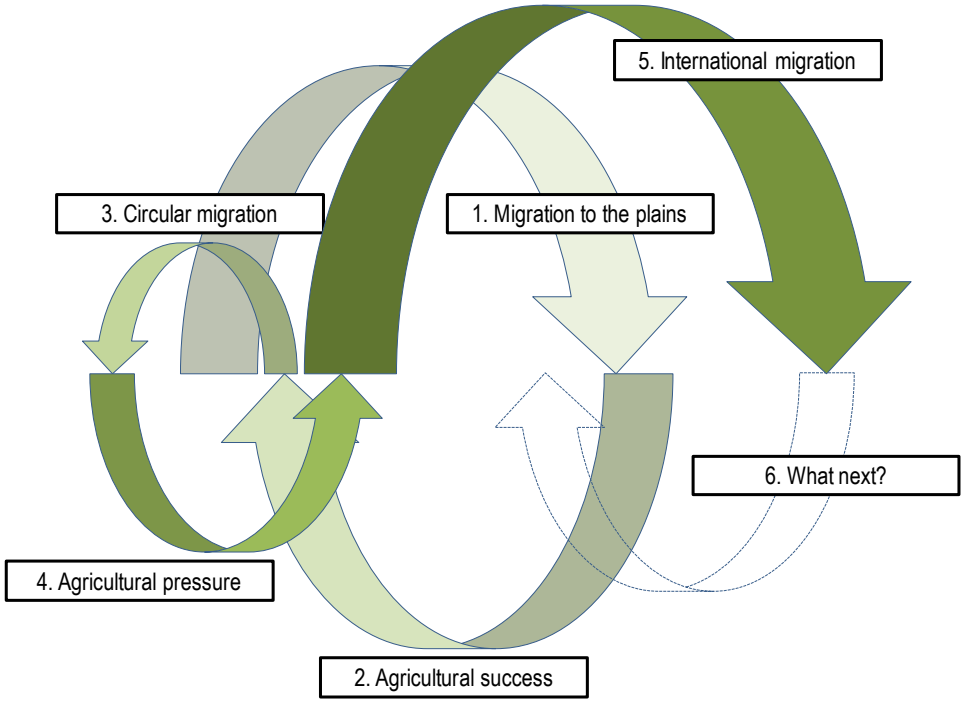
If current policies were to continue, support from the government for better agro-technologies could be expected to stay mediocre and any improvements in infrastructures are likely to be small. With the inevitable impacts of climate change, agricultural risks in the future will be more

intense eroding further the already fragile in-situ livelihood opportunities. This will push more farming households to send off migrant members, but households unable to do so will be most affected. Increased reliance on migration will also lead to disruption of the traditional farm management practices as household are faced with increased incentives to send a member to migrate effectively reducing labour availability in agriculture. A potential danger can be envisaged if the migration trends undermine agricultural production as households receiving remittances often do no need to engage in farming work to sustain livelihood, an example of modernisation generating its own, new risks (Beck 1992). A few cases from the survey described in Chapter 5 reveal that such a disconnect between remittances and agricultural development is already happening. The transition of the livelihood systems adopted by farming households in the Tarai in relation to the local environment and external opportunities, can be conceptualised as a series of attempts to maximise income from in-situ livelihoods followed by ex-situ migrations to strengthening the failing in-situ systems (Figure 7.2). The failure of agriculture to sustain livelihoods in the Hills and the Mountains partly resulted in the migration to the Tarai, but upon arriving in the Tarai, the settlers quickly realised the need for off-farm livelihood means as population pressure grew. Further pressures arising from economic, social and environmental factors have led the Tarai communities to seek alternative livelihood sources as reflected by the current international circular migration trends. Future livelihoods will based on the collective social learning of the Tarai communities as well as their ability to secure new avenues of livelihoods through a combination of in-situ and ex-situ (and possibly transnational) income sources.

As summarised in Figure 7.2, the Tarai socio-ecological system has undergone significant transitions which involves in-migration of external settlers to exploit agriculture, followed by attempts to expand ex-situ income opportunities initially at a regional scale, and later at a broader international scale. Firstly, the migration of Hill-origin settlers to the Tarai established the region as a populous hub [1]. In the post-settlement decades, the relative success of agriculture provided in-situ livelihood opportunities for the majority of households [2]. For the land-poor households, circular migration to India provided the essential income to supplement in-situ farm-based and off-farm income [3]. With limited improvements in infrastructure, lack of modernisation, and increased rainfall variability, agricultural development has stagnated, resulting in negative impacts to farm-based livelihoods [4]. Risks in agriculture and lack of in-situ opportunities have pushed many Tarai youths to opt for circular migration in distant international destinations in addition to India, as they are able to tap into transnational networks [5]. Global climate change is expected to further exacerbate the fragile conditions for agriculture in the Tarai in absence of proper adaptation measures. Furthermore, fluctuations in external factors such as the global

economic and political situation will determine the labour opportunities of low-skilled workers from the Tarai [6]. Together, the recent history of the Tarai suggests extraordinary adaptation capacities, but as households become more dependent on external labour, they have firmly extended a modern risk society and are exposed to modern risks. According to the concept of reflexive modernisation (Beck 1992), these modern risks are the inevitable consequences, or side effects of modernisation itself. In other words, as the Tarai society becomes more connected and the traditional livelihood systems are no longer dominant, they are inevitably exposed to new uncertainties and risks.

Figure 7.2 Conceptualisation of the evolution of livelihood pathways in the Tarai



As the Tarai become increasingly connected to global markets to supplement agriculture based livelihoods, it has been exposed more to global risks. Interconnected systems have added vulnerability compared to a less connected system in the sense that a failure of one sub-system will not impact other systems to a large extent (Ostrom 1997; Young et al. 2006). This increased connectedness of the Tarai socio-ecological system to global systems is thus exposing itself to additional global risks. The vulnerability of global systems have already been exposed through recent events such as the GFC, spread of viruses and the fall of oil prices. It is hence argued that although the Tarai farmers are poor, they are very much "transnationalised". In a situation similar to that described by the risk society theory, the Tarai is, to a large extent, has managed "traditional risks" like drought and floods, but are exposed to new "manufactured risks" such as global climate change and GFCs. Essentially, these new risks are global in nature and, unlike the traditional risks, cannot be addressed through local efforts. Circular migration has become

essential livelihood activity, and with that, Tarai residents have fully adopted transnationalism. As demonstrated in Chapter 6, climatic records reveal warming temperatures and shifting patterns of rainfall—such effects are also expected to be more pronounced in the future. As examined in Chapters 4 and 5, mechanisms for economic growth in-situ remains weak, and remittance incomes have largely been used for households' expenses. Tarai's rural livelihoods are tied to the world economy and are influenced by global market forces. In the absence of linkages to utilize remittances to fuel local businesses, erosion of in-situ opportunities has not stopped—this situation is likely to lead to an increase in the number of future circular migrants. The added interconnectedness to sustain livelihoods introduces new vulnerabilities posing serious risks to the Tarai because future opportunities will depend upon global market conditions. While the migrants can be expected to be flexible to respond in changes of destinations, impacts of financial stagnation, and competition with prospective circular migrants from other countries could likely impact earning potential.

While accepting the role migration can play in adapting to the impacts of environmental change, this study also highlights the pitfalls of existing migration pathways which force the poorest migrants out of destinations with higher remittance potential. The analysis of migration destinations and household demographic details revealed how existing structural inequalities are likely to be preserved even as households benefit from access to migration pathways. The disadvantaged groups who are unable to benefit from migration will be further disadvantaged if additional in-situ means of livelihoods are not provided. The underlying causes of vulnerability should address ensuring opportunities for households who are unable to migrate, and non-migrant members of households agricultural and other in-situ engagements. Broader development to generate local livelihood opportunities is necessary to ensure locally available manpower, are utilised for both farm and off-farm activities.

With Nepal opening up to the world to supply cheap labour force to world markets in the 2000s, the barrier of distance has disappeared. This in parts reflects the notion of modernisation and neo-liberalisation where national borders are porous and capita, goods and people move freely.

Since the establishment of the settlements, the Tarai socio-ecological system has undergone a major change. On the environmental side, the land-use now is predominantly occupied by agricultural land; the massive population influx has resulted in rapid and haphazard urbanisation; water sources have been tamed and used to exhaustion in some cases. As discussed in detail in Chapter 6, global climate change has resulted in warmer temperatures. Although this thesis focuses on the environmental and livelihood factors for migration decision, other factors at play

could include societal changes brought to the Tarai, like changes in the family structure, adoption of family planning measures, proliferation of mass media, and increased accessibility of education. Significant changes in family structures have been documented in Nepal (Ghimire & Axinn 2006; Goldstein & Beall 1986). Female headed households have increased, remittance contributions are higher than ever and cell-phones have reached 60 percent of rural households (CBS 2012a). On the societal side, amenities such as education, health care and telecommunication have been made more accessible; political representation is guaranteed; class distinctions and gender roles are slowly eroding; and residents are giving up traditional livelihoods for more contemporary options. While some of the shifts seem to originate from local or national initiatives, the process of globalisation has certainly made an impact on the Tarai socio-ecological system. On the flipside, circular migration patterns also already have implications on the Nepali family dynamics, especially when husband and wife migrate, leading to "split-households" and "dual-wage earner" families (Yamanaka 2005).

7.4 Limitations of the study and future research directions

This research has explored the interactions between the environment and the societal systems and demonstrated how influences from the environment translates into livelihood outcomes after being mediated by non-environmental factors. Nonetheless, there are some inevitable limitations that must be considered in judging the claimed interactions between environmental and social systems, and subsequent livelihood pathways.

Firstly, the analysis of trends in climate data was based on records from a limited number of meteorological stations and the records themselves had some missing values as discussed in detail in Chapter 6. Secondly, responses to questions regarding perceptions of flood and extreme rainfall events were strongly influenced by the events of the last monsoon, which had been particularly harsh. Thirdly, although the survey asked for the surname or caste group of the households, no analysis on the ethnicity was performed. The surname or caste group was used to differentiate whether the household belonged to groups indigenous to the Tarai or not, but a detailed analysis based on the caste hierarchy that is still prevalent in the Tarai could potentially reveal the role of socio-cultural factors.

For future research, the primary data collected from the household survey could possibly be used to predict the impact of extreme weather events on actual migration outcomes by applying a multilevel event history model. While this method has not been attempted in this thesis, the impact from extreme events can be represented by selected climate indices defined in chapter 6 and the number of flood incidents from DesInventar dataset. Taking various demographic and

socio-economic indicators such as education level, land owned and family size, such a model could be used to check if extreme events could be used as predictors of migration decisions. The research can be further extended by including detailed seasonal labour contribution to agricultural tasks by each household member. Environmental factors like soil quality, vegetation cover, water table etc. could also be integrated to garner a more detailed interaction to and from the environment. The understanding of interrelationships between environmental factors and livelihood could be made more comprehensive by utilising longitudinal data on households' perceptions, conditions and livelihood strategies. It may also be worthwhile for future scholarship to make use of existing longitudinal datasets like the NLSS data and integrate it with surveys on perception of environmental change to explore the environment-livelihood linkages. The study findings may apply to other municipalities or VDCs with similar livelihood experiences and socioeconomic conditions. However, the findings might differ in other contexts due to the specific socio-economic conditions of farming households and their access to markets and livelihood opportunities.

7.5 Conclusion

These case studies from Damak and Dhangadhi municipalities showcase how agricultural livelihoods are influence in non-linear ways by impacts from global environmental change, as well as transnational forces which shape global movements of goods, capital and people. The findings indicate that Tarai farmers evaluate environmental risks and livelihood adaptation measures in the context of external risks surrounding them. The Tarai residents are already faced with a myriad of socio-economic problems which limit their livelihood options, and climate change is expected to make these even more severe. Off-farm, ex-situ livelihoods has always been an integral household strategy in the Tarai, but recent trends among migrants suggest the popularity of distant international destinations. Trends in circular migration strategies also signify the role of Tarai migrants as essential transnational actors in a globalised world, and the connectedness of the Tarai rural communities to the rest of the world. Besides enabling the Tarai residents to better adapt to such changes with ex-situ measures to help households avoid poverty traps, policies should also be aimed at addressing issues in-situ, so that households unable to embrace circular migration are not vulnerable. Additionally, the goal of Tarai migrants to work in international destinations suggests the recognition of circular migration in adaptation policy to mitigate the impact on future climate change will be important for such resource-dependent communities. Although migration pathways increase prosperity for households, there are negative implications for labour intensive agriculture, which will pose further challenges unless people are supported to utilise their new financial capital to develop their local socio-ecosystems.

Appendix A: Household questionnaire survey form

प्रश्नावली Field Questionnaire

A प्रश्नावली फारम विवरण Questionnaire form details

प्रश्नावली नं:: Questionnaire no.:	☐☐☐☐☐☐		उत्तर दिनेको संकेत: Respondent ID:	☐☐☐☐☐☐	
सर्वेक्षक:: Surveyor:		मिती: Date:	☐☐-☐☐ - 20☐☐	शुरु हुदा समय: Start time:	समाप्त हुदा समय: End time:
स्थान: Location:		जिल्ला District		गाविस VDC	टोल / वडा Tole / Ward

B जनसांख्यिकीय Demographics

B.1 **लिङ्ग Sex** ☐ पुरुष Male ☐ महिला Female

B.2 **तपाईको जन्म साल बिक्रम संबतमा भन्नुहोस। यदि जन्म मिती याद छैन भने तपाईको उमेर भन्नु होस।**
Could you tell me your age or birth year in Bikram Sambat (BS)? If you don't remember birth year, tell me your age.

जन्म साल Birth year : _____ वा उमेर or Age: _____

B.3 **तपाई आफुलाई कुन जातीको भन्न रुचाउनु हुन्छ? Which cast do you prefer to identify your family?**

_____

B.4 **तपाईको परिवार यहाँ बस्नु भएको कति भयो? How long has your family lived here?** _____ year
वर्ष, वा बि. सं. _____ देखि or from _____B.S.

B.5 **तपाईको परिवार यहाँ बस्नु अगाडि कहां बस्नु हुन्थ्यो? Where did you family lived prior to moving here?**

_____ (जिल्ला district), _____ (गा.वि.स. VDC/न.पा. Municipality/म.न.पा. Metropolitan) नेपाल बाहिर भए देश र ठाउँको नाम name of place if outside of Nepal _____

B.6 **के कारण तपाईको परिवार यहाँ बस्न आउनु भएको हो? Why did your family move to this place?**

B.7 **तपाईको परिवारको विवरण Household profile**

व्यक्ति नं	पारिवारिक स्थान	वैवाहिक स्थिति (S/M/D/W)[9]	उमेर / जन्म साल	शिक्षा	लिङ्ग	प्रमुख पेशा / जीविका चलाउन गरिने मुख्य कार्य	अन्य पेशाको दखल
Person no.	Position in household	Marital status	Age / birth year	Education	Sex	Main occupation / activity for supporting household	Experience of any other occupation
1							
2							
3							
4							
5							
6							
7							

[9] S – Single, never married; M – Married; D – Divorced; W – Widowed

8							
9							

C घर-जमीन सम्बन्धि जानकारी Land and House details

C.1 तपाईको मुख्य घरको पर्खालको निर्माण कस्तो किसिमको छ? What is the type of wall construction of your primary house?

☐ सिमेन्ट - छड राखेको निर्माण Reinforced cement concrete masonry	☐ माटो, ढुङ्गाको निर्माण Mud-stone masonry	☐ काठको निर्माण Wooden construction	☐ अस्थाई निर्माण Temporary construction	☐ अन्य Other

C.2 तपाईको मुख्य घरको छानाको निर्माण कस्तो किसिमको छ? What is the type of roof construction of your primary house?

☐ सिमेन्ट - छड Reinforced concrete	☐ झिङ्गटी Tiles	☐ काठको फल्याक Wooden planks	☐ जस्ता पाता Galvanized steel	☐ खर/परालले छाएको Thatch	☐ अन्य Other

C.3 तपाईको घरमा कति तला छन्? How many floors are there in your house?	☐ १ 1	☐ २ 2	☐ ३ 3	☐ ४ वा बढी 4 or more
C.4 तपाईको घरले ओगटेको क्षेत्रफल कति होला? What is the approximate plinth area of your house?	☐ १० वर्ग मी सम्म up to 10 m^2	☐ १० देखी २० वर्ग मी सम्म >10-20 m^2	☐ २० देखी ४० वर्ग मी सम्म >20-40 m^2	☐ ४० वर्ग मी भन्दा वढी >40 m^2

C.5 तपाईको परिवारमा कति जना संग मोबाईल फोन छ? How many household members own a mobile phone?

☐ कसैसंग पनि छैन none	☐ १ जना 1	☐ २ जना 2	☐ ३ जना वा सो भन्दा बढी 3 or more

C.6 तपाईको परिवारको आमदानिको स्रोत के के हुन? What are the sources of income for your household?

प्राथमिक (मुख्य) **Primary**	द्रितीय Secondary	तृतीय Tertiary	अन्य Other

C.7 तपाईको घर-जग्गाको निम्न विवरण दिनुहोस। Please give details of the buildings or lands owned or managed by your household.

गा.वि.स./न.पा. - वडा नं. **VDC/Municipality – Ward no.**	जग्गाको किसिम **Type of land**	क्षेत्रफल (वि.-क.-धु. वा रो-आ-पै) **Area (B-K-D or R-A-P)**[10]			स्वामित्व प्रकार **Ownership type**[11]	हालको प्रयोग **Current use**

C.8 तपाईले प्रयोग गर्नु भएको जग्गा विगतको ५ वर्षमा घट-बढ भएको छ? Has the amount of land you use changed in the past 5 years? ☐ छ Yes ☐ छैन No

छ भने C.9 मा जानुहोस। छैन भने C.10 मा जानुहोस। If yes, answer C.9. If no, skip to C10.

[10] For Tarai region area measured in Bigha-Kattha-Dhur (B-K-D) and for hills and mountains measured in Ropani-Aana-Paisa (R-A-P).

[11] Full ownership / joint ownership with extended family / "mohi" (tenant system)

C.10

C.8

C.9 जग्गा घट-बढ हुनुको प्रमुख कारण के हो? What is the main reason for the change in the amount of land you use?

☐ जग्गा किनेकोले Bought land	☐ जग्गा बेचेकोले Sold land	☐ खेतीको लागि जग्गा अधिया लिएकोले Leased for use as *adhiya*	☐ खेतीको लागि जग्गा अधिया दिएकोले Leased out for use as *adhiya*	☐ अन्य Other _____

C.10 तपाईको परिवारले पशुपालन वा माछापालन गर्नु भएको छ? Do you own any livestock or fisheries?

☐ छ Yes ☐ छैन No

छ भने C.11 मा जानुहोस। छैन भने C.15 मा जानुहोस। If yes, answer C.11. If no, skip to C.15

C.11 पशुपालन वा माछापालन बारे विवरण

किसिम Type	संख्या Quantity	प्रयोजन Purpose	किसिम Type	संख्या Quantity	प्रयोजन Purpose
☐ कुखुरापालन Poultry			☐ माछापालन Aquaculture		
☐ बाखा पालन Goat			☐		
☐ गाई/भैसी पालन Cow/buffalo			☐		

C.12 तपाईले पशुपालन वा माछापालन बाट कुनै आम्दानी गर्नु भएको छ? Have you made income from livestock or fish farming? ☐ छ Yes ☐ छैन No

छ भने C.13 मा जानुहोस। छैन भने C.15 मा जानुहोस। If yes, answer C.13. If no, skip to C.15

C.13 गत १२ महिनामा पशुपालन वा माछापालनका कति उत्पादन आम्दानी गर्नु भयो? In the last 12 months how much income did you make from livestock or fish farming?

विषय Description	मात्रा / आम्दानि (रू) Quantity / Income (NPR)	विषय Description	मात्रा / आम्दानि (रू) Quantity / Income (NPR)

C.14 यदि तपाईको पशुपालनको लागि चरणको आवश्यक छ भने चरण सम्बन्धि विनरण दिनुहोस। If your livestock requires pasture, give details on the pasture.

पशुपालन रहेको स्थानदेखि चरणको दुरी **Distance to pasture from location of livestock**	चरणको क्षेत्रफल (बिघा) **Area (Bigha)**	किसिम (निजी/सार्वजनीक/सामुदायीक) **Type (Private/public/closed community)**

C.15 तपाईको परिवारले प्रयोग गरको जमीनमा खेतीपाती गर्नु हुन्छ? Do you grow or maintain crops on the land you own or use? ☐ गर्छौं Yes ☐ गर्दैनौ No

गर्नुहुन्छ भने C.16 मा जानुहोस। गर्नुहुन्न भने D मा जानुहोस। If yes, go to C.16, if no, skip to section D.

C.16 तपाईको जमिनमा कस्तो किसिमको खेती गर्नु हुन्छ (एक वा बढी छान्नुहोस)? What crops do you currently have in your land (you can select more than one)?

C.16.1 वार्षीक / अर्धवार्षीक बाली Annual or short-cycle crops

☐ धान Paddy	☐ मकै Maize	☐ गहु Wheat	☐ केरा Banana
☐ जौ Barley	☐ कोदो Millet	☐ जुट Jute	☐ तरकारी Vegetable ____

D

C.15

☐ तोरी Mustard	☐ अदुवा Ginger	☐	☐

C.16.2 सदावाहार बाली / रुख Perennial crops / trees

☐ चिया Tea	☐ कफी Coffee	☐ आँप Mango	☐ स्याऊ Apple
☐ सुर्ती Tobacco	☐ पान Betel		

C.17 तपाईले खेती गरेको उत्पादन आमदानीको लागि बेच्नु हुन्छ? Do you sell produce from the land you own or use for income? ☐ बेच्छु Yes ☐ बेच्दिन No

"बेच्छु" भने C.18. "बेच्दिन" भने C.19 मा जानुहोस। If yes, go to C.18. If no, skip to C.19.

C.18 माथि (C.16) भनेअनुसार गएको १२ महिनामा बालीको कति उत्पादन बिक्रि गर्नु भयो वा कति आमदानी गर्नु भयो? How much of each crops mentioned in C.16 have you sold or exchanged for other services in the past 12 months?

बाली Crop	मात्रा / आम्दानि (रू) Quantity / Income (NPR)	बाली Crop	मात्रा / आम्दानि (रू) Quantity / Income (NPR)

C.19 तपाईले गत ५ बर्षमा कुनै नयाँ बालीको सुरुवात गर्नुभएको छ? Have you started growing a new agricultural produce in the last five years? ☐ छ Yes ☐ छैन No

"छ" भने C.20. "छैन" भने C.21 मा जानुहोस। If yes, go to C.20. If no, skip to C.21.

C.20 कुन कुन नयाँ बाली सुरुवात गर्नुभयो? What new produce have been introduced?

C.21 तपाईले लगाउने बालीहरूको उत्पादन गत ५ बर्षमा कसरी हेरफेर भएको छ? How agricultural production changed in the past five years in the lands you own or use?

☐ धेरै बढेको छ Increased a lot	☐ बढेको छ Increased	☐ जस्ताको तस्तै छ Stayed same	☐ घटेको छ Declined	☐ धेरै घटेको छ Declined a lot

जस्ताको तस्तै छ भए D मा जानुहोस। अन्यथा C.22 मा अगाडि बढ्नुहोस। If "Stayed same", then skip to section D, else proceed to C.22.

C.22 तपाईले लगाउने बालीहरूको उत्पादनमा आएको हेरफेरको बारेमा व्याख्या गर्न सक्नु हुन्छ? Can you explain how the agricultural output have changed?

D

D पर्यावरणीय स्रोत Environmental resources

D.1 निम्न प्राकृतिक स्रोत साधनमा गत ५ बर्षमा आएको परिवर्तन बारे तपाईको धारणा दिनुहोस। Please give details on your experience of any changes in the availability of natural resources used by your household in the last 5 years?

स्रोतको नाम / स्थान **Resource Name/location**	प्रयोग (जीविका जलाउन / अन्य) **Use (livelihood/other)**	प्रयोगको आवृती र इकाई Frequency	उत्पादन (घास / दाउरा / पिउने पानी / खोलाको माछा) Product **(Fodder, firewood, drinking water, fishing etc.)**	गत ५ बर्षमा आएको परिवर्तन (१ देखि ५)[12] **Any significant change (1 to 5)**
बन-जंङ्गल Forest				
खोला **River**				
पोखरी **Pond**				
अन्य **Other**				

D.2 तपाईले खाना पकाउनको लागि कस्तो किसिमको ईन्धन प्रयोग गर्नु हुन्छ? What are the types of fuel do you use for cooking?

☐ दाउरा Firewood	☐ मट्टीतेल Kerosene	☐ ग्यास LPG	☐ बुजुली चुलो Electric stove	☐ अन्य other _____

E जलवायु सम्बन्धी अनुभव Perceptions on climactic and hydrological variables

E.1 तपाईले निम्न जलवायु सम्बन्धी सूचकहरुबारे कुनै परिवर्तन महसुस गर्नु भएको छ? Have you perceived following changes in the temperature?

	धेरै बढेको छ Increased a lot	बढेको छ Increased a little	जस्ताको तस्तै छ Stayed the same	घटेको छ Decreased a little	धेरै घटेको छ Decreased a lot

[12] 1 - धेरे सुधार भएको Improved a lot; 2 – सुधार भएको Improved; 3 – जस्ताको तस्तै रहेको Stayed the same; 4 – ह्रास आएको Worsened; 5- धेरै ह्रास आएको Worsened a lot

E.1.1	गर्मी मौसम (ग्रीष्म ऋतु) को गरमपना **Change in hotness of summer days**	☐	☐	☐	☐	☐
E.1.2	जाडो मौसम (शरद ऋतु) को चिसोपना **Change in coldness of winter days**	☐	☐	☐	☐	☐
E.1.3	जाडो मौसमको समय **Length of cold winter**	☐	☐	☐	☐	☐
E.1.4	गर्मी मौसमको समय **Length of hot summer**	☐	☐	☐	☐	☐
E.1.5	गर्मीको समयामा तातो हावा लाग्ने (गर्मी-लहर) **Heat wave in summer**	☐	☐	☐	☐	☐
E.1.6	जाडोको समयामा लाग्ने शीत-लहर **Cold wave in winter**	☐	☐	☐	☐	☐

E.1.7 तापक्रमा आएको परिवर्तन पारेको असर बारे कस्तो मुल्यांङकन गर्नुहुन्छ? How do you evaluate the impacts from changes in temperature?

☐ एकदमै प्रतिकुल Very negative	☐ प्रतिकुल Negative	☐ असर नपारेको No effect	☐ सकारात्मक Positive	☐ धेरै सकारात्मक Very positive

यदि "असर नपारेको" भए E.2 मा जानुहोस, नत्र E.1.8 मा अघि बढ्नुहोस। If "no impact" then skip to E.2, else, proceed to E.1.8.

E.1.8 तपाईको दैनिक जिविका संचालनमा तापक्रमा आएको परिवर्तनले कस्तो असर पारेको छ? What aspect of your livelihood has been impacted from the change in temperature?

E.1.9 तपाईको परिवारले तापक्रमा आएको परिवर्तनले ल्याएको असरलाई झेल्न कस्तो प्रबन्ध अपनाउनु भएको छ? How has your family coped with changing temperature?

E.1.10 तापक्रमा आएको परिवर्तन झेल्ने प्रबन्ध कतिको प्रभावकारी छ? How effective has the coping with changing temperature been?

☐ एकदमै प्रभावकारी Extremely effective	☐ धेरै प्रभावकारी Very Effective	☐ अलिकति प्रभावकारी Moderately effective	☐ थोरै प्रभावकारी Slightly effective	☐ पटकै प्रभावकारी छैन Not effective at all

E.2 तपाईले गत १० बर्षमा यहाँ हुने बर्षातको बारेमा कस्तो हेरफेर महसुस गर्नु भएको छ? Have you perceived following changes in the rainfall in the past 10 years?

	धेरै बढेको छ Increased a lot	बढेको छ Increased a little	जस्ताको तस्तै छ Stayed the same	घटेको छ Decreased a little	धेरै घटेको छ Decreased a lot

E.2.1	बर्षाको (असार-भदै) बेला पर्ने झरीको परिमाण **Amount of monsoon rainfall (Jun-Aug)**	☐	☐	☐	☐	☐
E.2.2	जाडो मौसम (हिउँद)मा पर्ने झरीको परिमाण **Amount of rainfall from Sep-Dec**	☐	☐	☐	☐	☐
E.2.3	बर्षा मौसम भन्दा अगाडिको (माघ-बैशाख) समायमा पर्ने झरीको परिमाण **Amount of pre-monsoon rainfall (Jan-May)**	☐	☐	☐	☐	☐

E.2.4 **कृपया बर्षाको हेरफेरले पारेको असरबारे तपाईको मुल्याङ्कन दिनुहोस। Please give an assessment of the effects that possible changes in rainfall is having.**

☐ एकदमै प्रतिकुल Very negative	☐ प्रतिकुल Negative	☐ असर नपारेको No effect	☐ सकारात्मक Positive	☐ धेरै सकारात्मक Very positive

यदि "असर नपारेको" भए F मा जानुहोस, नत्र E.2.5 मा अघि बढ्नुहोस। If "No effect" skip to section F. else, continue to E.2.5

E.2.5 **तपाईको दैनिक जिविका संचालनमा वर्षातको मात्रामा आएको परिवर्तनले कस्तो असर पारेको छ? What aspect of your livelihood has been impacted from the change in rainfall?**

E.2.6 **वर्षातको मात्रामा आएको परिवर्तन झेल्ने प्रबन्ध कतिको प्रभावकारी छ? How effective has the coping with changing rainfall been?**

☐ एकदमै प्रभावकारी Extremely effective	☐ धेरै प्रभावकारी Very Effective	☐ अलिकति प्रभावकारी Moderately effective	☐ थोरै प्रभावकारी Slightly effective	☐ पटक्कै प्रभावकारी छैन Not effective at all

E.2.7 **तपाईकप विचारमा वर्षातको मात्राम आएको परिवर्तन झेल्ने क्षमता बढाउन के गर्नु पर्ला? What do you think can be done to increase coping capacity for the change in rainfall?**

F पानीको प्रयोग र खडेरी Water use and drought

F.1 **तपाईले गएको ५-१० बर्षमा निम्न बुदाहरूमा कुनै परिवर्तन महसुस गर्नु भएको छ? Have you perceived following changes in the occurrence of drought in the past 10 years?**

	धेरै बढेको छ Increased a lot	बढेको छ Increased a little	जस्ताको तस्तै छ Stayed the same	घटेको छ Decreased a little	धेरै घटेको छ Decreased a lot

F.1.1	खाने पानीको स्रोतको संख्या **No. of water sources for drinking water**	☐	☐	☐	☐	☐
F.1.2	भुमिगत (जमीन मुनिको) पानीको प्रयोग **Underground water use**	☐	☐	☐	☐	☐
F.1.3	पोखरी / तालको पानीको सतह **Water level in ponds/lakes**	☐	☐	☐	☐	☐
F.1.4	वर्षाको बेलामा खोलाको पानीको सतह **Water flow in rivers during monsoon**	☐	☐	☐	☐	☐
F.1.5	हिउदको बेलामा खोलाको पानीको सतह **Water flow in rivers during dry season**	☐	☐	☐	☐	☐

F.1.6 **तपाईले घरमा प्रयोग गर्नुहुने पानीको गुणस्तरमा गतको ५-१० बर्षमा कस्तो परिवर्तन पाउनु भएको छ? Has the quality of water you use for household use changed in the past 5-10 years?**

☐ धेरे सुधार भएको Improved a lot	☐ सुधार भएको Improved	☐ जस्ताको तस्तै रहेको Stayed same	☐ ह्रास आएको Declined	☐ धेरै ह्रास आएको Declined a lot

F.1.7 **तपाईले घरमा प्रयोग गर्नुहुने पानीको पहुच ५ बर्ष भन्दा अगाडि भन्दा अहिले कस्तो पाउनु भएको छ? What is your assessment of accessibility of water for household use compared to 5 years ago?**

☐ धेरै सजिलो भएको छ Highly accessible	☐ सजिलो भएको छ More accessible	☐ जस्ताको तस्तै छ Stayed same	☐ गार्हो भएको छ Difficult to access	☐ धेरै गार्हो बएको छ A lot difficult to access

F.1.8 **तपाईको परिवारले घरायसी कामको लागि पटक-पटक प्रयोग गर्ने पानीको तीन वटा सम्म स्रोतको विवरण दिनुहोस। Give details on three sources of water that you use regularly for household use.**

स्रोतको प्रकार **Source type**	प्रयोग **Use**	स्थान **Location**	स्रोतबाट घरसम्म पानी ल्याउन लाग्ने समय (मिनेटमा) **Time taken in minutes to make a round trip from home**	उक्त स्रोत कतिको प्रयोग गर्नु हुन्छ? **How often do you use the source**

F.1.9 **गत ५ वर्षमा, के तपाईको परिवारले १ दिन वा बढी समय सम्म निम्न घरायसी प्रयोजनको लागि पर्याप्त पानी नपुगेको महसुस गर्नु भएको छ? In the past five years, has your family experienced a day or more during which your family did not have enough water for basic household use (like cooking, washing, bathing and drinking)?**

Cooking: Yes No	Washing: Yes No	Bathing: Yes No
खाना पकाउन: ☐ छ ☐ छैन	**लुगा धुन:** ☐ छ ☐ छैन	**नुहाउन:** ☐ छ ☐ छैन

यदि कुनैपनि एक उत्तर "छ" हो भने F.1.10 मा जानुहोस, नत्र भने F.2 मा जानुहोस। If answered "yes" in any of the options, proceed to F.1.16, else, skip to F.2.

F.1.10 **गत ५ बर्षमा कति पटक तपाईको परिवारले पानिको अभाव भोग्नु पर्यो? How frequent did your family face water scarcity in the last decade?**

☐ एक बर्षमा धेरै पटक Multiple times a year	☐ प्रत्यक बर्ष १-२ पटक Every year	☐ २-४ बर्षमा १-२ पटक Every few years	☐ अहिले सम्म १ पटक मात्र Only once

F.1.11 **पछिल्लो पटक तपाईको परिवारले भोग्नु परेको पानीको अभाव को बारेमा केहि भन्न सक्नु हुन्छ? Could you please tell us about the last time when your family faced water scarcity?**

F.2

F.1.9

F.2 के तपाईले गएको ५-१० बर्षमा खडेरि सम्बन्धी निम्न बुदाहरूमा कुनै हेरफेर पाउनु भएको छ? Have you perceived any of the following changes in the occurrence of drought in the past 10 years?

	धेरै बढेको छ Increased a lot	बढेको छ Increased a little	जस्ताको तस्तै छ Stayed the same	घटेको छ Decreased a little	धेरै घटेको छ Decreased a little
F.2.1 सिंचाइको लागि प्रयोग गरिने पानी **Water for crop irrigation**	☐	☐	☐	☐	☐
F.2.2 खडेरी घटनाको संख्या **No. of drought in the past 10 years**	☐	☐	☐	☐	☐
F.2.3 खडेरीले कृषी उत्पादनमा गरेको बिगार **Damage to agricultural produce from drought**	☐	☐	☐	☐	☐

F.2.4 यस स्थानमा खडेरीको घटना भएको तपाईलाई थाहँ छ? Do you know of any incidence of drought in this place? ☐ छ Yes ☐ छैन No

छ भने F.2.5 मा जानुहोस। छैन भने F.2.8 मा जानुहोस। If Yes, procede to F.2.5, if No, Skip to F.2.8.

F.2.5 तपाईको परिवारले खडेरीको घटना झेल्न के कस्तो प्रबन्ध अपनाउनु भएको छ? How has your family coped with drought?

F.2.6 खडेरी झेल्न तपाईले अपनाउनु भएको प्रबन्ध कतिको प्रभावकारी छ? How effective has the coping with drought been?

☐ एकदमै प्रभावकारी Extremely effective	☐ धेरै प्रभावकारी Very Effective	☐ अलिकति प्रभावकारी Moderately effective	☐ थोरै प्रभावकारी Slightly effective	☐ पटक्कै प्रभावकारी छैन Not effective at all

F.2.7 कृपया तपाईको समुदायले भोग्नु परेको पछिल्लो खडेरीको घटना बारे केहि भनिदिनुहोस। Tell us about the last drought event that your community faced.

F.2.8 गत ५ वर्षमा, के तपाईको परिवारले १ दिन वा बढी समय सम्म सिंचाइको लागि पर्याप्त पानी नपुगेको महसुस गर्नु भएको छ? In the past five years, has your family experienced a day or more during which your family did not have enough water for irrigation? ☐ छ Yes ☐ छैन No

"छ" हो भने F.2.9 मा जानुहोस, नत्र भने G मा जानुहोस। If Yes, proceed to F.2.9, else skip to section G.

F.2.9 गत १० बर्षमा कति पटक तपाईको परिवारले सिंचाइको लागि पानिको अभाव भोग्नु पर्यो? How frequent did your family face water scarcity in the last decade?

☐ एक बर्षमा धेरै पटक Multiple times a year	☐ प्रत्यक बर्ष १-२ पटक Every year	☐ २-४ बर्षमा १-२ पटक Every few years	☐ अहिले सम्म १ पटक मात्र Only once

F.2.10 **पछिल्लो पटक तपाईको परिवारले भोग्नु परेको सिंचाइको लागि प्रयोग हुने पानीको अभाव को बारेमा केहि भन्न सक्नु हुन्छ? Could you please tell us about the last time when your family faced water scarcity for irrigation purpose?**

G बाढी Flood

G.1.1 **के तपाईको यस स्थानको घर वा जमीन गत १० बर्षमा बाढीमा परेको छ? Has your home or land been flooded in the past 10 years?** ☐ छ Yes ☐ छैन No

छ भने G.1.2 मा जानुहोस। छैन भने H मा जानुहोस। If yes, proceed to G.1.2, if no, skip to section H.

G.1.2 **पछिल्लो पटको बाढी कति समय सम्मको आएको थियो?** _____ दिन। **For how many days did the flood last? _____ days.**

G.1.3 **त्यो बाढी कति स्थान सम्म फैलिएको थियो? What was the extent of that flood?**

☐ पुरै जिल्ला र त्यस भन्दा पनि बाहिर Whole district and beyond	☐ पुरै जिल्ला Whole district	☐ केहि गाबिसहरू Few VDCs	☐ यस गाविस मात्र Only this VDC	☐ कुनै कुनै वडा हरू मात्र Few wards of this VDC

G.1.4 **बाढी जमीनबाट कति सम्म माथि आएको थियो? How high was the flood?**

☐ >१२० से.मि.	☐ >६०-१२० से.मि.	☐ >३०-६० से.मि.	☐ >१५-३० से.मि.	☐ ३० से.मि. भन्दा बढि
☐ >120cm	☐ >60-120cm	☐ >30-60cm	☐ >15-30cm	☐ more than 30 cm

G.1.5 **तपाईको घर वा जमीनमा के कस्तो क्षति पुर्यायो? What damage was done by the flood to your property?**

G.1.6 **बाढि आउनु भन्दा अगाडि कुनै सूचना पाउनु भएको थियो? Did you receive any warning regarding the flood event?** ☐ पाएको थिए Yes ☐ पाएको थिएन No

पाउनु भएको थियो भने G.1.7 मा जानुहोस। पाउनु भएको थिएन भने G.1.11 मा जानुहोस। If yes, proceed to G.1.7, if no, skip to G.1.11.

G.1.7 **अग्रिम सुचना बाढी आउनु भन्दा कति समय अगाडि पाउनु भएको थियो? How long before the event did you receive the warning?**

☐ १ हप्ता भन्दा अगाडि A week or more ahead	☐ ४-७ दिन अगाडि 4-7 days	☐ २-३ दिन अगाडि 2-3 days	☐ एक दिन अगाडि One day	☐ एक दिन भन्दा कम Less than a day

G.1.8 **अग्रिम सूचना के कस्तो माध्यम बाट प्राप्त गर्नु भयो? How did learn about the warning? Please select one or more?**

☐ रेडियो Radio	☐ टिभी TV	☐ मोबाईल फोन Cell phone call	☐ साधारण फोन (ल्यान्ड लाईन) Land-line phone call	☐ छिमेकी बाट Neighbours
☐ सावधानी सूचना घण्टी Warning sirens	☐ स्थानीय सूचना Local Announcement	☐ अन्य (कृपया भन्नुहोस्) Other: (please specify)		

G.1.9 **सूचनाले भने अनुसार गर्नु भयो कि भएन? Did you heed to the warning?** ☐ गरे Yes ☐ गरिन No

"गरे" भने G.1.10 मा जानुहोस। "गरिन" भने G.1.11 मा जानुहोस। If yes, proceed to G.1.10, if no, skip to G.1.11.

G.1.10 **किन सूचनाले भने अनुसार गर्नु भएन? Why did you not heed to the warning?**

G.1.11 **बाढी बाट तपाईको घर-जमीन बचाउन के कस्तो बिधि अपनाउनु भएको छ? What measures have you carried out to protect your land and house from being damaged by flood?**

1.	2.
3.	4.

G.1.12 **बाढी झेल्ने प्रबन्ध कतिको प्रभावकारी रह्यो? How effective has the coping with flood been?**

☐ एकदमै धेरै प्रभावकारी Extremely effective	☐ धेरै प्रभावकारी Very Effective	☐ ठिकठिकै प्रभावकारी Moderately effective	☐ थोरै प्रभावकारी Slightly effective	☐ प्रभावकारी छैन Not effective at all

G.1.13 **कुनै यस्तो बिधि अपनाउने बिचार छ जुन अपनाउन सक्नु भएको छैन? Are there any measures that you wanted to carry out to protect your house from being damaged by flood/landslide but could not carry out?**

☐ छ Yes ☐ छैन No

छ भने G.1.14 मा जानुहोस। छैन भने H मा जानुहोस। If yes, proceed to G.1.16, if no, skip to section H.

G.1.14 **सो बिधि के हो र किन अपनाउन किन नसक्नु भएको हो? Why were you unable to carry out the measure?**

H संस्थागत व्यवस्था Institutional mechanisms

7.6 **के तपाईले सरकार वा अन्य संघ-संस्थाबाट बाढीले गरेको बिगारको लागि क्षतिपूर्ति पाउनु भएको छ? Have you received any help from the government or other agencies as compensation for the water-induced hazards like flood, landslide or drought?**

☐ छ Yes ☐ छैन No

7.7 **यदि छ भने विवरण दिनुहोस छैन भने (।) मा जानुहोस। If yes, please give the details of the event and subsequent aid received. If no, skip to section I.**

घटना/बर्ष Event / Year	सहयोगको प्रकार / Aid type	संघ/संस्था Agency / Institution	सहयोगको प्रभागकारिता[13] Aid effectiveness

I बाहिरि रोजगार External employment

I.1 **तपाईको परिवारको कुनै सदस्यले रोजगारीको लागि घर छोडेर अन्य स्थान (देश भित्रै वा विदेशमा) मा जानुभएको छ? Do any of your family members have left the household to live and work elsewhere (either within the country or abroad)?** ☐ छ Yes ☐ छैन No

छ भने I.2 मा जानुहोस। छैन भने I.14 मा जानुहोस। If yes, proceed to J.2. If no, skip to J.8.

[13] 1- एकदमै धेरै प्रभावकारी Extremely effective; 2 - धेरै प्रभावकारी Very Effective; 3 - ठिकठिकै प्रभावकारी Moderately effective; 4 - थोरै प्रभावकारी Slightly effective; 5 - प्रभावकारी छैन Not effective at all

J

I.2 सो सदस्य काम गर्ने स्थानबारे बिवरण दिनुहोस. Please give the details on where you or your family members work.

व्यक्ति नं (B.7 अनुसार) **Person number** (same as B.7)	कार्य स्थान (नगर/शहर/देश) **Work location (town/city/country)**	समयावधि (मौसमी/दीर्घकालिन) **Seasonal/long term**	कामको किसिम **Work type**	उक्त स्थानमा काम गरेको कति वर्ष भयो? How many years has the person been working there?	उक्त स्थान रोज्नुको कारण Reason for selecting the location

I.3 वर्षको कति पटक बाहिर काम गर्न गएको परिवारको सदस्य भेट्नलाई घर आउनुहुन्छ? How often in a year do the family members who have left household for work come back for visit?

_____

I.4 यदि बाहिर काम गर्ने परिवारको सदस्य विवाहित हुनु हुन्छ भने, उहाँको पति/पत्नीलाई पनि संगै लानु भएको छ वा लाने योजन बनाउनु भएको छ? If the member is married, has the spouse joined or planning to join? ☐ छ Yes ☐ छैन No

I.5 जुन सदस्य कामको लागि बाहिर जानु भयो, उहाँ को कामको लागि जानु भन्दा अगाडि के काम गर्दै हुनुहुन्थ्यो (जस्तै खेती, पढाई, कामको खोजि)? What were the members who left for work doing (working in farm, studying, looking for job) in the year prior to leaving for work?

I.6 सो सदस्य किन कामको लागि घर छोड्नु परेको हो? Why did the member leave household to work outside?

I.7 सो सदस्यले अहिले काम गरेको स्थानमा उहाको नातेदार वा साथी कोहि हुनुहुन्छ ? Did the member who moved had a relative/friend at the destination?

☐ हुनुहुन्छ Yes ☐ हुनुहुन्न No

I.8 के रोजगारीको लागि जानुभएको बेलामा कुनै आर्थिक सहयोग लिनुभएको थियो? Did the member who moved receive any assistance from the relative/friend when he moved to the place?

☐ थियो Yes ☐ थिएन No

I.9 आर्थिक बाहेक अन्य कुनै सहयोग प्राप्त भएको थियो? Besides financial assistance, did you receive any other help?

I.10 बाहिर काम गर्न जानु भएको कुनै सदस्यले गत २ बर्षमा पैस पठाउनु भएको छ? Has the migrant member sent remittance in the last 2 years? ☐ छ Yes ☐ छैन No

छ भने I.11 मा जानुहोस। छैन भने I.14 मा जानुहोस। If yes, proceed to I.11, else, skip to I.14

I.11 एक बर्षमा कति पटक तपाईको परिवारले रकम प्राप्त गर्छ? **How frequently do you receive remittances? _____**

I.12 गत साल अन्दाजी कति रकम प्राप्त भएको थियो? **How much remittance did your household receive last year _____**

I.13 प्रात रकम के-कस्तो कार्यमा प्रयोग भयो? **What was the money received used for?**

I.14 के तपाईको परिवारको (अन्य) कुनै सदस्यले यस ठाउँ छोडेर कामको लागि अन्य स्थानमा जाने योजना बनाउनु भएको छ? **Do any member of your household plan to leave this place for work?**

☐ छ Yes ☐ छैन No

यदि छ भने अगाडि I.15 मा जानुहोस। छैन भने I.16 मा जानुहोस।

I.15 कुन सदस्यले यस्तो योजना बनाउनु भएको छ? **Which member of your family has made such a plan?**

B.7 मा भरे अनुसार व्यक्ति नं. Person no. as per B.7 _____

I.16 तपाईको परिवारले गत ५ बर्षमा कुनै आर्थिक सहयोग प्राप्त गर्नु भएको छ? **Has your household taken any financial assistance in the past 5 years?** ☐ छ Yes ☐ छैन No

यदि छ भने अगाडि I.17 मा जानुहोस। छैन भने J मा जानुहोस। If yes, proceed to I.17. If no, skip to J.

I.17 तपाईले आर्थिक सहयोग कहाँबाट प्राप्त गर्नु भयो? **Where did you get the financial assistance from?**

☐ आफन्त Loan from Relatives	☐ स्थानीय व्यापरी Loan from local business person	☐ बैक / वित्तीय संस्था Bank loan	☐ सहकारी संस्था Loan from co-operatives
☐ लघू-ऋण Micro-finance	☐ अन्य (कृपया भन्नुहोस) Others (Please specify):		

I.18 ब्याज दर र धितो राखेको सम्पत्तिको विवरण. **Please list the interest rate and collateral for the financial assistance that you received.**

I.19 ऋण कसरी तिर्नु भयो वा कसरी तिर्ने योजना बनाउनु भएको छ? **How did you pay or plan to pay the loan?**

J

J अभिमत **Opinion**

J.1 तपाईलाई कुनै कुरा थप्न मनलागेको छ? **Is there anything that you would like to add?**

यस प्रश्नावली मा भाग लिनुभएको मा धन्यबाद!

Thank you for participating in the survey!

Appendix B: Participant Information Sheet – questionnaire survey

Information Sheet for Participants of Questionnaire Survey

We, Douglas Bardsley and Asheshwor Shrestha, are researchers at University of Adelaide investigating the vulnerability of the social and environmental systems to water-induced hazards like floods, landslides and droughts in Nepal. The primary objectives are to provide a understanding of the physical change as evident from recorded measurements and from perceptions of the inhabitants and to recommend directions for the community for better management of water-induced hazards.

The questionnaire seeks to gather information about your household, the environment and climate of your village and water-induced hazard events like landslides, droughts and floods that you may have experienced. The survey takes about 30-45 minutes. You have the right to withdrawal from the survey at any time.

The outcome of the survey will be used in academic publications and presented in academic settings. Information regarding individual participation will be kept confidential. Identifying the respondent from the data collected in the questionnaire forms is not possible.

Please answer all questions to the best of your knowledge, feelings and experiences. The information gathered in this study will provide the basis for understanding of the local environment and their relationship with the community. No personal benefit to the respondents is assured. However, the research will assist in the management of water-induced hazards and preparation of the community from possible increased incidence of such events in the advent of climate change.

By completing this questionnaire, you are agreeing to participate in the above described research project.

For any questions about this research you can contact either of the researches or if you wish to make an independent inquiry, please follow the **Contacts for Information on Project and Independent Complaints Procedure** sheet handed to you.

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or

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Appendix C: Participant Information Sheet – expert interviews

Information Sheet for Participants – Expert Key-Informants

We, Douglas Bardsley and Asheshwor Shrestha, are researchers at University of Adelaide investigating the vulnerability of the social and environmental systems to water-induced hazards like floods, landslides and droughts in Nepal. The primary objectives are to provide a understanding of the physical change as evident from recorded measurements and from perceptions of the inhabitants and to recommend directions for the community for better management of water-induced hazards.

The interview takes about 1 hour. You have the right to withdrawal from the interview at any time. The questions will be focused on:

- Major issues in climate change adaptation and water-induced hazard management in the region.
- Your observation regarding trends in the current climate and local environment and subsequent responses.
- The role of your organization in climate change adaptation and water-induced hazard management in the region.

Real names of the interviewees will not be used in any publications. When quoting from the interview, any identifying information such as name or position in an organization of the interviewee will not be used and the interviewees will only be referred to by codes.

The outcome of the survey will be used in academic publications and presented in academic settings. Information regarding individual participation will be kept confidential. Identifying the respondent from the data collected in the questionnaire forms is not possible.

Please answer all questions to the best of your knowledge, feelings and experiences. The information gathered in this study will provide the basis for understanding of the local environment and their relationship with the community. No personal benefit to the respondents is assured. However, the research will assist in the management of water-induced hazards and preparation of the community from possible increased incidence of such events in the advent of climate change.

For any questions about this research you can contact either of the researches or if you wish to make an independent inquiry, please follow the **Contacts for Information on Project and Independent Complaints Procedure** sheet handed to you.

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Appendix D: Participant Information Sheet – general interviews

Information Sheet for Participants – Local Key-Informants

We, Douglas Bardsley and Asheshwor Shrestha, are researchers at University of Adelaide investigating the vulnerability of the social and environmental systems to water-induced hazards like floods, landslides and droughts in Nepal. The primary objectives are to provide a understanding of the physical change as evident from recorded measurements and from perceptions of the inhabitants and to recommend directions for the community for better management of water-induced hazards.

The interview takes about 1 hour. You have the right to withdrawal from the interview at any time. The questions will be focused on:

- Your perception regarding trends in the current climate and local environment.
- Your experience of dealing with any water induced disaster events.

Real names of the interviewees will not be used in any publications. When quoting from the interview, any identifying information such as name or position in an organization of the interviewee will not be used and the interviewees will only be referred to by codes.

The outcome of the survey will be used in academic publications and presented in academic settings. Information regarding individual participation will be kept confidential. Identifying the respondent from the data collected in the questionnaire forms is not possible.

Please answer all questions to the best of your knowledge, feelings and experiences. The information gathered in this study will provide the basis for understanding of the local environment and their relationship with the community. No personal benefit to the respondents is assured. However, the research will assist in the management of water-induced hazards and preparation of the community from possible increased incidence of such events in the advent of climate change.

For any questions about this research you can contact either of the researches or if you wish to make an independent inquiry, please follow the **Contacts for Information on Project and Independent Complaints Procedure** sheet handed to you.

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Appendix E: Consent form (English version)

Human Research Ethics Committee (HREC)

CONSENT FORM

1. I have read the attached Information Sheet and agree to take part in the following research project:

Title:	Climate change and water hazard management: a comparative study of socio-ecological linkages in the Nepali Mid-Hills and Tarai
Ethics Approval Number:	HP-2013-021

2. I have had the project, so far as it affects me, fully explained to my satisfaction by the research worker. My consent is given freely.
3. I have been given the opportunity to have a member of my family or a friend present while the project was explained to me.
4. Although I understand the purpose of the research project it has also been explained that involvement may not be of any benefit to me.
5. I have been informed that, while information gained during the study may be published, I will not be identified and my personal results will not be divulged.
6. I understand that I am free to withdraw from the project at any time.
7. I agree to the interview being audio recorded. Yes ☐ No ☐
8. I am aware that I should keep a copy of this Consent Form, when completed, and the attached Information Sheet.

Participant to complete:

Name: _____ Signature:_____
Date:_____

Researcher/Witness to complete:

I have described the nature of the research to

_____

and in my opinion she/he understood the explanation.

Signature: _____ Position:_____
Date:_____

Appendix F: Complaints procedure form (English version)

The University of Adelaide
Human Research Ethics Committee (HREC)

CONTACTS FOR INFORMATION ON PROJECT AND INDEPENDENT COMPLAINTS PROCEDURE

The following study has been reviewed and approved by the University of Adelaide Human Research Ethics Committee:

Project Title:	Climate change and water hazard management: a comparative study of socio-ecological linkages in the Nepali Mid-Hills and Tarai
Approval Number:	HP-2013-021

The Human Research Ethics Committee monitors all the research projects which it has approved. The committee considers it important that people participating in approved projects have an independent and confidential reporting mechanism which they can use if they have any worries or complaints about that research.

This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research (see http://www.nhmrc.gov.au/publications/synopses/e72syn.htm)

1. If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the project co-ordinator:

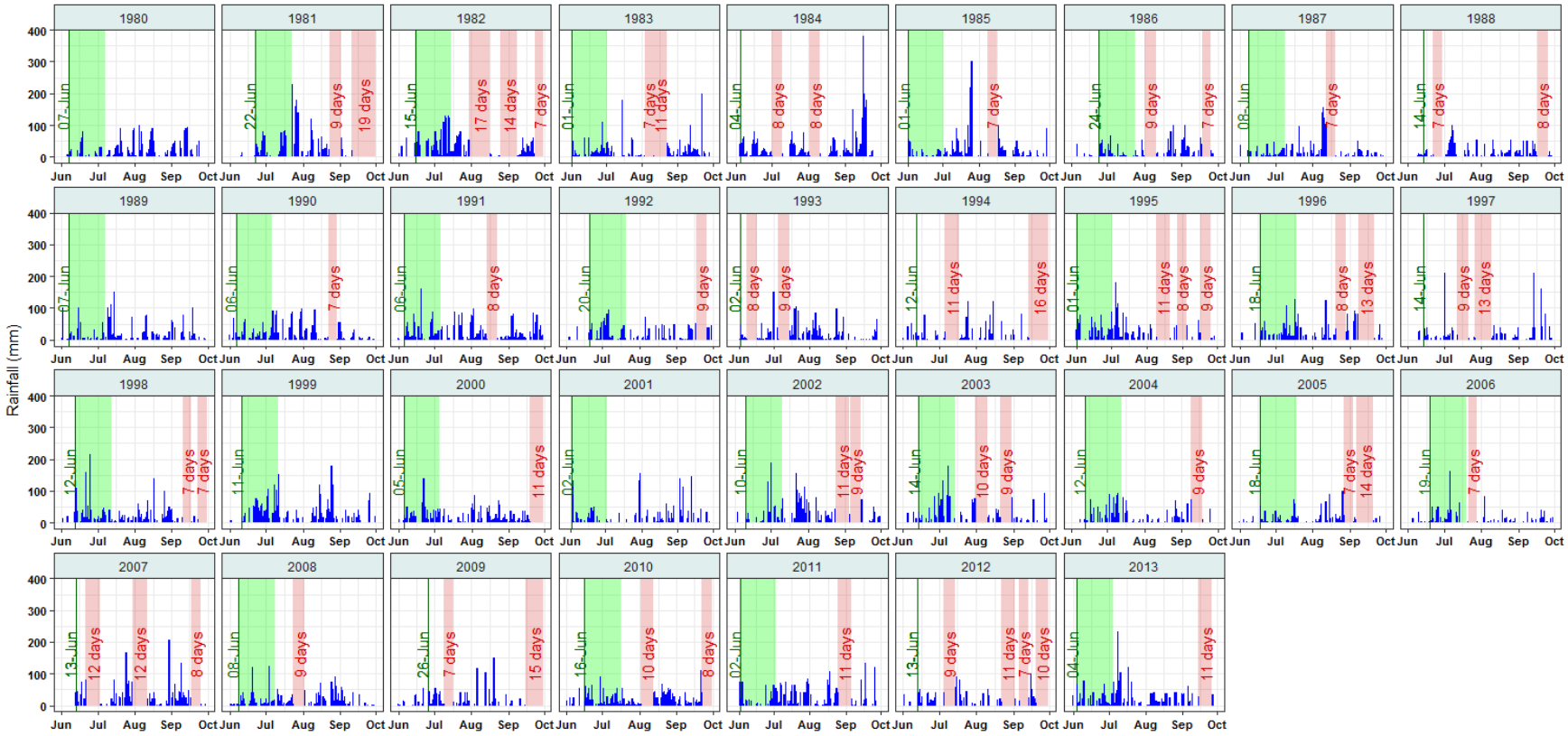
Name:	Dr. Douglas Bardsley, Senior Lecturer (Primary contact) Asheshwor Man Shrestha, PhD Candidate (Alternate contact)
Phone:	+61 8 831 34490

2. If you wish to discuss with an independent person matters related to:
   - making a complaint, or
   - raising concerns on the conduct of the project, or
   - the University policy on research involving human participants, or
   - your rights as a participant,

   contact the Human Research Ethics Committee's Secretariat on phone (08) 8313 6028 or by email to hrec@adelaide.edu.au

Appendix G: Daily rainfall, monsoon onset day, dry-spell days and successful plantation days

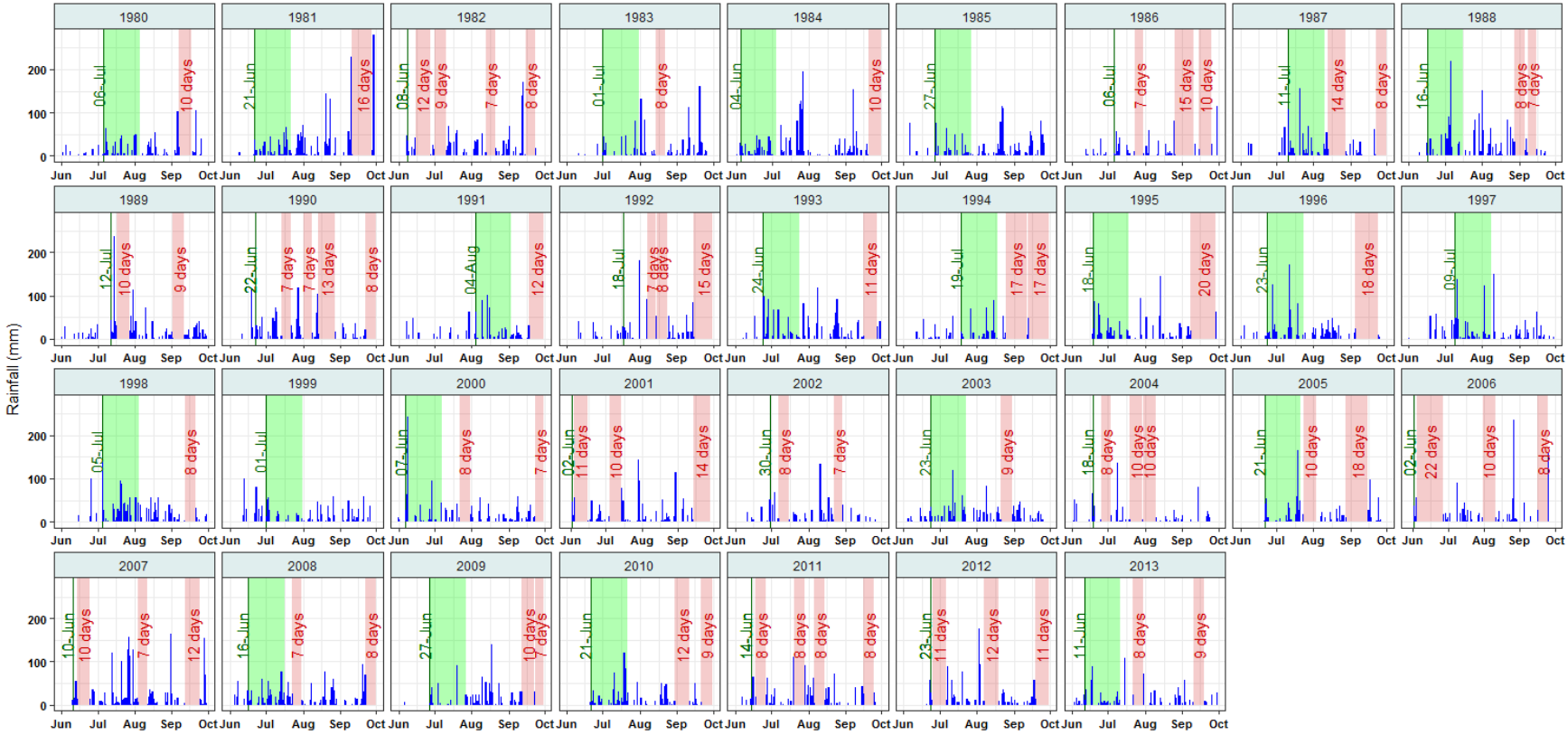
Chandra Gadhi Station



Source: Constructed from unpublished DHM data.

Note: Daily rainfall amount shown as blue vertical bars, the monsoon onset date for each year marked by a green vertical bar, a green shaded period after the onset of monsoon represents a successful plantation period (if there is one), and a red shaded region for marking dry spells of seven days or longer.

Nepalgunj Regional Office Station



Source: Constructed from unpublished DHM data.

Note: Daily rainfall amount shown as blue vertical bars, the monsoon onset date for each year marked by a green vertical bar, a green shaded period after the onset of monsoon represents a successful plantation period (if there is one), and a red shaded region for marking dry spells of seven days or longer.

Tarahara Station

Source: Constructed from unpublished DHM data.
Note: Daily rainfall amount shown as blue vertical bars, the monsoon onset date for each year marked by a green vertical bar, a green shaded period after the onset of monsoon represents a successful plantation period (if there is one), and a red shaded region for marking dry spells of seven days or longer.

Appendix H: Trend statistics for 26 selected ETCCDI variables.

Indices	Western - Dhangadhi Atariya					Western - Nepalgunj Regional Ofice					Eastern - Tarahara					Eastern - Chandra Gadhi				
	R^2	p	τ	MK p	Slope	R^2	p	τ	MK p	Slope	R^2	p	τ	MK p	Slope	R^2	p	τ	MK p	Slope
TXx			0.0498	0.1778	0.0083			0.0498	0.1778	0.0000			-0.0389	0.3352	0.0000					
TNx			0.0261	0.4814	0.0000			0.0261	0.4814	0.0000			0.0872	0.0338	0.0000					
TXn			-0.0456	0.2141	-0.0170			-0.0456	0.2141	0.0000			-0.0728	0.0691	-0.0238					
TNn			0.1674	0.0000	0.0357			0.1674	0.0000	0.0071			0.1150	0.0048	0.0222					
DTR			-0.0708	0.0526	-0.0166			-0.0708	0.0526	-0.0129			-0.1558	0.0001	-0.0316					
TN10p	0.2717	0.0025	-0.4790	0.0002	-0.2707	0.1073	0.0514	-0.1570	0.1971	-0.0885	0.2349	0.0096	-0.3033	0.0285	-0.2226					
TX10p	0.0012	0.9090	0.0345	0.7987	0.0143	0.0084	0.6707	0.0749	0.5433	0.0460	0.0022	0.8717	0.0430	0.7702	0.0196					
TN90p	0.1188	0.0677	0.3014	0.0181	0.1632	0.0195	0.4808	0.1006	0.4143	0.0526	0.0139	0.5879	0.0858	0.5452	0.0987					
TX90p	0.0037	0.7820	0.1122	0.3858	0.0950	0.0042	0.6632	-0.0627	0.6140	-0.0342	0.0461	0.2664	-0.1255	0.3699	-0.1117					
WSDI	0.0762	0.1387	0.1973	0.1447	0.0833	0.0308	0.3335	0.1381	0.2942	0.0000	0.0048	0.7372	0.1091	0.5068	0.0000					
CSDI	0.1047	0.0749	-0.2956	0.0467	0.0000	0.0021	0.7840	0.0139	0.9319	0.0000	0.0998	0.1101	0.2495	0.1215	0.0000					
SU25	0.0437	0.5966	0.1694	0.1900	0.2857	0.0305	0.8088	0.0831	0.5039	0.0139	0.1336	0.0209	-0.2155	0.1224	-0.6250					
TR20	0.3038	0.0049	0.3664	0.0044	0.5385	0.0814	0.2569	0.1351	0.2719	0.2222	0.1396	0.1140	0.2410	0.0832	0.5714					
RX1day								-0.0567	0.0927	0.0000			-0.0064	0.8482	0.0000			-0.0081	0.8094	0.0000
RX5day								-0.0360	0.3551	0.0000			0.0163	0.6675	0.0000			-0.0552	0.1450	0.0000
SDII						0.0100	0.4584	-0.1159	0.3427	-0.0638	0.0011	0.7254	-0.0053	0.9763	-0.0037	0.0259	0.2899	-0.0838	0.4953	-0.0728
R10						0.0683	0.1043	-0.1688	0.1714	-0.2188	0.0000	0.8478	0.0091	0.9526	0.0000	0.0037	0.6190	-0.0485	0.6996	-0.0833
R20						0.1149	0.0391	-0.2485	0.0445	-0.2000	0.0101	0.6710	0.0713	0.5716	0.0588	0.0009	0.9640	0.0109	0.9408	0.0000
R50						0.0492	0.1811	-0.1455	0.2541	-0.0435	0.0006	0.8180	-0.0223	0.8695	0.0000	0.1191	0.0385	-0.2485	0.0445	-0.1818
R100						0.0932	0.0731	-0.3395	0.0105	-0.0400	0.0067	0.6232	-0.0258	0.8542	0.0000	0.0233	0.3692	-0.1012	0.4336	0.0000
CDD						0.1894	0.0135	0.2624	0.0314	0.8500	0.0445	0.2794	0.1292	0.2921	0.3333	0.0037	0.8095	0.0859	0.4857	0.2069
CWD						0.0250	0.3201	-0.1168	0.3742	0.0000	0.0323	0.2698	-0.1521	0.2264	-0.0690	0.0005	0.8598	-0.0903	0.4741	-0.0455
CDDm						0.0203	0.4701	0.0627	0.6226	0.0000	0.0704	0.1578	0.2254	0.0813	0.0417	0.0122	0.5883	0.1812	0.1506	0.0952
R95p						0.0269	0.3271	-0.1427	0.2773	0.0000	0.0134	0.4802	-0.0252	0.8559	0.0000	0.0991	0.0622	-0.2200	0.0862	-0.0333
R99p						0.0605	0.1550	-0.1776	0.2189	0.0000	0.0223	0.3885	-0.0881	0.5354	0.0000	0.0666	0.1357	-0.1668	0.2385	0.0000
PRCPTOT						0.1535	0.0163	-0.3084	0.0108	-15.8545	0.0046	0.6004	-0.0125	0.9291	-0.5067	0.0585	0.1327	-0.1658	0.1726	-12.5000

Source: Calculated from unpublished DHM data.

Appendix I: R code for climate data analysis

Reading rainfall data

```
dirData <- "X:/metro_data/rainfall"
dirList <- list.dirs(dirData, full.names=TRUE, recursive=FALSE)
#function to read and compile rainfall data
readRain <- function(xdir) {
  xfilelist <- list.files(xdir, full.names=TRUE, pattern="AS")
  rainrecx <- data.frame(do.call("rbind", lapply(xfilelist,
                                                 function(xfile) {
    tempdata <- read.table(xfile, header=FALSE)
    dayNos <- tempdata$V1
    yearNos <- paste0(substr(xfile, nchar(xfile)-4, nchar(xfile)-3),
                      substr(xfile, nchar(xfile)-1, nchar(xfile)))
    originDate <- paste0(yearNos, "-01-01")
    varDate <- as.Date(dayNos - 1, origin = originDate)
    varDate <- as.character(strptime(varDate, "%Y-%m-%d"))
    varRain <- as.character(tempdata$V2)
    varDay <- format(as.Date(varDate), "%j")
    cbind(varDate, varRain, varDay)
  })))
  outputFile <- paste0(dirData, "/", substr(xdir, nchar(xdir)-3, nchar(xdir))
,
                       "rain.csv")
  write.csv(rainrecx, file = outputFile, row.names=F)
  return(outputFile)
}
lapply(dirList, readRain)
```

Reading temperature data

```
dirData <- "X:/metro_data/temperature"
dirList <- list.dirs(dirData, full.names=TRUE, recursive=FALSE)
#function to read and compile temperature data
readTemperature <- function(xdir) {
  xfilelist <- list.files(xdir, full.names=TRUE, pattern="TA")
  temprecx <- data.frame(do.call("rbind", lapply(xfilelist, function(xfile) {
    tempdata <- read.table(xfile, header=FALSE, skip=2)
    dayNos <- tempdata$V1
    yearNos <- paste0(substr(xfile, nchar(xfile)-4, nchar(xfile)-3),
                      substr(xfile, nchar(xfile)-1, nchar(xfile)))
    originDate <- paste0(yearNos, "-01-01")
    varDate <- as.Date(dayNos - 1, origin = originDate)
    varDate <- as.character(strptime(varDate, "%Y-%m-%d"))
    varMax <- as.character(tempdata$V2)
    varMin <- as.character(tempdata$V3)
    varDay <- format(as.Date(varDate), "%j")
    cbind(varDate, varMax, varMin, varDay)
  })))
  outputFile <- paste0(dirData, "/", substr(xdir, nchar(xdir)-3, nchar(xdir))
,
                       "temp.csv")
  write.csv(temprecx, file = outputFile, row.names=F)
  return(outputFile)
}
lapply(dirList, readTemperature)
```

Compiling daily records for

```
filelist <- list.files("X:/metro_data/Run7/Temp/",
                       full.names=TRUE, pattern=".csv")
#read and merge all station records
temprec <- do.call("rbind", lapply(filelist, function(xfile) {
  cbind(station=substring(xfile, nchar(xfile)-11, nchar(xfile)-8),
        read.table(xfile, header=TRUE, sep=",", na.strings = c("DNA", "NA"),
                   stringsAsFactors=FALSE))
}))
names(temprec) <- c("Station", "Date", "Max", "Min", "DOY")
#factorize station names
stationlist <- read.xlsx("X:/metro_data/StationsNP.xlsx", 1)
stationlist <- data.table(stationlist[ , c(5, 3, 11)]) #col 5 has index; col
3 has name
# , 17, 18, 11
currentlist <- data.table(index = as.numeric(levels(as.factor(temprec$Station
))))
stationmerged <- merge(currentlist, stationlist, by="index")
temprec$Station <- factor(as.numeric(temprec$Station),
                          levels=rownames(currentlist),
                          labels=as.character(stationmerged$name))
#add year, month col
temprec$Year <- as.numeric(strftime(as.Date(temprec$Date, "%Y-%m-%d"), format
='%Y'))
temprec$Month <- as.numeric(strftime(as.Date(temprec$Date), format='%m'))
temprec$Date <- as.Date(temprec$Date)
temprec <- temprec[temprec$Year >= 1980,]
# Function to get station code from station name
getStationCode <- function(stationName) {
  return(stationmerged[stationmerged$name == stationName, index])
}
# Function to get altitude from station name
getStationAltitude <- function(stationName) {
  return(stationmerged[stationmerged$name == stationName, ele])
}
```

Missing value imputation - rainfall

```
tempproxy <- function(xlist) {
  nax <- which(is.na(xlist))
  naxi <- nax + 365 #next year; does not take into a/c of leap year
  naxii <- nax + 365*2
  naxo <- nax - 365 #previous year
  naxoo <- nax - 365*2
  nay <- which(naxo <= 0)
  naxo[nay] <- naxi[nay] #for cases with data from 1st/2nd year missing
  nayy <- which(naxoo <=0)
  naxoo[nayy] <- naxii[nayy] #for cases with data from 1st year missing
  xlist[nax] <- rowMeans(cbind(xlist[naxi], xlist[naxo],
                               xlist[naxii], xlist[naxoo]), na.rm=TRUE)
  return(xlist)
}
temprec <- ddply(temprec, c("Station"), transform,
                 Max2 = tempproxy(Max), Min2=tempproxy(Min))
#replace temperature records with max temperature greater than 500 with 500 s
ubstracted
temprec[temprec$Max2 > 500, c("Max2")] <- temprec[temprec$Max2 > 500, c("Max2
")] - 500
temprec <- temprec[!((temprec$Station == "Nepalgunj_RO") &
                     (temprec$Year == 2013)), ]
temprec.sub <- temprec[,-c(3:7)]
temprecMelt <- melt(temprec.sub, id=c("Station", "Date"))
```

Calculating ETCCDI indices

Computing TXx - monthly maximum value of daily maximum temperature; TNx - monthly maxim value of daily minimum temperature; TNx - monthly minimum value of daily maximum temperature; TNn - monthly minimum value of daily minimum temperature; and DTR - monthly mean difference between daily maximum and daily minimum.

```
txx <- ddply(temprec, c("Station","Year", "Month"),
                  function(xdf) c(TXx = max(xdf$Max2, na.rm=TRUE),
                                  TNx = max(xdf$Min2, na.rm=TRUE),
                                  TXn = min(xdf$Max2, na.rm=TRUE),
                                  TNn = min(xdf$Min2, na.rm=TRUE),
                                  DTR = mean(xdf$Max2 -xdf$Min2, na.rm=TRUE))
                                  )
#summary for all stations
txx.summary <- ddply(txx, c("Station", "Month"),
                     function(xdf) c(TXx = mean(xdf$TXx, na.rm = TRUE),
                                     # TNx = mean(xdf$TNx, na.rm = TRUE),
                                     # TXn = mean(xdf$TXn, na.rm=TRUE),
                                     TNn = mean(xdf$TNn, na.rm=TRUE)))
```

Computing SU25 - summer days which is annual count when the daily maximum temperature is above 25. TR20 - which is the annual count when the daily minimum temperature is more than 20.

```
summerdays <- function(xdf) {
  countsummer <- sapply(xdf$Max2, function(x) x > 25)
  counttropical <- sapply(xdf$Min2, function(x) x > 20)
  return(data.frame(SU25 = sum(countsummer, na.rm=TRUE),
         TR20 = sum(counttropical, na.rm=TRUE))) #no NAs at this pt.
}
summer <- ddply(temprec, c("Station","Year"), summerdays)
```

Computing TN10p - cool nights

```
# 1) Fix a baseline: 1981-1990 (missing years are ignored)
list.station
temprec.sub2 <- temprec[temprec$Station %in% list.station[c(1,2,3)], ]
temprec.base <- temprec.sub2[temprec.sub2$Year > 1980 & temprec.sub2$Year <=
1990, ]
```

Using PCICt package. The package uses the Zhang bootstrapping method described in Zhang et al. (2005) to compute percentile based indices.

```
my.station <- list.station[1]
temprec.my <- temprec[temprec$Station == my.station, ]
my.dates <- as.PCICt(as.character(temprec.my$Date), cal="gregorian")
my.ci <- climdexInput.raw(tmax = temprec.my$Max2,
                          tmin = temprec.my$Min2,
                          tmax.dates = my.dates,
                          tmin.dates = my.dates,
                          base.range = c(1984, 1993),
                          n = 5,
                          northern.hemisphere = TRUE,
                          tavg = NULL,
                          tavg.dates = NULL,
                          quantiles = NULL,
                          temp.qtiles = c(0.1, 0.9),
                          prec.qtiles = c(0.95, 0.99),
```

```
                          max.missing.days = c(annual = 15, monthly = 3),
                          min.base.data.fraction.present = 0.1)
tx10p <- climdex.tx10p(my.ci,  freq  = "annual")
tn10p <- climdex.tn10p(my.ci, freq = "annual")
tx90p <- climdex.tx90p(my.ci,  freq  = "annual")
tn90p <- climdex.tn90p(my.ci, freq = "annual")
wsdi <- climdex.wsdi(my.ci)
tempindices <- data.frame(tn10p, tx10p, tn90p, tx90p, wsdi, csdi)
tempindices$Year <- row.names(tempindices)
tempindices$Station <- my.station
```

Preparing rainfall records

```
filelist <- list.files("X:/metro_data/Run7/Rain/",
                       full.names=TRUE, pattern=".csv")
#read and merge all station records
rainrec <- do.call("rbind", lapply(filelist, function(xfile) {
  cbind(station=substring(xfile, nchar(xfile)-11, nchar(xfile)-8),
        read.table(xfile, header=TRUE, sep=",", na.strings = c("DNA", "NA"),
                   stringsAsFactors=FALSE))
  }))
names(rainrec) <- c("Station", "Date", "Rainfall", "DOY")
#factorize station names
stationlist <- read.xlsx("X:/metro_data/StationsNP.xlsx", 1)
stationlist <- data.table(stationlist[,c(5,3,11)]) #col 5 has index; col 3 ha
s name
currentlist <- data.table(index = as.numeric(levels(as.factor(rainrec$Station
))))
stationmerged <- merge(currentlist, stationlist, by="index")
rainrec$Station <- factor(as.numeric(rainrec$Station),
                          levels=rownames(currentlist),
                          labels=as.character(stationmerged$name))
list.station <- levels(rainrec$Station)
# Function to get station code from station name
getStationCode <- function(stationName) {
  return(stationmerged[stationmerged$name == stationName, index])
}
# Function to get altitude from station name
getStationAltitude <- function(stationName) {
  return(stationmerged[stationmerged$name == stationName, ele])
}
rainrec$Year <- as.numeric(strftime(as.Date(rainrec$Date, "%Y-%m-%d"), format
='%Y'))
rainrec$Month <- as.numeric(strftime(as.Date(rainrec$Date), format='%m'))
rainrec$Date <- as.Date(rainrec$Date)
rainrec <- rainrec[rainrec$Year >= 1980,] #filter early years
this.station <- c("Nepalgunj_RO", "Tarahara", "Chandra_Gadhi")
rainrec <- rainrec[rainrec$Station %in% this.station, ]
```

Missing value imputation

```
rainrec$Rainfall[rainrec$Rainfall == "T"] <- 0
rainrec$Rainfall <- as.numeric(rainrec$Rainfall)
rainproxy <- function(xlist) {
  nax <- which(is.na(xlist))
  naxi <- nax + 365 #next year; does not take into a/c of leap year
  naxii <- nax + 365*2
  naxo <- nax - 365 #previous year
  naxoo <- nax - 365*2
  nay <- which(naxo <= 0)
  naxo[nay] <- naxi[nay] #for cases with data from 1st/2nd year missing
```

```
  nayy <- which(naxoo <=0)
  naxoo[nayy] <- naxii[nayy] #for cases with data from 1st year missing
  xlist[nax] <- rowMeans(cbind(xlist[naxi], xlist[naxo], xlist[naxii], xlist[
naxoo]), na.rm=TRUE)
  return(xlist)
}
rainrec <- ddply(rainrec, c("Station"), transform,
                 Rainfall2 = rainproxy(Rainfall))
```

Compute seasonal statistics

```
rainrec$Season <- sapply(rainrec$Month,
                         function(x) { if(x < 3) 4 else
                           (if (x <= 5) 1 else
                             (if (x <= 9) 2 else
                               (if (x < 11) 3 else
                                 (4) )))})
rainrec$Season <- factor(rainrec$Season, levels=c(1:4),
                         labels=c("Pre-monsoon", "Monsoon",
                                  "Post-monsoon", "Winter"))
seasonal <- ddply(rainrec, c("Station","Year", "Season"),
                  function(df) c(Total = sum(as.numeric(df$Rainfall2), na.rm=
TRUE),
                  Mean = mean(as.numeric(df$Rainfall2), na.rm=TRUE)))
seasonal.summary <- ddply(seasonal, c("Station", "Season"),
                  function(df) c(Total = sum(as.numeric(df$Total), na.rm=TRUE
),
                  Mean = mean(as.numeric(df$Total), na.rm=TRUE),
                  SD = sd(as.numeric(df$Total), na.rm = TRUE)))
```

Annual and seasonal statistics

```
ann.total <- ddply(rainrec, c("Station","Year"),
                  function(df) c(Total = sum(as.numeric(df$Rainfall2), na.rm=
TRUE),
                  Mean = mean(as.numeric(df$Rainfall2), na.rm=TRUE)))
ann.total.summary <- ddply(ann.total, c("Station"),
                           function(df) c(Mean = mean(as.numeric(df$Total), n
a.rm=TRUE),
                                          SD = sd(as.numeric(df$Total), na.rm
=TRUE),
                           Min = min(as.numeric(df$Total), na.rm=TRUE),
                           Max = max(as.numeric(df$Total), na.rm=TRUE),
                           Median = median(as.numeric(df$Total), na.rm=TRUE))
)
day.total.summary <- ddply(rainrec, c("Station"),
                           function(df) c(Mean = mean(as.numeric(df$Rainfall2
), na.rm=TRUE),
                           Min = min(as.numeric(df$Rainfall2), na.rm=TRUE),
                           Max = max(as.numeric(df$Rainfall2), na.rm=TRUE),
                           Median = median(as.numeric(df$Rainfall2), na.rm=TR
UE)))
sea.total.summary <- ddply(seasonal, c("Station", "Season"),
                           function(df) c(Mean = mean(as.numeric(df$Total), n
a.rm=TRUE),
                           Min = min(as.numeric(df$Total), na.rm=TRUE),
                           Max = max(as.numeric(df$Total), na.rm=TRUE),
                           Median = median(as.numeric(df$Total), na.rm=TRUE))
)
```

Computing dry spell days

```
is.rain <- function(x) x >= 0.85
drySpell3 <- function(xdf) {
  monindex <- 0
  monindex <- min(which(sapply(rollapply(xdf$Rainfall2, 3, sum, partial=1), f
unction(x) x>= 30)))
  monindex2 <- min(which(sapply(rollapply(xdf$Rainfall2, 2, sum, partial=1),
function(x) x>= 25)))
  if (monindex == Inf) {monindex = NA;
                        return(data.frame(monsoon1 = NA,
                                          monsoon1DOY = NA,
                                          monsoon2 = NA,
                                          monsoon2DOY = NA,
                                          drycount = NA,
                                          drylength = NA))}
  rainlist.F.count <- 0
  rainlist.F.len <- 0
  start <- monindex + 1
  end <- monindex + 90
  xlist <- sapply(xdf$Rainfall2[start:end], is.rain)
  rle.rain <- rle(xlist)
  rainlist.F <- rle.rain$lengths[!rle.rain$values]
  if (length(rainlist.F) == 0) {return(data.frame(monsoon1 = xdf$Date[moninde
x],
                                                  monsoon1DOY = xdf$DOY[monin
dex],
                                                  monsoon2 = xdf$Date[moninde
x2],
                                                  monsoon2DOY = xdf$DOY[monin
dex2],
                                                  drycount = 0,
                                                  drylength = 0))}
  rainlist.F.count <- sum(sapply(rainlist.F, function(x) x >= 7), na.rm=TRUE)
  rainlist.F.len <- 0
  if (rainlist.F.count >= 1)
  { rainlist.F.len <- sum(sapply(rainlist.F[rainlist.F >= 7], sum)) }
  return(data.frame(monsoon1 = xdf$Date[monindex],
                    monsoon1DOY = xdf$DOY[monindex],
                    monsoon2 = xdf$Date[monindex2],
                    monsoon2DOY = xdf$DOY[monindex2],
                    drycount = rainlist.F.count,
                    drylength = rainlist.F.len))
}
drydate3 <- ddply(rainrec.mon, c("Station", "Year"), drySpell3)
```

Computing consecutive dry days

```
cdd <- function(xdf) {
  rle.rain <- rle(sapply(xdf$Rainfall2, is.rain))
  rainlist.F <- rle.rain$lengths[!rle.rain$values]
  rainlist.T <- rle.rain$lengths[rle.rain$values]
  rle.rain.mon <- rle(sapply(xdf$Rainfall2[xdf$Season == "Monsoon"],
                             is.rain))
  rainlistm.F <- rle.rain.mon$lengths[!rle.rain.mon$values]
  rainlistm.T <- rle.rain.mon$lengths[rle.rain.mon$values]
  return(data.frame(cdd = max(rainlist.F),
                    cwd = max(rainlist.T),
                    cddm = max(rainlistm.F)))
}
cdd3 <- ddply(rainrec.mon, c("Station", "Year"), cdd)
```

Computing highest rainfall in consecutive 2,3, and 4 days

```
greatrain <- function(xdf) {
  gcount <- 0
  rainlen <- length(xdf$Rainfall)
  rainsort <- sort(xdf$Rainfall[1:rainlen], decreasing=TRUE) #sort rainfall
  return(sum(rainsort[1:4]))
}
grain <- ddply(rainrec.mon, c("Station" , "Year"), greatrain)
rainrecgood <- cbind(rainrecgood, GreatRain = grain$V1)

RX1day <- ddply(rainrec, c("Station","Year", "Month"),
                  function(xdf) c(RX1day = max(xdf$Rainfall2, na.rm=TRUE)))
head(RX1day)

consecutiveRain <- function(xdf, roll=5) {
  rainlist <- xdf$Rainfall2
  rainlist[!is.rain(rainlist)] <- NA
  rainsum <- rollapply(rainlist, roll, sum, fill=c(0))
  return(data.frame(RX5day = max(rainsum, na.rm=TRUE)))
}
RX5day <- ddply(rainrec, c("Station" , "Year", "Month"), consecutiveRain)
head(RX5day)

intensityIndex <- function(xdf) {
  total <- sum(xdf$Rainfall2, na.rm=TRUE)
  wet <- sum(sapply(xdf$Rainfall2, is.rain))
  return(data.frame(SDII = total/wet))
}
SDII <- ddply(rainrec, c("Station" , "Year"), intensityIndex)
```

Computing rainfall for different thresholds

```
Rnn <- ddply(rainrec, c("Station","Year"), function(df)
  c(R10 = sum(sapply(df$Rainfall2,
                     function(x) x >= 10)),
    R20 = sum(sapply(df$Rainfall2,
                       function(x) x > 20)),
    R50 = sum(sapply(df$Rainfall2,
                       function(x) x > 50)),
    R100 = sum(sapply(df$Rainfall2,
                       function(x) x > 100)))
  )

cdd <- function(xdf) {
  rle.rain <- rle(sapply(xdf$Rainfall2, is.rain)) #threshold defined by is.ra
in
  rainlist.F <- rle.rain$lengths[!rle.rain$values]
  rainlist.T <- rle.rain$lengths[rle.rain$values]
  rle.rain.mon <- rle(sapply(xdf$Rainfall2[xdf$Season == "Monsoon"],
                             is.rain))
  rainlistm.F <- rle.rain.mon$lengths[!rle.rain.mon$values]
  rainlistm.T <- rle.rain.mon$lengths[rle.rain.mon$values]
  return(data.frame(cdd = max(rainlist.F),
                    cwd = max(rainlist.T),
                    cddm = max(rainlistm.F)))
}
cdwd <- ddply(rainrec, c("Station", "Year"), cdd) #debug flag

rainTotal <- ddply(rainrec, c("Station","Year"),
                  function(xdf) c(PRCPTOT =
                                    sum(xdf$Rainfall2[sapply(xdf$Rainfall, is
.rain)],
                                        na.rm=TRUE)))
```

```
rainrec.sub <- rainrec
rainrec.base <- rainrec.sub[rainrec.sub$Year > 1980 &
                              rainrec.sub$Year <= 1990, ] #missing years are
ignored
# 2) compute quantile for base data i.e. 95th percentile of precipitation
#   on wet days in the base period.
rain.quantile <- ddply(rainrec.base, c("Station"),
                  function(xdf)
                    quantile(xdf$Rainfall2[sapply(xdf$Rainfall2,
                                                  is.rain)],
                                       c(0.95, 0.99),
                             type = 8,
                             na.rm=TRUE))
# 3) Check each year to count days where the annual total rainfall
#   exceeds the base quantile
Rq <- ddply(rainrec.sub, #only check subset
             c("Station", "Year"),
             function(xdf)
               c(R95p = sum(sapply(xdf$Rainfall2, function(x)
                 x > rain.quantile[rain.quantile$Station == xdf$Station[1],
                                   "95%"]))
                 ,
                 R99p = sum(sapply(xdf$Rainfall2, function(x)
                 x > rain.quantile[rain.quantile$Station == xdf$Station[1],
                                   "99%"]))
                   )
             )
```

Monthly and annual trends

```
trend.annual <- function(ydf) {
  ddply(ydf, c("Station"), function(xdf) {
    odf <- data.frame(do.call(cbind, lapply(3:ncol(xdf), function(i) {
      fit <- lm(xdf[,i] ~ xdf$Year)
      x <- summary(fit)
      p <- round(x$coefficients[7], 7)
      r <- round(x$r.squared, 7)
      y <- MannKendall(xdf[,i])
      dx <- as.numeric(xdf$Year)
      dy <- xdf[,i]
      s <- zyp.sen(dy ~ dx)
      return(data.frame(lm_r_squared = r,
                        lm_p_value = p,
                        mk_tau = round(y$tau[1], 7),
                        mk_p_value = round(y$sl[1], 7),
                        sen_i = s$coefficients[1],
                        sen_slope = s$coefficients[2]
      ))
    }
    )))
  })}

trend.monthly <- function(ydf) {
  ddply(ydf, c("Station"), function(xdf) {
    odf <- data.frame(do.call(cbind, lapply(4:ncol(xdf), function(i) {
      y <- SeasonalMannKendall(as.ts(ts(xdf[,i]), start=c(xdf$Year[1], 1, fre
quency = 12)))
      myrkt <- rkt(xdf$Year, xdf[,i], xdf$Month, correct=TRUE)
      return(data.frame(mk_tau = round(y$tau[1], 4),
                        mk_p_value = round(y$sl[1], 4),
                        theil_sen = myrkt$B, #theil-sen's slope for MK or Sea
```

```
sonal MK
                        ken_s = myrkt$S, #kendall's score
                        ken_p = myrkt$sl, #two-sided p value
                        ken_tau = myrkt$tau #kendall tau
      ))
    }
    )))
  })}
```

Bibliography

Acharya, DR, Bell, JS, Simkhada, P, van Teijlingen, ER & Regmi, PR 2010, 'Women's autonomy in household decision-making: a demographic study in Nepal', *Reproductive Health*, vol. 7, no. 1, pp. 1-12.

Adamo, SB 2009, 'Environmentally induced population displacements', *IHDP Update*.

Adams, RH, Jr. 1993, 'The Economic and Demographic Determinants of International Migration in Rural Egypt', *Journal of Development Studies*, vol. 30, no. 1, pp. 146-167.

Adger, NW 1999, 'Social Vulnerability to Climate Change and Extremes in Coastal Vietnam', *World Development*, vol. 27, pp. 249-269.

Adger, WN 2003, 'Social capital, collective action, and adaptation to climate change', *Economic geography*, vol. 79, pp. 387-404.

Adger, WN 2006, 'Vulnerability', *Global Environmental Change*, vol. 16, no. 3, 8//, pp. 268-281.

Adger, WN & Kelly, PM 1999, 'Social Vulnerability to Climate Change and the Architecture of Entitlements', *Mitigation and Adaptation Strategies for Global Change*, vol. 4, no. 3, pp. 253-266.

Adger, WN, Kelly, PM, Winkels, A, Huy, LQ & Locke, C 2002, 'Migration, Remittances, Livelihood Trajectories, and Social Resilience', *Ambio*, vol. 31, no. 4, pp. 358-366.

Adhikari, J 2001, 'Mobility and agarian change in central Nepal', *Contributions to Nepalese Studies*, vol. 28, no. 2, pp. 247-267.

Adhikari, J & Bohle, H-G 1998, 'Rural livelihoods at risk: Determinants of the abilities of Nepali Hill farmers to cope with food deficiency', *Studies in Nepali History and Society*, vol. 3, no. 1, pp. 35-86.

Advancing Justice - LA 2015, 'U.S. Government Grants Nepal Earthquake Victims Temporary Protected Status', *Advancing Justice - LA Stands Ready to Assist And Reminds Community Members to be Cautious of Immigration Scams*, Asian Americans Advancing Justice - Los Angeles (Advancing Justice - LA), Los Angeles, <http://advancingjustice-la.org/sites/default/files/20150624%20-%20MR%20-%20Nepal%20TPS.pdf>.

Agarwal, A, Babel, MS, Maskey, S, Shrestha, S, Kawasaki, A & Tripathi, NK 2015, 'Analysis of temperature projections in the Koshi River Basin, Nepal', *International Journal of Climatology*, pp. n/a-n/a.

Agence France-Presse 2009, *Nepal government raises war death toll*, viewed 10-09 2016, <http://reliefweb.int/report/nepal/nepal-government-raises-war-death-toll>.

Ainsworth, EA 2008, 'Rice production in a changing climate: a meta-analysis of responses to elevated carbon dioxide and elevated ozone concentration', *Global Change Biology*, vol. 14, no. 7, pp. 1642-1650.

Alexander, LV, Zhang, X, Peterson, TC, Caesar, J, Gleason, B, Klein Tank, AMG, Haylock, M, Collins, D, Trewin, B, Rahimzadeh, F, Tagipour, A, Rupa Kumar, K, Revadekar, J, Griffiths, G, Vincent, L, Stephenson, DB, Burn, J, Aguilar, E, Brunet, M, Taylor, M, New, M, Zhai, P, Rusticucci, M & Vazquez-Aguirre, JL 2006, 'Global observed changes in daily climate extremes of temperature and precipitation', *Journal of Geophysical Research: Atmospheres*, vol. 111, no. D5, pp. n/a-n/a.

Allendorf, K 2007, 'Do Women's Land Rights Promote Empowerment and Child Health in Nepal?', *World Development*, vol. 35, no. 11, 11//, pp. 1975-1988.

Armstrong, R 2010, *The glaciers of the Hindu Kush-Himalayan Region: A summary of the science regarding glacier melt/retreat in the Himalayan, Hindu Kush, Karakoram, Pamir, and Tien Shan mountain ranges*, ICIMOD Technical Paper, ICIMOD, Kathmandu, Nepal.

Aryal, S 2012, 'Rainfall and water requirement of rice during growing period', *The Journal of Agriculture and Environment*, vol. 13, pp. 1-4.

Aryal, S, Cockfield, G & Maraseni, TN 2014, 'Vulnerability of Himalayan transhumant communities to climate change', *Climatic Change*, vol. 125, no. 2, pp. 193-208.

Asseng, S, Foster, IAN & Turner, NC 2011, 'The impact of temperature variability on wheat yields', *Global Change Biology*, vol. 17, no. 2, pp. 997-1012.

Aubriot, O 2010, 'International and national migrations from a village in Western Nepal: Changes and imapct on local life', *European Bulletin of Himalayan Research*, vol. 35-36, pp. 43-61.

Baidya, SK, Shrestha, ML & Sheikh, MM 2008, 'Trends in daily climatic extremes of temperature and precipitation in Nepal', *Journal of Hydrology and Meterology*, vol. 5, no. 1, pp. 38-51.

Bailey, KD 1987, *Methods of social research*, 3rd edn, The Free Press, New York, USA.

Banerjee, S, Yuves-Gerlitz, J & Kniveton, D 2011, 'Remittances as a Key to Adaptation Perspectives on remittances from communities exposed to water hazards in the Hindu Kush-Himalayan region', in pp. 24-27.

Bapuji Rao, B, Santhibhushan Chowdary, P, Sandeep, VM, Rao, VUM & Venkateswarlu, B 2014, 'Rising minimum temperature trends over India in recent decades: Implications for agricultural production', *Global and Planetary Change*, vol. 117, 6//, pp. 1-8.

Bardsley, DK & Hugo, GJ 2010, 'Migration and climate change: examining thresholds of change to guide effective adaptation decision-making', *Population and Environment*, vol. 32, pp. 238-262.

Bardsley, DK & Pech, P 2012, 'Defining Spaces of Resilience within the Neoliberal Paradigm: Could French Land Use Classifications Guide Support for Risk Management Within an Australian Regional Context?', *Human Ecology*, vol. 40, no. 1, pp. 129-143.

Bardsley, DK & Wiseman, ND 2012, 'Climate change vulnerability and social development for remote indigenous communities of South Australia', *Global Environmental Change*, vol. 22, no. 3, 8//, pp. 713-723.

Barnett, J 2001, 'Adapting to climate change in Pacific island countries : the problem of uncertainty', *World Development*, vol. 29, no. 6, pp. 977-993.

Barnett, J 2010, 'Adapting to climate change: three key challenges for research and policy-an editorial essay', *Wiley Interdisciplinary Reviews: Climate Change*, vol. 1, pp. 314-317.

Barnett, J & Adger, WN 2007, 'Climate change, human security and violent conflict', *Political Geography*, vol. 26, no. 6, 8//, pp. 639-655.

Barros, AP & Lang, TJ 2003, 'Monitoring the Monsoon in the Himalayas: Observations in Central Nepal, June 2001', *Monthly Weather Review*, vol. 131, no. 7, 2003/07/01, pp. 1408-1427.

Beck, U 1992, 'From Industrial Society to the Risk Society: Questions of Survival, Social Structure and Ecological Enlightenment', *Theory, Culture and Society*, vol. 9, no. 1, pp. 97-123.

Beck, U 1999, *World Risk Society*, Blackwell Publishers, Massachusetts.

Beck, U 2000, 'The cosmopolitan perspective: sociology of the second age of modernity', *British Journal of Sociology*, vol. 51, no. 1, pp. 79-105.

Beck, U 2009, *World at Risk*, John Wiley & Sons.

Beck, U 2010, 'Climate for Change, or How to Create a Green Modernity?', *Theory, Culture & Society*, vol. 27, no. 2-3, March 1, 2010, pp. 254-266.

Beck, U & Lau, C 2005, 'Second modernity as a research agenda: theoretical and empirical explorations in the 'meta-change' of modern society', *Br J Sociol*, vol. 56, no. 4, Dec, pp. 525-557.

Beck, U & Levy, D 2013, 'Cosmopolitanized Nations: Re-imagining Collectivity in World Risk Society', *Theory, Culture & Society*, vol. 30, no. 2, pp. 3-31.

Bee, B 2013, 'Who Reaps What is Sown? A Feminist Inquiry into Climate Change Adaptation in Two Mexican Ejidos', *ACME: An International Journal for Critical Geographies*, vol. 12, pp. 131-154.

Beema Samiti 2014, *Beema Samiti's detailed economic status and financial standing F/Y 2070-071 (*बीमा समितिको आ.ब. २०७०-०७१ को समष्टिगत आर्थिक स्थिति तथा वित्तीय अवस्था), Beema Samiti - Insurance Regulatory Authority of Nepal.

Beniston, M, Diaz, HF & Bradley, RS 1997, 'Climcatic change at high elevation sites: an overview', *Climatic Change*, vol. 36, no. 3, pp. 233-251.

Berkes, F, Colding, J & Folke, C 2003, *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*, Cambridge University Press, United Kingdom.

Berkes, F, Folke, C & Colding, J 2000, *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*, Cambridge University Press.

Berkes, F & Jolly, D 2001, 'Adapting to Climate Change: Social-Ecological Resilience in a Canadian Western Arctic Community', *Conservation Ecology*, vol. 5.

Bhandari, P 2004, 'Relative deprivation and migration in an agricultural setting of Nepal', *Population & Environment*, vol. 25, no. 5, pp. 475-499.

Bhatt, D, Maskey, S, Babel, MS, Uhlenbrook, S & Prasad, KC 2014, 'Climate trends and impacts on crop production in the Koshi River basin of Nepal', *Regional Environmental Change*, vol. 14, no. 4, pp. 1291-1301.

Bhatta, GD & Aggarwal, PK 2015, 'Coping with weather adversity and adaptation to climatic variability: a cross-country study of smallholder farmers in South Asia', *Climate and Development*, vol. 8, no. 2, pp. 145-157.

Bhatta, LD, van Oort, BEH, Stork, NE & Baral, H 2015, 'Ecosystem services and livelihoods in a changing climate: Understanding local adaptations in the Upper Koshi, Nepal', *International Journal of Biodiversity Science, Ecosystem Services & Management*, vol. 11, no. 2, 2015/04/03, pp. 145-155.

Bhattarai, K, Conway, D & Shrestha, N 2005, 'Tourism, Terrorism And Turmoil In Nepal', *Annals of Tourism Research*, vol. 32, no. 3, 7//, pp. 669-688.

Bilsborrow, RE & Henry, SJF 2012, 'The use of survey data to study migration–environment relationships in developing countries: alternative approaches to data collection', *Population and Environment*, vol. 34, no. 1, pp. 113-141.

Birks, M 2014, 'Quality in qualitative research', in J Mills & M Birks (eds), *Qualitative methodology - a practical guide*, SAGE, London.

Birks, M & Mills, J 2011, *Grounded Theory: A Practical Guide*, SAGE Publications, London.

Bitew, MM & Gebremichael, M 2011, 'Assessment of satellite rainfall products for streamflow simulation in medium watersheds of the Ethiopian highlands', *Hydrol. Earth Syst. Sci.*, vol. 15, no. 4, pp. 1147-1155.

Black, R, Kniveton, D & Schmidt-Verkerk, K 2011, 'Migration and climate change: towards and integrated assessment of sensitivity', *Environment and Planning A*, vol. 73, pp. 431-450.

Blaikie, PM & Muldavin, JSS 2004, 'Upstream, Downstream, China, India: The Politics of Environment in the Himalayan Region', *Annals of the Association of American Geographers*, vol. 94, no. 3, pp. 520-548.

Bodvarsson, ÖB & Van den Berg, H 2013, 'The Determinants of International Migration: Theory', in *The Economics of Immigration: Theory and Policy*, Springer New York, New York, NY, pp. 27-57.

Boyle, PJ, Halfacree, K & Robinson, V 1998, *Exploring Contemporary Migration*, Longman.

Bronaugh, D, 2015, *climdex.pcic: PCIC Implementation of Climdex Routines*, ver. 1.1-5, R package,

Brown, K 1997, 'Plain tales from the grasslands: extraction, value and utilization of biomass in Royal BardiaNational Park, Nepal', *Biodiversity & Conservation*, vol. 6, no. 1, 1997//, pp. 59-74.

Brown, K 1998, 'The political ecology of biodiversity, conservation and development in Nepal's Terai: Confused meanings, means and ends', *Ecological Economics*, vol. 24, no. 1, 1998/01/01/, pp. 73-87.

Bruneau, M 2010, 'Diasporas, transnational spaces and communities', in R Bauböck & T Faist (eds), *Diaspora and Transnationalism : Concepts, Theories and Methods*, Amsterdam University Press, Amsterdam, pp. 35-49.

Bruslé, T 2008, 'Choosing a destination and work: Migration strategies of Nepalese workers in Uttarakhand, Northen India', *Mountain Research and Development*, vol. 28, no. 3/4, pp. 240-247.

Brydon, HW, Joshi, G & Pradhan, S 1961, 'Anopheles distribution and its relation to the malaria eradication program in central Nepal', *Mosq. News*, vol. 21, pp. 102-105.

Bryman, A 2012, *Social Research Methods*, 4th edn, Oxford University Press, Oxford, UK.

Burton, I, Huq, S, Lim, B, Pilifosova, O & Schipper, EL 2002, 'From impacts assessment to adaptation priorities: the shaping of adaptation policy', *Climate Policy*, vol. 2, no. 2-3, 2002/01/01, pp. 145-159.

Caesar, J, Alexander, LV, Trewin, B, Tse-ring, K, Sorany, L, Vuniyayawa, V, Keosavang, N, Shimana, A, Htay, MM, Karmacharya, J, Jayasinghearachchi, DA, Sakkamart, J, Soares, E, Hung, LT, Thuong, LT, Hue, CT, Dung, NTT, Hung, PV, Cuong, HD, Cuong, NM & Sirabaha, S 2011, 'Changes in temperature and precipitation extremes over the Indo-Pacific region from 1971 to 2005', *International Journal of Climatology*, vol. 31, no. 6, pp. 791-801.

Calhoun, C 2010, 'Beck, Asia and second modernity', *The British Journal of Sociology*, vol. 61, no. 3, pp. 597-619.

Campbell, RK, Talegawkar, SA, Christian, P, LeClerq, SC, Khatry, SK, Wu, LSF & West, KP 2014, 'Seasonal Dietary Intakes and Socioeconomic Status among Women in the Terai of Nepal', *Journal of Health, Population, and Nutrition*, vol. 32, no. 2, pp. 198-216.

Caplan, L 1970, *Land and Social Change in East Nepal: A Study of Hindu-Tribal Relations*, Taylor & Francis.

Carr, ER 2005a, 'Placing the environment in migration: environment, economy, and power in Ghana's Central Region', *Environment and Planning A*, vol. 37, pp. 925-946.

Carr, ER 2005b, 'Placing the environment in migration: environment, economy, and power in Ghana's Central Region', *Environment and Planning A*, vol. 37, no. 5, pp. 925-946.

Castles, S 2002, *Environmental Change and Forced Migration: Making Sense of the Debate*, New Issues in Refugee Research, Working Paper 70.

Castles, S, de Haas, H & Miller, MJ 2013, *The Age of Migration: International Population Movements in the Modern World*, Palgrave Macmillan.

Castles, S & Miller, MJ 2003, *The Age of Migration: International Population Movements in the Modern World*, American Foreign Policy Interests, The Guilford Press.

CBS 2002, *Nepal - National Population Census 2001*, Central Bureau of Statistics, Kathmandu, Nepal.

CBS 2012a, 'National Population and Housing Census 2011 (National Report)', in Kathmandu, p. 278.

CBS 2012b, *National Population Census 2011 - Household and Population by Sex - Ward Level Eastern Development Region*, Central Bureau of Statistics,, CBo Statistics, Thapathali, Kathmandu, Nepal.

CBS 2012c, *National Population Census 2011 - Household and Population by Sex - Ward Level Far Western Development Region*, Central Bureau of Statistics,, CBo Statistics, Thapathali, Kathmandu, Nepal.

CBS 2012d, *National Population Census 2011 - National Report*, Central Bureau of Statistics,, CBo Statistics, Thapathali, Kathmandu, Nepal.

CBS 2013a, *Environmental Statistics of Nepal 2013*, Central Bureau of Statistics, Kathmandu, Nepal.

CBS 2013b, *National Sample Census of Agriculture: Nepal 2011/12*, National Report, Central Bureau of Statistics, Government of Nepal, National Planning Commission Secretariat, Kathmandu, Nepal.

CBS 2014a, *Population Monograph of Nepal 2014 - Population Dynamics*, NP Commission, Kathmandu.

CBS 2014b, *Population Monograph of Nepal 2014 - Social Demography*, NP Commission, Kathmandu.

CBS 2014c, *Statistical Pocket Book 2014*, Central Bureau of Statistics, Kathmandu, Nepal.

Central Bureau of Statistics 2011, *Poverty in Nepal (*नेपालमा गरिबी), Central Bureau of Statistics, Kathmandu, Nepal.

Centre for Engineering Research and Development 2007, *Development of database for irrigation development in Nepal*, Government of Nepal, Department of Irrigation, Kathmandu, Nepal.

Chambers, L & Griffiths, G 2008, 'The changing nature of temperature extremes in Australia and New Zealand', *Australian Meteorological Magazine*, vol. 57, no. 1, pp. 13-35.

Chapagain, D 2000, 'Land Tenure and Poverty: Status and Trends Land Systems in the Hills and Mountains of Nepal', in TS Papola, J Richter & M Banskota (eds), *Growth, Poverty Alleviation and Sustainable Resource Management in the Mountain Areas of South Asia*, ICIMOD, Kathmandu, Nepal, pp. 407-432.

Chaudhari, P, Rai, S, Wangdi, S, Mao, A, Rehman, N, Chettri, S & Bawa, KS 2011, 'Consistency of local perceptions of climate change in the Kangchenjunga Himalaya landscape', *Current Science*, vol. 101, no. 4, pp. 504-513.

Chaudhary, P & Bawa, KS 2011, 'Local perceptions of climate change validated by scientific evidence in the Himalayas', in *Biology Letters*.

Chaulagain, NP 2006, 'Impacts of climate change on water resources onf Nepal: The physical and socioeconomic dimensions', PhD thesis, University of Flensburg, Flensburg, Germany, <http://www.zhb-flensburg.de/dissert/chaulagain/Dissertation-Chaulagain.pdf>.

Cherchi, A, Alessandri, A, Masina, S & Navarra, A 2011, 'Effects of increased CO2 levels on monsoons', *Climate Dynamics*, vol. 37, no. 1-2, 2011/07/01, pp. 83-101.

Choi, G, Collins, D, Ren, G, Trewin, B, Baldi, M, Fukuda, Y, Afzaal, M, Pianmana, T, Gomboluudev, P, Huong, PTT, Lias, N, Kwon, W-T, Boo, K-O, Cha, Y-M & Zhou, Y 2009, 'Changes in means and extreme events of temperature and precipitation in the Asia-Pacific Network region, 1955–2007', *International Journal of Climatology*, vol. 29, no. 13, pp. 1906-1925.

Christensen, JH, Hewitson, B, Busuioc, A, Chen, A, Gao, X, Held, I, Jones, R, Kolli, RK, Kwon, W-T, Laprise, R, Magaña Rueda, V, Mearns, LO, Menéndez, CG, Räisänen, J, Rinke, A, Sarr, AT & Whetton, P 2007, 'Regional climate projections', in S Solomon, D Qin, M Manning, Z Chen, M Marquis, KB Averyt, M Tignor & HL Miller (eds), *Climate Change 2007 - The Physical Science Basis: Working Group I Contribution to the Fourth Assessment Report of the IPCC*, Cambridge University Press, Cambridge, United Kingdom, pp. 236-336.

Christensen, JH, Krishna Kumar, K, Aldrian, E, An, S-I, Cavalcanti, I, de Castro, M, Dong, W, Goswami, P, Hall, A, Kanyanga, JK, Kitoh, A, Kossin, J, Lau, N-C, Renwick, J, Stephenson, DB, Xie, S-P & Zhou, T 2013, 'Climate phenomena and their relevance for future regional climate

change', in TF Stocker, D Qin, G-K Plattner, M Tignor, SK Allen, J Boschung, A Nauels, Y Xia, V Bex & PM Midgley (eds), *In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press.

Ciais, P, Reichstein, M, Viovy, N, Granier, A, Ogee, J, Allard, V, Aubinet, M, Buchmann, N, Bernhofer, C, Carrara, A, Chevallier, F, De Noblet, N, Friend, AD, Friedlingstein, P, Grunwald, T, Heinesch, B, Keronen, P, Knohl, A, Krinner, G, Loustau, D, Manca, G, Matteucci, G, Miglietta, F, Ourcival, JM, Papale, D, Pilegaard, K, Rambal, S, Seufert, G, Soussana, JF, Sanz, MJ, Schulze, ED, Vesala, T & Valentini, R 2005, 'Europe-wide reduction in primary productivity caused by the heat and drought in 2003', *Nature*, vol. 437, no. 7058, 09/22/print, pp. 529-533.

Clark, VLP & Creswell, JW 2007, *The Mixed Methods Reader*, SAGE Publications.

Clason, DL & Dormody, TJ 1994, 'Analyzing Data Measured by Individual Likert-Type Items', *Journal of Agricultural Education*, vol. 35, no. 4, pp. 31-35.

Clay, DC & Vander Haar, JE 1993, 'Patterns of Intergenerational Support and Childbearing in the Third World', *Population Studies*, vol. 47, no. 1, pp. 67-83.

'The Constitution of Nepal' 2015, <http://www.can.gov.np/downloads/b5974dee7486162e922dfec46027b1b5.pdf>.

Cox, T 1990, 'Land Rights and Ethnic Conflict in Nepal', *Economic and Political Weekly*, vol. 25, no. 24/25, pp. 1318-1320.

Craik, KH 1972, 'An ecological perspective on environmental decision-making', *Human Ecology*, vol. 1, pp. 69-80.

Crate, SA 2008, 'Gone the Bull of Winter? Grappling with the Cultural Implications of and Anthropology's Role(s) in Global Climate Change', *Current Anthropology*, vol. 49, pp. 569-595.

Dahal, DR & Chaitanya, M 1987, *Seminar on Nepali Emigrants in India 13th November, 1987 / Centre of Nepal and Asian Studies, Tribhuvan University, Kirtipur, Kathmandu*, Current Issue Series ; CNAS Forum 4, eds DR Dahal, C Mishra & K Nepāla ra Eśiyālī Anusandhāna, CNAS, Tribhuvan University, Kathmandu.

Dahal, DR, Rai, NK & Manzardo, AE 1977, *Land and migration in far-western Nepal*, Tribhuvan University, Institute of Nepal and Asian Studies, Kirtipur, Nepal, 1977.

Dangol, DR & Gurung, SB 1991, 'Ethnobotany of the Tharu Tribe of Chitwan District, Nepal', *International Journal of Pharmacognosy*, vol. 29, no. 3, pp. 203-209.

de Haan, A 2000, *Migrants, livelihoods, and rights: The relevance of migration in development policies*, Social Development Working Paper No.4.

DesInventar 2013, 'Disaster Information Management System (DesInventar) Open Source Initiative - Multi-hazard profile - Nepal', in National Society for Earthquake Technology (ed.)Kathmandu, Nepal, viewed February 28, 2013, <http://www.desinventar.net/DesInventar/profiletab.jsp?countrycode=npl>.

Devi, M 2007, 'Economic History of Nepali Migration and Settlement in Assam', *Economic and Political Weekly*, vol. 42, no. 29, pp. 3005-3007.

Devkota, LP 1984, 'Onset of summer monsoon in Nepal', *The Himalayan Review*, vol. 15, no. 1983-84, pp. 11-20.

Devkota, RN 1993, 'Wheat Breeding Objectives in Nepal: The National Testing System and Recent Progress', in DA Saunders & GP Hettel (eds), *Wheat in Heat-stressed Environments: Irrigated, Dry Areas, and Rice-wheat Farming systems,* Wad Medani, Sudan and Dinajpur, Bangladesh, p. 415.

Devkota, RP 2014, 'Climate Change: Trends and People's Perception in Nepal', *Journal of Environmental Protection*, vol. 5, pp. 255-265

Devkota, RP, Bajracharya, B, Maraseni, TN, Cockfield, G & Upadhyay, BP 2011, 'The perception of Nepal's Tharu community in regard to climate change and its impacts on their livelihoods', *International Journal of Environmental Studies*, vol. 68, no. 6, 2011/12/01, pp. 937-946.

Diodato, N, Bellocchi, G & Tartari, G 2012, 'How do Himalayan areas respond to global warming?', *International Journal of Climatology*, vol. 32, no. 7, pp. 975-982.

Diro, GT, Grimes, DIF, Black, E, O'Neill, A & Pardo-Iguzquiza, E 2009, 'Evaluation of reanalysis rainfall estimates over Ethiopia', *International Journal of Climatology*, vol. 29, no. 1, pp. 67-78.

DoFE 2014, *Annual report for fical year 2070-071* आ ब. २०७०-०७१ को बार्षिक प्रतिवेदन, Department of Foreign Employment.

Dulal, HB, Brodnig, G, Thakur, HK & Green-Onoriose, C 2010, 'Do the poor have what they need to adapt to climate change? A case study of Nepal', *Local Environment*, vol. 15, pp. 621-635.

Duncan, JMA, Biggs, EM, Dash, J & Atkinson, PM 2013, 'Spatio-temporal trends in precipitation and their implications for water resources management in climate-sensitive Nepal', *Applied Geography*, vol. 43, no. 0, 9//, pp. 138-146.

Eckholm, EP 1976, *Losing Ground: Environmental Stress and World Food Prospects*, Worldwatch Institute, New York.

Elder, JW, Ale, M, Evans, MA, Gillespie, DP, Nepali, RK, Poudyal, SP & Smith, BP 1976, *Planned Resettlement in Nepal's Terai - A Social Analysis of the Khajura/Bardia Punarvas Projects*, Institute of Nepal and Asian Studies, Tribhuvan University ; Department of Sociology, University of Wisconsin, Kathmandu, Nepal.

Ellis, F 2000, 'The Determinants of Rural Livelihood Diversification in Developing Countries', *Journal of Agricultural Economics*, vol. 51, no. 2, pp. 289-302.

Erda, L, Wei, X, Hui, J, Yinlong, X, Yue, L, Liping, B & Liyong, X 2005, 'Climate change impacts on crop yield and quality with CO(2) fertilization in China', *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 360, no. 1463, 10/24, pp. 2149-2154.

ETCCDI 2013, *ETCCDI/CRD Climate Change Indices - Overview*, viewed 10 Sep 2015 2015, <http://etccdi.pacificclimate.org/index.shtml>.

Ezzy, D 2010, 'The Research Process', in M Walter (ed.), *Social Research Methods*, Second Edition edn, Oxford University Press, Victoria, Australia.

FAO 2016, 'FAOSTAT - Crops and livestock products', in FaAOotU Nations (ed.)<http://www.fao.org/faostat/en/#data/TP/metadata>.

Feldman, D & Fournier, A 1976, 'Social relations and agricultural production in Nepal's Terai', *The Journal of Peasant Studies*, vol. 3, no. 4, 1976/07/01, pp. 447-464.

Findlay, AM 2011, 'Migrant destinations in an era of environmental change', *Global Environmental Change*, vol. 2011.

Findley, SE 1994, 'Does drought increase migration? A study of migration from rural Mali during the 1983-1985 drought', *International Migration Review*, vol. 28, pp. 539-553.

Füssel, H-M 2007, 'Adaptation planning for climate change: concepts, assessment approaches, and key lessons', *Sustainability Science*, vol. 2, no. 2, pp. 265-275.

Füssel, H-M & Klein, RJT 2006, 'Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking', *Climatic Change*, vol. 75, pp. 301-329.

Gallopín, GC 2006, 'Linkages between vulnerability, resilience, and adaptive capacity', *Global Environmental Change*, vol. 16, no. 3, 8//, pp. 293-303.

Gartaula, H, Niehof, A & Visser, L 2012, 'Shifting perceptions of food security and land in the context of labour out-migration in rural Nepal', *Food Security*, vol. 4, no. 2, pp. 181-194.

Gartaula, HN & Niehof, A 2013, 'Migration to and from the Nepal terai: shifting movements and motives', *The South Asianist*, vol. 2, no. 2, pp. 29-51.

Gentle, P & Maraseni, TN 2012, 'Climate change, poverty and livelihoods: adaptation practices by rural mountain communities in Nepal', *Environmental Science & Policy*, vol. 21, 8//, pp. 24-34.

Ghimire, DJ & Axinn, WG 2006, 'Family change in Nepal: evidence from Western Chitwan', *Contributions to Nepalese Studies*, vol. 33, 2006/07//

//, p. 177+.

Ghimire, R 2013, 'Crops and Livestock Insurance Practices in Nepal', *Journal of Business and Social Sciences - Nepal School of Management and Social Sciences*, vol. 1, no. 1, pp. 1-14.

Gillies, RR, Wang, S-Y, Sun, Y & Chung, O-Y 2013, 'Supportive empirical modelling for the forecast of monsoon precipitation in Nepal', *International Journal of Climatology*, vol. 33, no. 14, pp. 3047-3054.

Goldstein, MC & Beall, CM 1986, 'Family change, caste, and the elderly in a rural locale in Nepal', *Journal of Cross-Cultural Gerontology*, vol. 1, no. 3, pp. 305-316.

Gore, C 1993, 'Entitlement relations and 'unruly' social practices: A comment on the work of Amartya Sen', *The Journal of Development Studies*, vol. 29, no. 3, 1993/04/01, pp. 429-460.

Goss, J & Lindquist, B 1995a, 'Conceptualizing International Labor Migration: A Structuration Perspective', *The International Migration Review*, vol. 29, no. 2, pp. 317-351.

Goss, J & Lindquist, B 1995b, 'Conceptualizing international labor migration: a structuration perspective', *International Migration Review*, vol. 29, pp. 317-351.

Government of Canada 2015, *ARCHIVED – Notice – Immigration measures in support of the Government's response to the earthquake in Nepal*, Government of Canada, viewed 18 Sep 2016, <http://www.cic.gc.ca/english/department/media/notices/2015-04-27.asp>.

Graner, E 2010, 'Leaving Hills and Plains, Migration and Remittances in Nepal', *European Bulletin of Himalayan Research*, vol. 35-36, pp. 14-42.

Graner, E & Seddon, D 2004, 'Nepal's Remittance Economy. A decade of change (1996 to 2004)', in M Dahal (ed.), *Nepalese Economy: Towards Building a Strong Economic Nation-State*, Kathmandu, Nepal.

Gray, C & Mueller, V 2012, 'Drought and Population Mobility in Rural Ethiopia', *World Development*, vol. 40, no. 1, 1//, pp. 134-145.

Gurung, G 2004, *An Overview Paper on Overseas Employment in Nepal*, International Labour Office in Nepal, Kathmandu, Nepal.

Gurung, H 1989, *Regional Patterns of Migration in Nepal*, Paper of the East-West population institute, East-West Center, Hawaii, USA.

Guthman, J 1997, 'Representing Crisis: The Theory of Himalayan Environmental Degradation and the Project of Development in Post-Rana Nepal', *Development and Change*, vol. 28, no. 1, pp. 45-69.

Gyanwaly, RP 2014, 'Population and Economic Development', in *Population Monograph of Nepal - Economic Demography*, vol. III, Central Bureau of Statistics, p. 346.

Haas, PM 1999, 'Social constructivism and the evolution of multilateral environmental governance', in A Prakash & JA Hart (eds), *Globalization and Governance*, Routledge, London, pp. 103–133.

Hannah, DM, Kansakar, SR, Gerrard, aJ & Rees, G 2005, 'Flow regimes of Himalayan rivers of Nepal: nature and spatial patterns', *Journal of Hydrology*, vol. 308, pp. 18-32.

Hartmann, DL, Klein Tank, AMG, Rusticucci, M, Alexander, LV, Brönnimann, S, Charabi, Y, Dentener, FJ, Dlugokencky, EJ, Easterling, DR, Kaplan, A, Soden, BJ, Thorne, PW, Wild, M & Zhai, PM 2013, 'Observations: Atmosphere and Surface', in TF Stocker, D Qin, G-K Plattner, M Tignor, A Allen, J Boschung, A Nauels, Y Xia, V Bex & PM Midgley (eds), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK and New York, NY, USA.

Hattlebakk, M 2007, *Economic and social structures that many explain the recent conflicts in the Terai of Nepal*, Chr. Michelsen Institute, Bergen, Norway.

Henry, S, Schoumaker, B & Beauchemin, C 2004, 'The Impact of Rainfall on the First Out-Migration: A Multi-level Event-History Analysis in Burkina Faso', *Population and Environment*, vol. 25.

Hormann, K 1994, *Computer based climatological maps for high mountain areas*, Mountain Environment Series, International Centre for Integrated Mountain Development, ICIMOD, Kathmandu, Nepal.

Hrabovszky, JP & Miyan, K 1987, 'Population Growth and Land Use in Nepal "The Great Turnabout"', *Mountain Research and Development*, vol. 7, no. 3, pp. 264-270.

Hugo, G 1982, 'Circular Migration in Indonesia', *Population and Development Review*, vol. 8, no. 1, pp. 59-83.

Hugo, G 1996, 'Environmental concerns and international migration', *International Migration Review*, vol. 30, pp. 105-131.

Hugo, G 1998, 'Migration as a survival strategy: the family dimension of migration', in *United Nations Expert Group Meeting on Population Distribution and Migration,* United Nations, Santa Curz, Bolivia, pp. 139-149.

Hugo, G 2006, 'Immigration Responses to Global Change in Asia: a Review', *Geographical Research*, vol. 44, no. 2, pp. 155-172.

Hugo, G 2008, *Migration, development and environment*, International Organization for Migration, IOf Migration, Geneva.

Hugo, G 2012a, 'Climate Change and Migration: Some Lessons from Existing Knowledge of Migration in Southeast Asia', in L Elliott (ed.), *Climate Change, Migration and Human Security in Southeast Asia*, S. Rajaratnam School of International Studies, Singapore, pp. 45-59.

Hugo, G 2012b, 'Migration and development in low-income countries: a role for destination country policy?', *Migration and Development*, vol. 1, no. 1, 2012/06/01, pp. 24-49.

Hugo, G 2013, *What we know about circular migration and enhanced mobility*, MPI Policy Brief, Migration Policy Institute.

Hugo, G & Bardsley, D 2013, 'Migration and Environmental Change in Asia', in E Piguet & F Laczko (eds), *People on the Move in a Changing Climate, Global Migration Issues*, vol. 2, Springer, pp. 21-48.

Hulme, M 2008a, 'The conquering of climate: discourses of fear and their dissoultion', *The Geographical Journal*, vol. 174, no. 1, pp. 5-16.

Hulme, M 2008b, 'Governing and adapting to climate. A response to Ian Bailey's Commentary on 'Geographical work at the boundaries of climate change'', *Transactions of the Institute of British Geographers*, vol. 33, no. 3, //, pp. 424-427.

Hulme, M 2012, ''Telling a different tale': literary, historical and meteorological readings of a Norfolk heatwave', *Climatic Change*, vol. 113, no. 1, 2012//, pp. 5-21.

International Labour Organisation 2016, *When the safety of Nepali migrant workers fail: A review of data on the number of causes of death of Nepali migrant workers*, International Labour Organization, IL Organization, Kathmandu, Nepal.

IPCC 2001, *Climate change 2001: Synthesis report*, A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), eds RT Watson & Core Writing Team, Cambridge University Press, New York.

IPCC 2013, 'Annexx III: Glossary', in S Planton (ed.), *Climate Change 2012: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report in the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge and New York.

IPCC 2014, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Iversen, V, Chhetry, B, Francis, P, Gurung, M, Kafle, G, Pain, A & Seeley, J 2006, 'High value forests, hidden economies and elite capture: Evidence from forest user groups in Nepal's Terai', *Ecological Economics*, vol. 58, no. 1, 2006/06/10/, pp. 93-107.

Global Averages, Local Extremes: The Subtelties and Complexities of Climate Change in Papua New Guinea (2009) at 197-208

Jain, SK, Kumar, V & Saharia, M 2013, 'Analysis of rainfall and temperature trends in northeast India', *International Journal of Climatology*, vol. 33, no. 4, pp. 968-978.

Jensen, KB & Glasmeier, AK 2010, 'Policy, Research Design and teh Socially Situated Researcher', in D DeLyser, S Herbert, S Aitken, M Crang & L McDowell (eds), *The SAGE Handbook of Qualitative Geography*, SAGE Publications Ltd., London, pp. 82-93.

Jones, H & Basnett, Y 2013, *Foreign employment and inclusive growth in Nepal: what can be done to improve impacts for the people and the country?*, Overseas Development Institute, London, UK.

Jury, MR 2009, 'An Intercomparison of Observational, Reanalysis, Satellite, and Coupled Model Data on Mean Rainfall in the Caribbean', *Journal of Hydrometeorology*, vol. 10, pp. 413-430.

Kadga, B 1992, 'Conservation Practices in Nepal: Past and Present', *Ambio*, vol. 21, no. 6, pp. 390-393.

Kale, V 2012, 'On the link between extreme floods and excess monsoon epochs in South Asia', *Climate Dynamics*, vol. 39, pp. 1107-1122.

Kansakar, VBS 1985, 'Land resettlement policy as a population distribution strategy in Nepal', in LA Kosinski & KM Elahi (eds), *Population redistribution and development in South Asia*, D. Reidel Publisihing Company, Dordrecht, Holland.

Kansakar, VBS 2003, 'International Migration and Citizenship in Nepal', in *Population Monograph Volume 1*, vol. 1, pp. 85-119.

Karmacharya, J 2010, *Exploring daily rainfall data to investigate evidence of climate change in Kathmandu Valley and its implication in rice farming in the area*, Ministry of Agriculture, Kathmandu, Nepal.

Karmacharya, J, Levine, RC, Jones, R, Moufouma-Okia, W & New, M 2015, 'Sensitivity of systematic biases in South Asian summer monsoon simulations to regional climate model domain size and implications for downscaled regional process studies', *Climate Dynamics*, vol. 45, no. 1-2, 2015/07/01, pp. 213-231.

Katz, RW & Brown, BG 1992, 'Extreme events in a changing climate: Variability is more important than averages', *Climatic Change*, vol. 21, no. 3, 1992/07/01, pp. 289-302.

KC, B & Nagata, S 2006, 'Refugee impact on collective management of forest resources: a case study of Bhutanese refugees in Nepal's Eastern Terai region', *Journal of Forest Research*, vol. 11, no. 5, pp. 305-311.

Kelly, PM & Adger, WN 2000, 'Theory and Practice in Assessing Vulnerability to Climate Change andFacilitating Adaptation', *Climatic Change*, vol. 47, no. 4, pp. 325-352.

Kenway, AE, López-Moreno, JI & Vicente-Serrano, SM 2011, 'Recent trends in daily temperature extremes over northeastern Spain (1960-2006)', *Natural Hazards and Earth System Sciences*, vol. 11, pp. 2583-2603.

Klein Tank, AMG & Können, GP 2003, 'Trends in Indices of Daily Temperature and Precipitation Extremes in Europe, 1946–99', *Journal of climate*, vol. 16, no. 22, 2003/11/01, pp. 3665-3680.

Klein Tank, AMG, Peterson, TC, Quadir, DA, Dorji, S, Zou, X, Tang, H, Santhosh, K, Joshi, UR, Jaswal, AK, Kolli, RK, Sikder, AB, Deshpande, NR, Revadekar, JV, Yeleuova, K, Vandasheva, S, Faleyeva, M, Gomboluudev, P, Budhathoki, KP, Hussain, A, Afzaal, M, Chandrapala, L, Anvar, H, Amanmurad, D, Asanova, VS, Jones, PD, New, MG & Spektorman, T 2006, 'Changes in daily temperature and precipitation extremes in central and south Asia', *Journal of Geophysical Research: Atmospheres*, vol. 111, no. D16.

Kniveton, D, Schmidt-Verkerk, K, Smith, C & Black, R 2008, *Climate Change and Migration: Improving Methodologies to Estimate Flows*, IOM Migration Research Series, International Organization for Migration, Geneva, Switzerland.

Kripalani, RH, Oh, JH, Kulkarni, A, Sabade, SS & Chaudhari, HS 2007, 'South Asian summer monsoon precipitation variability: Coupled climate model simulations and projections under IPCC AR4', *Theoretical and Applied Climatology*, vol. 90, no. 3-4, 2007/11/01, pp. 133-159.

Lawoti, M 2003, 'Centralizing Politics and the Growth of the Maoist Insurgency in Nepal', *Himalaya, the Journal of the Association for Nepal and Himalayan Studies*, vol. 23, no. 1, pp. 49-58.

Leach, M, Mearns, R & Scoones, I 1997, 'Editorial: Community-Based Sustainable Development: Consensus or Conflict?', *IDS Bulletin*, vol. 28, no. 4, pp. 1-3.

Lebel, L, Anderies, J, Campbell, B, Folke, C, Hatfield-Dodds, S, Huges, TP & Wilson, J 2006, 'Governance and the Capacity to Manage Resilience in Regional Social-Ecological Systems', *Ecology and Society*, vol. 11, no. 1, p. 19.

Lemke, P, Ren, J, Alley, RB, Allison, I, Carrasco, J, Flato, G, Fujii, Y, Kaser, G, Mote, P, Thomas, RH & Zhang, T 2007, 'Observations: changes in snow, ice and frozen ground', in S Solomon, D Qin, M Manning, Z Chen, M Marquis, KB Averyt, M Tignor & HL Miller (eds), *Climate Change 2007 - The Physical Science Basis: Working Group I Contribution to the Fourth Assessment Report of the IPCC*, Cambridge University Press, Cambridge, United Kingdom, pp. 236-336.

Leonard, L 2014, 'Reconsidering the 'risk society theory' in the South: The case of civil society actions against a proposed industrial risk facility in Durban, South Africa', *South African Review of Sociology*, vol. 45, no. 3, pp. 74-93.

Likert, R 1932, 'A Technique for the Measurement of Attitudes', *Archives of Psychology*, vol. 22, no. 140, pp. 5-55.

Lillard, LA & Willis, RJ 1997, 'Motives for Intergenerational Transfers: Evidence from Malaysia', *Demography*, vol. 34, no. 1, pp. 115-134.

Lohani, S, Singh, RB & Lohani, J 2010, 'Universal primary education in Nepal: Fulfilling the right to education', *PROSPECTS*, vol. 40, no. 3, pp. 355-374.

Macchi, M, Gurung, AM & Hoermann, B 2014, 'Community perceptions and responses to climate variability and change in the Himalayas', *Climate and Development*, pp. 1-12.

Manandhar, S, Pandey, V & Kazama, F 2013, 'Climate change and adaptation: an integrated framework linking social and physical aspects in poorly-gauged regions', *Climatic Change*, 2013/08/01, pp. 1-13.

Manandhar, S, Vogt, D, Perret, S & Kazama, F 2011, 'Adapting cropping systems to climate change in Nepal: a cross-regional study of farmers' perception and practices', *Regional Environmental Change*, vol. 11, no. 2, 2011/06/01, pp. 335-348.

Marino, E & Schweitzer, P 2009, 'Talking and Not Talking about Climate Change in Northwestern Alaska', in SA Crate & M Nuttall (eds), *Anthropology and Climate Change: From Encounters to Actions*, Left Coast Press, California.

Massey, DS 1990, 'Social Structure, Household Strategies, and the Cumulative Causation of Migration', *Population Index*, vol. 56, no. 1, pp. 3-26.

Massey, DS, Alarcon, R, Durand, J & González, H 1990, *Return to Aztlan: The Social Process of International Migration from Western Mexico*, University of California Press.

Massey, DS, Arango, J, Hugo, G, Kouaouci, A & Pellegrino, A 1999, *Worlds in Motion : Understanding International Migration at the End of the Millennium: Understanding International Migration at the End of the Millennium*, Clarendon Press.

Massey, DS, Arango, J, Hugo, G, Kouaouci, A, Pellegrino, A & Taylor, JE 1993, 'Theories of International Migration: A Review and Appraisal', *Population Council*, vol. 19, no. 3, pp. 431-466.

Massey, DS, Axinn, WG & Ghimire, DJ 2010a, 'Environmental change and out-migration: evidence from Nepal', *Population and Environment*, vol. 32, no. 2-3, 2010/12/01, pp. 109-136.

Massey, DS, Williams, N, Axinn, WG & Ghimire, DJ 2010b, 'Community Services and Out-Migration', *International Migration*, vol. 48, no. 3, pp. 1-41.

Mathema, KB & Bista, MB 2006, *Study on student performance in SLC*, Ministry of Education and Sports.

Matten, D 2004, 'The impact of the risk society thesis on environmental politics and management in a globalizing economy--principles, proficiency, perspectives', *Journal of Risk Research*, vol. 7, no. 4, pp. 377-398.

Matthews, R & Nee, V 2000, 'Gender Inequality and Economic Growth in Rural China', *Social Science Research*, vol. 29, no. 4, 2000/12/01, pp. 606-632.

May, W 2004, 'Variability and extremes of daily rainfall during the Indian summer monsoon in the period 1901–1989', *Global and Planetary Change*, vol. 44, no. 1–4, 12//, pp. 83-105.

Mbow, C, Mertz, O, Diouf, A, Rasmussen, K & Reenberg, A 2008, 'The history of environmental change and adaptation in eastern Saloum–Senegal—Driving forces and perceptions', *Global and Planetary Change*, vol. 64, no. 3–4, 12//, pp. 210-221.

McDowell, G, Ford, JD, Lehner, B, Berrang-Ford, L & Sherpa, A 2012, 'Climate-related hydrological change and human vulnerability in remote mountain regions: a case study from Khumbu, Nepal', *Regional Environmental Change*.

McLeman, R, Mayo, D, Strebeck, E & Smit, B 2007, 'Drought adaptation in rural eastern Oklahoma in the 1930s: lessons for climate change adaptation research', *Mitigation and Adaptation Strategies for Global Change*, vol. 13, pp. 379-400.

McLeod, AI, 2011, *Kendall: Kendall rank correlation and Mann-Kendall trend test*, ver. 2.2, R package,

McNeely, JA 1994, 'Protected areas for the 21st century: working to provide benefits to society', *Biodiversity & Conservation*, vol. 3, no. 5, pp. 390-405.

Messerschmidt, DA 1976, 'Ecological change and adaptation among the Gurungs of the Nepal Himalaya', *Human Ecology*, vol. 4, no. 2, April 01, pp. 167-185.

Meyer, WB & Turner, BL 1992, 'Human Population Growth and Global Land-Use/Cover Change', *Annual Review of Ecology and Systematics*, vol. 23, no. 1, pp. 39-61.

Meze-Hausken, E 2000a, 'Migration caused by climate change: How vulnerable are people in dryland areas?', *Mitigation and Adaptation Strategies for Global Change*, vol. 5, no. 4, pp. 379-406.

Meze-Hausken, E 2000b, 'Migration caused by climate change: how vulnerable are people inn dryland areas?', *Mitigation and Adaptation Strategies for Global Change*, vol. 5, no. 4, pp. 379-406.

Millock, K 2015, 'Migration and Environment', *Annual Review of Resource Economics*, vol. 7, no. 1, pp. 35-60.

Mills, J 2014, 'Methodology and Methods', in J Mills & M Birks (eds), *Qualitative Methodology*, SAGE, London.

Ministry of Agricultural Development 2013, *Statistical Information on Nepalese Agriculture 2012/2013 (2069/070)*, Ministry of Agricultural Development, Agribusiness Promotion and Statistics Division, Agri Statistics section, Kathmandu, Nepal.

Ministry of Agricultural Development & CBS 2016, *Food and nutrition security in Nepal: A status report*, Ministry of Agricultural Development and Central Bureau of Statistics for the Nepal component of the FAO Porject, Kathmandu, Nepal.

Ministry of Health and Populaton 2011, *Nepal Malaria Strategic Plan 2011-2016*, Department of Health Services, Epidemiology & Disease Control Division, EDCD Department of Health Services, Kathmandu, Nepal.

Ministry of Labour and Employment 2014, *Labour Migration for Employment: A Status Report for Nepal: 2013/2014*, Ministry of Labour and Employment, Government of Nepal.

Ministry of Labour and Employment 2016, *Labour Migration for Employment: A Status Report for Nepal: 2014/2015*, Ministry of Labour and Employment, Government of Nepal.

Mirza, MM 2011, 'Climate change, flooding in South Asia and implications', *Regional Environmental Change*, vol. 11, no. 1, 2011/03/01, pp. 95-107.

Mitchell, JFB, Lowe, J, Wood, RA & Vellinga, M 2006, *Extreme events due to human-induced climate change*, vol. 364.

Molho, I 2013, 'Theories of Migration: A Review', *Scottish Journal of Political Economy*, vol. 60, no. 5, pp. 526-556.

Mortimore, M & Adams, WM 1999, *Working the Sahel - Environment and society in northern Nigeria*, Routledge, New York.

Müller-Böker, U 1991, 'Knowledge and Evaluation of the Environment in Traditional Societies of Nepal', *Mountain Research and Development*, vol. 11, no. 2, pp. 101-114.

Mythen, G 2004, *Ulrich Beck: a critical introduction to the risk society*, Pluto Press.

Nag, S 2003, 'Fei-isation of the Nepalis of Northeast India', in AC Sinha & TB Subba (eds), *The Nepalis in Northeast India: A Community in Search of Indian Identiy*, Indus, New Delhi.

Naidu, CV, Dharma Raju, A, Satyanarayana, GC, Vinay Kumar, P, Chiranjeevi, G & Suchitra, P 2015, 'An observational evidence of decrease in Indian summer monsoon rainfall in the recent three decades of global warming era', *Global and Planetary Change*, vol. 127, 4//, pp. 91-102.

National Research Council 2012, *Himalayan Glaciers: Climate Change, Water Resources, and Water Security*, The National Academies Press, Washington, DC.

Nayava, JL 1980, 'Rainfall in Nepal', *Himalayan Review*, vol. 12, pp. 1-18.

Nepal Human Development Report 2014 2014, National Planning Commission, <http://hdr.undp.org/sites/default/files/nepal_nhdr_2014-final.pdf>.

Neuman, WL 2014, *Social Research Methods: Qualitative and Quantitative Approaches*, Pearson New International Editio, Seventh Edition edn, Pearson Education Limited, Essex, England.

NIDS & NCCR North-South 2010, *Nepal Migration Yearbook 2009*, NIDS,

NCCR North-South,, NIoDSNSARCOSNCoCiRN North-South, Kathmandu.

Nielsen, JØ & Vigh, H 2012, 'Adaptive lives. Navigating the global food crisis in a changing climate', *Global Environmental Change*, vol. 22, pp. 659-669.

Niroula, BP 1998, 'Caste/ethnic composition of population of Nepal', *Contributions to Nepalese Studies*, vol. 25, no. 1, pp. 15-56.

Nogués-Bravo, D, Araújo, MB, Errea, MP & Martínez-Rica, JP 2007, 'Exposure of global mountain systems to climate warming during the 21st Century', *Global Environmental Change*, vol. 17, no. 3–4, 8//, pp. 420-428.

Nyaupane, GP & Chhetri, N 2009, 'Vulnerability to Climate Change of Nature-Based Tourism in the Nepalese Himalayas', *Tourism Geographies*, vol. 11, pp. 95-119.

Ojha, HR, Khatri, DB, Shrestha, KK, Bhattarai, B, Baral, JC, Basnett, BS, Goutam, K, Sunam, R, Banjade, MR, Jana, S, Bushley, B, Dhungana, SP & Paudel, D 2016, 'Can Evidence and Voice Influence Policy? A Critical Assessment of Nepal's Forestry Sector Strategy, 2014', *Society & Natural Resources*, vol. 29, no. 3, 2016/03/03, pp. 357-373.

Oliver-smith, EA, Shen, X, Moriniere, LE, Larzus, H, Marino, E, Schmidt-Verkerk, K, Kavanova, K, Bronen, R & Sgro, A 2009, 'Linking Environmental Change, Migration & Social Vulnerability', in EA Oliver-smith & X Shen (eds).

Opitz-Stapleton, S & MacClune, K 2012, 'Scientific and Social Uncertainties in Climate Change: The Hindu Kush-Himalaya in Regional Perspective', in A Lamadrid & I Kelman (eds), *Climate Change Modeling For Local Adaptation In The Hindu Kush-Himalayan Region*, Emerald Group Publishing Limited, pp. 207-237.

Osei, A, Pandey, P, Spiro, D, Nielson, J, Shrestha, R, Talukder, Z, Quinn, V & Haselow, N 2010, 'Household Food Insecurity and Nutritional Status of Children Aged 6 to 23 Months in Kailali District of Nepal', *Food and Nutrition Bulletin*, vol. 31, no. 4, December 1, 2010, pp. 483-494.

Ostrom, E 2009, 'A General Framework for Analyzing Sustainability of Social-Ecological Systems', *Science*, vol. 325, no. 5939, pp. 419-422.

Ostrom, V 1997, *The Meaning of Democracy and the Vulnerabilities of Democracies: A Response to Tocqueville's Challenge*, The University of Michigan Press, Michigen.

Otenyo, SM 2015, 'Greenhouse Gas, Climate Change and Carbon Sequestration: Overview and General Principles', in V Sejian, J Gaughan, L Baumgard & C Prasad (eds), *Climate Change Impact on Livestock: Adaptation and Mitigation*, Springer India, New Delhi, pp. 27-35.

Panday, PK, Thibeault, J & Frey, KE 2014, 'Changing temperature and precipitation extremes in the Hindu Kush-Himalayan region: an analysis of CMIP3 and CMIP5 simulations and projections', *International Journal of Climatology*, pp. n/a-n/a.

Paudel, B, Acharya, B, Ghimire, R, Dahal, K & Bista, P 2014, 'Adapting Agriculture to Climate Change and Variability in Chitwan: Long-Term Trends and Farmers' Perceptions', *Agricultural Research*, vol. 3, no. 2, 2014/06/01, pp. 165-174.

Pelling, M 1999, 'The political ecology of flood hazard in urban Guyana', *Geoforum*, vol. 30, pp. 249-261.

Pelling, M 2010, 'Hazards, risks and global patterns of urbanization', in B Wisner, I Kelman & JC Gaillard (eds), *Routledge Handbook of Natural Hazards and Disaster Risk Reduction and Management*, Routledge, London.

Pelling, M 2011, *Adaptation to Climate Change: From resilience to transformation*, Routledge, New York.

Pelling, M & High, C 2005, 'Understanding adaptation: What can social capital offer assessments of adaptive capacity?', *Global Environmental Change*, vol. 15, pp. 308-319.

Pfefferle, A 2015, 'Nepal: Paving the Way for Reconstruction', viewed 5 September 2016, <http://www.crisis.acleddata.com/nepal-paving-the-way-for-reconstruction/>.

Phillips, T 2010, 'Analysing Quantitative Data', in M Walter (ed.), *Social Research Methods*, Second Edition edn, Oxford University Press, Victoria, Australia.

Piguet, E, Pecoud, A & de Guchteneire, P 2011, 'Introduction: migration and climate change', in E Piguet, A Pecoud & P de Guchteneire (eds), *Migration and Climate Change*, 1 edn, Cambridge University Press, Geneva, pp. 1-10.

Poffenberger, M & McGean, B 1998, *Village Voices, Forest Choices: Joint Forest Management in India*, Oxford University Press.

Pokhrel, D, Bhandari, BS & Viraraghavan, T 2009, 'Arsenic contamination of groundwater in the Terai region of Nepal: An overview of health concerns and treatment options', *Environment international*, vol. 35, no. 1, 1//, pp. 157-161.

PovcalNet 2013, 'Regional aggregation using 2011 PPP and $1.9/day poverty line', in The World Bank Group (ed.)<http://iresearch.worldbank.org/PovcalNet/povDuplicateWB.aspx>.

Pradhan, EK, West, KP, Katz, J, LeClerq, SC, Khatry, SK & Shrestha, SR 2007, 'Risk of flood-related mortality in Nepal', *Disasters*, vol. 31, no. 1, pp. 57-70.

Prasad, AK, Yang, K-H, El-Askary, H & Kafatos, M 2009, 'Melting of major Glaciers in the western Himalayas: evidence of climatic changes from long term MSU derived tropospheric temperature trend (1979–2008)', *Annales Geophysicae*, vol. 27, no. 12, pp. 4505-4519.

Prescott, JRV 1965, *The Geography of Frontiers and Boundaries*, Hutchinson University Library, London.

Qi, W, Zhang, Y, Gao, J, Yang, X, Liu, L & Khanal, NR 2013, 'Climate change on the southern slope of Mt. Qomolangma (Everest) Region in Nepal since 1971', *Journal of Geographical Sciences*, vol. 23, no. 4, pp. 595-611.

R Core Team, 2015, *R: A language and environment for statistical computing*, ver. 3.1.3, Computer Software, R Foundation for Statistical Computing, Vienna, Austria.

Rao, KK, Patwardhan, SK, Kulkarni, A, Kamala, K, Sabade, SS & Kumar, KK 2014, 'Projected changes in mean and extreme precipitation indices over India using PRECIS', *Global and Planetary Change*, vol. 113, 2//, pp. 77-90.

Ratha, D, De, S, Plaza, S, Schuettler, K, Shaw, W, Wyss, H & Yi, S 2016, *Migration and Remittances – Recent Developments and Outlook*, Migration and Development Brief, The World Bank, TW Bank, Washington DC.

Regmi, MC 1961, 'Recent Land Reform Programs in Nepal', *Asian Survey*, vol. 1, no. 7, pp. 32-37.

Regmi, MC 1971, *A Study in Nepali Economic History, 1768-1846*, Mamjusri Publishing House.

Renaud, FG, Dun, O, Warner, K & Bogardi, J 2011, 'A Decision Framework for Environmentally Induced Migration', *International Migration*, vol. 49, pp. e5-e29.

Roberts, KD & Morris, MDS 2003, 'Fortune, Risk, and Remittances: An Application of Option Theory to Participation in Village-Based Migration Networks', *The International Migration Review*, vol. 37, no. 4, pp. 1252-1281.

Rose, LE 1966, 'Nepal in 1965: Focus on Land Reform', *Asian Survey*, vol. 6, no. 2, pp. 86-89.

Runfola, DM, Romero-Lankao, P, Jiang, L, Hunter, LM, Nawrotzki, R & Sanchez, L 2016, 'The Influence of Internal Migration on Exposure to Extreme Weather Events in Mexico', *Society & Natural Resources*, vol. 29, no. 6, 2016/06/02, pp. 750-754.

Salinger, MJ 2005, 'Climate Variability and Change: Past, Present and Future — an Overview', in J Salinger, MVK Sivakumar & R Motha (eds), *Increasing Climate Variability and Change*, Springer Netherlands, pp. 9-29.

Sanders, SC 2014, *Resettled and remaining*, <http://kathmandupost.ekantipur.com/printedition/news/2014-06-19/resettled-and-remaining.html>.

Sapkota, C 2013, 'Remittances in Nepal: Boon or Bane?', *The Journal of Development Studies*, vol. 49, no. 10, 2013/10/01, pp. 1316-1331.

Scheffer, M & Carpenter, SR 2003, 'Catestrophic regime shifts in ecosystems: linking theory to observation', *Trends in Ecology and Evolution*, vol. 18, pp. 648-656.

Scheffran, J, Marmer, E & Sow, P 2012, 'Migration as a contribution to resilience and innovation in climate adaptation: Social networks and co-development in Northwest Africa', *Applied Geography*, vol. 33, pp. 119-127.

Schewe, J, Levermann, A & Meinshausen, M 2011, 'Climate change under a scenario near 1.5 °C of global warming: monsoon intensification, ocean warming and steric sea level rise', *Earth Syst. Dynam.*, vol. 2, no. 1, pp. 25-35.

Seddon, D & Adhikari, J 1998, 'Foreign Labour Migration and the Remittance Economy of Nepal', *Himalayan Research Bulletin*, vol. 18, pp. 3-10.

Sen, A 1981, *Poverty and Famines: An Essay on Entitlement and Deprivation*, OUP Oxford.

Sen, A 1997, *Resources, Values and Development*, Harvard University Press.

Shah, T, Singh, OP & Mukherji, A 2006, 'Some aspects of South Asia's groundwater irrigation economy: analyses from a survey in India, Pakistan, Nepal Terai and Bangladesh', *Hydrogeology Journal*, vol. 14, pp. 286-309.

Sharma, JR 2013, 'Marginal but modern: young Nepali labour migrants in India', *Young*, vol. 21, no. 4, pp. 347-362.

Sharma, RH & Shakya, NM 2006, 'Hydrological changes and its impact on water resources of Bagmati watershed, Nepal', *Journal of Hydrology*, vol. 327, pp. 315-322.

Sharma, S, Pandey, S, Pathak, D, Sijapati-Basnett, B & Sanjay Sharma, SP 2014, *State of Migration in Nepal*, Research Paper VI, Centre for the Study of Labour and Mobility, Kathmandu, Nepal.

Sharmila, S, Joseph, S, Sahai, AK, Abhilash, S & Chattopadhyay, R 2015, 'Future projection of Indian summer monsoon variability under climate change scenario: An assessment from CMIP5 climate models', *Global and Planetary Change*, vol. 124, 1//, pp. 62-78.

Shearer, C 2012, 'The political ecology of climate adaptation assistance: Alaska Natives, displacement, and relocation', *Journal of Political Ecology*, vol. 19.

Sheikh, MM, Manzoor, N, Ashraf, J, Adnan, M, Collins, D, Hameed, S, Manton, MJ, Ahmed, AU, Baidya, SK, Borgaonkar, HP, Islam, N, Jayasinghearachchi, D, Kothawale, DR, Premalal, KHMS, Revadekar, JV & Shrestha, ML 2015, 'Trends in extreme daily rainfall and temperature indices over South Asia', *International Journal of Climatology*, vol. 35, no. 7, pp. 1625-1637.

Sheller, M & Urry, J 2003, 'Mobile Transformations of `Public' and `Private' Life', *Theory, Culture & Society*, vol. 20, no. 3, June 1, 2003, pp. 107-125.

Sherpa, PY 2014, 'Climate change impacts among the Sherpas: an anthropological study in the Everest region, Nepal', *Habitat Himalaya*, vol. XVIII, no. I, pp. 1-2.

Shrestha, AB & Aryal, R 2011, 'Climate change in Nepal and its impact on Himalayan glaciers', *Regional Environmental Change*, vol. 11, pp. 65-77.

Shrestha, AB, Wake, CP, Dibb, JE & Mayewski, PA 2000, 'Precipitation fluctuations in the Nepal Himalaya and its vicinity and relationship with some large scale climatological parameters', *International Journal of Climatology*, vol. 20, no. 3, pp. 317-327.

Shrestha, AB, Wake, CP, Mayewski, PA & Dibb, JE 1999a, 'Maximum temperature trends in the Himalaya and its vicinity: An analysis based on temperature records from Nepal for the period 1971-94', *Journal of climate*.

Shrestha, AB, Wake, CP, Mayewski, PA & Dibb, JE 1999b, 'Maximum temperature trends in the Himalaya and its vicinity: An analysis based on temperature records from Nepal for the period 1971-94', *American Meteorological Society*, vol. 12, pp. 2775-2786.

Shrestha, KLS 2005, 'Global Change Impact Assessment for Himalayan Mountain Regions for Environmental Management and Sustainable Development', *Global Change Impact Assessment for Himalayan Mountain*, pp. 69-81.

Shrestha, MB & Chaudhary, SK 2014, 'The Economic Cost of General Strikes in Nepal', *NRB Economic Review*, vol. 26, no. 1, pp. 1-23.

Shrestha, N & Bhattarai, K 2003, *Historical dictionary of Nepal / Nanda R. Shrestha, Keshav Bhattarai*, Asian/Oceanian historical dictionaries ; no. 46., ed. K Bhattarai, Scarecrow Press, Lanham, Md. ; Oxford.

Shrestha, NR 1985, 'The political economy of economic underdevelopment and external migration in Nepal', *Political Geography Quarterly*, vol. 4, no. 4, pp. 289-306.

Shrestha, NR 1989, 'Settlement and Landlessness Frontier among Hill Migrants in Nepal Tarai', *Annals of the Association of American Geographers*, vol. 79, pp. 370-389.

Shrestha, NR, Velu, RP & Conway, D 1993, 'Frontier Migration and Upward Mobility: The Case of Nepal', *Economic Development and Cultural Change*, vol. 41, no. 4, pp. 787-816.

Shrestha, RP & Nepal, N 2016, 'An assessment by subsistence farmers of the risks to food security attributable to climate change in Makwanpur, Nepal', *Food Security*, vol. 8, no. 2, pp. 415-425.

Shrestha, RR, Shrestha, MP, Upadhyay, NP, Pradhan, R, Khadka, R, Maskey, A, Maharjan, M, Tuladhar, S, Dahal, BM & Shrestha, K 2003, 'Groundwater Arsenic Contamination, Its Health

Impact and Mitigation Program in Nepal', *Journal of Environmental Science and Health, Part A*, vol. 38, no. 1, 2003/03/01, pp. 185-200.

Shrestha, S, Burningham, K & Grant, CB 2014, 'Constructions of Climate Change on the Radio and in Nepalese Lay Focus Groups', *Environmental Communication*, vol. 8, no. 2, 2014/04/03, pp. 161-178.

Shrestha, UB, Gautam, S & Bawa, KS 2012, 'Widespread Climate Change in the Himalayas and Associated Changes in Local Ecosystems', *Plos One*, vol. 7, no. 5, p. e36741.

Sijapati, B 2015, *Migration and Resilience: Experience from Nepal's 2015 earthquake*, Research Paper VIII, Center for the Study of Labour and Mobility, Social Science Baha.

Sijapati, B, Bhattarai, A & Pathak, D 2015, *Analysis of Labour Market and Migration Trends in Nepal*, GIZ and ILO, DGfIZGGaIL Organization, Kathmandu, Nepal.

Sijapati, B & Limbu, A 2012, *Governing Labour Migration in Nepal - An Analysis of Existing Policies and Institutional Mechanisms*, Himal Books, Kathmandu, Nepal.

Singh, SS & Wright, D 1877, *History of Nepal*, Nepal Antiquated Book Publishers.

Song, C, Ke, L, Huang, B & Richards, KS 2015, 'Can mountain glacier melting explains the GRACE-observed mass loss in the southeast Tibetan Plateau: From a climate perspective?', *Global and Planetary Change*, vol. 124, pp. 1-9.

Springate-Baginski, O & Blaikie, P 2007, 'Annexation, Struggle and Response: Forest, People and Power in India and Nepal', in O Springate-Baginski & P Blaikie (eds), *Forests, People and Power: The Political Ecology of Reform in South Asia*, Earthscan, Londong, UK, pp. 27-60.

Stahl, CW & Arnold, F 1986, 'Overseas Workers' Remittances in Asian Development', *The International Migration Review*, vol. 20, no. 4, pp. 899-925.

Stark, O 1995, 'The Sharing and Distribution of the Returns to Migration in Developiong Countries', in JH Ong, KB Chan & SB Chew (eds), *Crossing Borders: Transmigration in Asia Pacific*, Prentice Hall, Singapore.

Stewart, A 2014, 'Case Study', in J Mills & M Birks (eds), *Qualitative Methodology*, SAGE, London.

Subedi, BP 1991, 'International Migration in Nepal: Towards an Analytical Framework', *Contributions to Nepalese Studies*, vol. 18, no. 1, pp. 83-102.

Sugden, F & Gurung, G 2012, *Absentee landordism and agrarian stagnation in Nepal: A case from the Eastern Tarai*, Nepal Institute of Development Studies.

Sveinbjörnsson, D & Björnsson, H 2011, 'Mass Balance Approach to Study Glaciers Dynamics in the Himalayas', in R Lal, MVK Sivakumar, SMA Faiz, AHM Mustafizur Rahman & KR Islam (eds), *Climate Change and Food Security in South Asia*, Springer Netherlands, pp. 43-53.

Tacoli, C 2009, 'Crisis or adaptation? Migration and climate change in a context of high mobility', *Environment and Urbanization*, vol. 212, pp. 513-525.

Tacoli, C & Mabala, R 2010, 'Exploring mobility and migration in the context of rural—urban linkages: why gender and generation matter', *Environment and Urbanization*, vol. 22, no. 2, October 1, 2010, pp. 389-395.

Taranter, B 2010, 'Sampling', in M Walter (ed.), *Social Research Methods*, 2nd edn, Oxford University Press, Victoria, Australia.

Terrenato, L, Shrestha, S, Dixit, KA, Luzzatto, L, Modiano, G, Morpurgo, G & Arese, P 1988, 'Decreased malaria morbidity in the Tharu people compared to sympatric populations in Nepal', *Annals of tropical medicine and parasitology*, vol. 82, no. 1, 1988/02//, pp. 1-11.

Thapa, A 2013, 'Does private school competition improve public school performance? The case of Nepal', *International Journal of Educational Development*, vol. 33, no. 4, 7//, pp. 358-366.

The Himalayan Times 2016, *Insurance Board (IB) to allow weather index-based crop insurance schemes*, viewed 20 Apr 2016, <https://thehimalayantimes.com/business/ib-to-allow-weather-index-based-crop-insurance-schemes/>.

The Kathmandu Post 2016, *Slow growth in crop insurance coverage*, Kantipur Publications, viewed 20 Apr 2016, <http://kathmandupost.ekantipur.com/news/2016-03-28/slow-growth-in-crop-insurance-coverage.html>.

The World Bank 2016a, *Foreign direct investment, net inflows (% of GDP)*, viewed 10/10 2016, <http://data.worldbank.org/indicator/BX.KLT.DINV.WD.GD.ZS>.

The World Bank 2016b, 'GDP per capita', in TW Bank (ed.)<http://data.worldbank.org/indicator/NY.GDP.PCAP.CD>.

Thieme, S 2010, 'Social networks and migration: Women's livelihoods between Far West Nepal and Delhi', *European Bulletin of Himalayan Research*, vol. 35-36, pp. 107-121.

Tiwary, M 2005, 'Marginal farmers, agricultural practices, and rural poverty in Nepal', *Jahrbuch der Österreichischen Gesellschaft für Agrarökonomie*, vol. 12, pp. 123-147.

Tong, K, Su, F, Yang, D & Hao, Z 2014, 'Evaluation of satellite precipitation retrievals and their potential utilities in hydrologic modeling over the Tibetan Plateau', *Journal of Hydrology*, vol. 519, Part A, 11/27/, pp. 423-437.

Tschakert, P 2007, 'Views from the vulnerable: Understanding climatic and other stressors in the Sahel', *Global Environmental Change*, vol. 17, pp. 381-396.

Tschakert, P 2013, 'From impacts to embodied experiences Tracing political ecology in climate change research', *Geografisk Tidsskrift-Danish Journal of Geography*, pp. 37-41.

Turner, AG & Slingo, JM 2009, 'Subseasonal extremes of precipitation and active-break cycles of the Indian summer monsoon in a climate-change scenario', *Quarterly Journal of the Royal Meteorological Society*, vol. 135, no. 640, pp. 549-567.

Turner, BL, Kasperson, RE, Matson, PA, McCarthy, JJ, Corell, RW, Christensen, L, Eckley, N, Kasperson, JX, Luers, A, Martello, ML, Polsky, C, Pulsipher, A & Schiller, A 2003, 'A framework for vulnerability analysis in sustainability science', *Proceedings of the National Academy of Sciences*, vol. 100, no. 14, July 8, 2003, pp. 8074-8079.

Uddin, TA 2013, 'Which Household Characteristics Help Mitigate the Effects of Extreme Weather Events? Evidence from the 1998 Floods in Bangladesh', in T Faist & J Schade (eds), *Disentangling Migration and Climate Change: Methodologies, Political Discourses and Human Rights*, Springer Netherlands, Dordrecht, pp. 101-141.

UN 2015, 'International migration flows to and from selected countries: The 2015 revision', in UN (ed.)2015 revision edn, <http://www.un.org/en/development/desa/population/migration/data/empirical2/migrationflows.shtml>.

UNDP 2015, *Human Development Index and its components*, UNDP, viewed 22-May 2016, <http://hdr.undp.org/en/composite/HDI>.

UNHCR 2016, 'Resettlement Statistical Database Portal', <http://www.unhcr.org/en-au/resettlement-statistical-database-portal.html>.

UNHCR/WFP 2014, *Assistance to the refugees from Bhutan in Nepal*, Joint Assessment Mission Report, UNHCR / WFP, Damak, Nepal.

Upadhyay, S 2010, 'Monsoon variability analysis in Nepal from 1979 to 2008', Department of Environmental Science and Engineering, BSc Thesis thesis, Bachelor of Science (Honors) thesis, Kathmandu University, Dhulikhel, Nepal.

Urwin, K & Jordan, A 2008, 'Does public policy support or undermine climate change adaptation? Exploring policy interplay across different scales of governance', *Global Environmental Change*, vol. 18, no. 1, pp. 180-191.

Vedwan, N & Rhoades, RE 2001, 'Climate change in the Western Himalayas of India: a study of local perception and response', *Climate Research*, vol. 19, pp. 109-117.

Vincent, LA, Peterson, TC, Barros, VR, Marino, MB, Rusticucci, M, Carrasco, G, Ramirez, E, Alves, LM, Ambrizzi, T, Berlato, MA, Grimm, AM, Marengo, JA, Molion, L, Moncunill, DF, Rebello, E, Anunciação, YMT, Quintana, J, Santos, JL, Baez, J, Coronel, G, Garcia, J, Trebejo, I, Bidegain, M, Haylock, MR & Karoly, D 2005, 'Observed Trends in Indices of Daily Temperature Extremes in South America 1960–2000', *Journal of climate*, vol. 18, no. 23, 2005/12/01, pp. 5011-5023.

von Storch, H 1999, 'Misuses of Statistical Analysis in Climate Research', in HV Storch & A Navarra (eds), *Analysis of climate variability - Application of Statistical Techniques*, 2nd edn, Springer.

Wang, B, Liu, J, Kim, H-J, Webster, P & Yim, S-Y 2012, 'Recent change of the global monsoon precipitation (1979–2008)', *Climate Dynamics*, vol. 39, no. 5, 2012/09/01, pp. 1123-1135.

Wang, X, Siegert, F, Zhou, A-g & Franke, J 2013, 'Glacier and glacial lake changes and their relationship in the context of climate change, Central Tibetan Plateau 1972–2010', *Global and Planetary Change*, vol. 111, 12//, pp. 246-257.

Warner, K 2010, 'Global environmental change and migration: Governance challanges', *Global Environmental Change*, vol. 20, pp. 402-413.

Warner, K, Erhart, C, de Sherbinin, A, Adamo, SB & Chai-Onn, T 2009, *In search of Shelter: Mapping the Effects of Climate Change on Human Migration and Displacement*, United Nations University, CARE, and CIESIN-Columbia University and in close collaboration with the European Commission "Environmental Change and Forced Migration Scenarios Project", the UNHCR, and the World Bank.

Wiltshire, AJ 2013, 'Climate change implications for the glaciers of the Hindu-Kush, Karakoram and Himalayan region', *The Cryosphere Discuss*, vol. 7, pp. 3717–3748.

Wiseman, ND & Bardsley, DK 2013, 'Climate change and indigenous natural resource management: a review of socio-ecological interactions in the Alinytjara Wilurara NRM region', *Local Environment*, vol. 18, no. 9, 2013/10/01, pp. 1024-1045.

Wood, W 2001, 'Ecomigration: Linkages between environmental change and migration', in AR Zolberg & PM Benda (eds), *Global migrants, global refugees: Problems and solutions*, Berghahn Books, New York, pp. 42-61.

Wrathall, DJ 2012, 'Migration Amidst Social-Ecological Regime Shift: The Search for Stability in Garífuna Villages of Northern Honduras', *Human Ecology*, vol. 40, pp. 583-596.

Xu, J, Shrestha, AB, Vaidya, R, Eriksson, M & Hewitt, K 2007, *The melting Himalayas: Regional challenges and local impacts of climate change on Mountain ecosystems and livelihoods*, ICIMOD Technical Paper, ICIMOD, Kathmandu, Nepal.

Yamanaka, K 2005, 'Changing family structures of Nepalese transmigrants in Japan: split-households and dual-wage earners', *Global Networks*, vol. 5, no. 4, pp. 337-358.

Yatagai, A, Kamiguchi, K, Arakawa, O, Hamada, A, Yasutomi, N & Kitoh, A 2012, 'APHRODITE: Constructing a Long-Term Daily Gridded Precipitation Dataset for Asia Based on a Dense Network of Rain Gauges', *Bulletin of the American Meteorological Society*, vol. 93, no. 9, 2012/09/01, pp. 1401-1415.

Yohe, G & Tol, RSJ 2002, 'Indicators for social and economic coping capacity—moving toward a working definition of adaptive capacity', *Global Environmental Change*, vol. 12, no. 1, 4//, pp. 25-40.

Young, OR, Berkhout, F, Gallopin, GC, Janssen, MA, Ostrom, E & van der Leeuw, S 2006, 'The globalization of socio-ecological systems: An agenda for scientific research', *Global Environmental Change*, vol. 16, no. 3, 8//, pp. 304-316.

Zhang, G, Yao, T, Xie, H, Wang, W & Yang, W 2015, 'An inventory of glacial lakes in the Third Pole region and their changes in response to global warming', *Global and Planetary Change*, vol. 131, 8//, pp. 148-157.

Zhang, JH, Hegerl, GC, Zwiers, FW & Keynyon, J 2005, 'Avoiding Inhomogeneity in Percentile-Based Indices of Temperature Extremes', *Journal of climate*, vol. 18, pp. 1647-1648.

Zhang, L & Zhou, T 2011, 'An assessment of monsoon precipitation changes during 1901–2001', *Climate Dynamics*, vol. 37, no. 1-2, 2011/07/01, pp. 279-296.

Zhang, X, Alexandar, L, Hegerl, GC, Jones, P, Tank, AK, Peterson, TC, Blair, T & Zwiers, FW 2011, 'Indices for monitoring changes in extremes based on daily temperature and precipitation data', *WIREs Climate Change*.

Zhang, X & Zwiers, FW 2004, 'Comment on ‘‘Applicability of prewhitening to eliminate the influence of serial correlation on theMann-Kendall test’’ by Sheng Yue and Chun Yuan Wang', *Water Resources Research*, vol. 40.