ICIMOD

FOR MOUNTAINS AND PEOPLE

Climate Variability and Change in the Himalayas

Community perceptions and responses

IFAD

Climate Variability and Change in the Himalayas

Community perceptions and responses

Mirjam Macchi
Amanda Manandhar Gurung
Brigitte Hoermann
Dhrupad Choudhury

International Centre for Integrated Mountain Development, Kathmandu, Nepal, 2011

Published by

International Centre for Integrated Mountain Development
GPO Box 3226, Kathmandu, Nepal

ISBN 978 92 9115 226 1 (printed)
978 92 9115 227 8 (electronic)

LCCN 2011 312017

Printed and bound in Nepal
Quality Printers (P) Ltd., Kathmandu, Nepal

Production team
A Beatrice Murray (Consultant editor)
Andrea Perlis (Senior editor)
Punam Pradhan (Layout and design)
Asha Kaji Thaku (Editorial assistant)

Photos: Cover, pp 6, 12, 14, 18, 48, 50, 53 – Alex Treadway;
pp 2, 33, 37 – Amanda Gurung; pp 25, 28, 30, 34 – Mirjam Macchi;
pp 40, 45 – Zoe Lucia Lüthi

This publication is available in electronic form at
www.icimod.org/publications

Citation: Macchi, M; Gurung, AM; Hoermann, B; Choudhary, D (2011) *Climate variability and change in the Himalayas: Community perceptions and responses.* Kathmandu: ICIMOD

Contents

Acknowledgements

This study was conducted as part of the International Fund for Agricultural Development (IFAD) Technical Assistance Grant (TAG) 1113 activities. We would like to express our gratitude to IFAD for their financial support and trust in this research and for their strategic partnership with ICIMOD. Particular thanks also go to the Swiss Agency for Development and Cooperation (SDC) which provided the funding for this publication under the Junior Professional Officer Programme. We would also like to thank the many staff of the IFAD-supported projects and organisations Aajeevika, Meghalaya Rural Development Society (MRDS, India), Resources Centre for Sustainable Development (RCSD, India), Environment, Culture, Agriculture, Research and Development Society (ECARDS, Nepal), the Western Uplands Poverty Alleviation Project (WUPAP, Nepal), and the Agriculture Marketing and Enterprise Promotion Program (AMEPP, Bhutan) for their support in arranging field logistics and interviews in the villages. Special thanks go to the consultants Anmol Jain, responsible for the field studies in Uttarakhand, and Zoe Lucia Lüthi, responsible for the field studies in Bhutan.

We are particularly grateful to Lisa Schipper, senior scientist at the Stockholm Environment Institute, for agreeing to review this document and providing useful and constructive comments and suggestions, and to Rajan Kotru and Neera Shrestha Pradhan from ICIMOD for acting as internal reviewers.

We also wish to thank the many colleagues in ICIMOD for their valuable ideas, thoughts, and inputs which were indispensable for this study. Special thanks go to Dr Michael Kollmair, Programme Manager, for his valuable support and feedback during the field studies, data analysis, and reporting process. We thank Mandira Shrestha and Aseem Sharma from ICIMOD, and Zoe Lucia Lüthi (consultant), for analysing the climate data. We thank Yukta Kumar, Andrea Perlis, Punam Pradhan, the editorial team of ICIMOD, and A Beatrice Murray, consultant, for their help in bringing the document to its present form, as well as the many others who helped make this publication possible. Last but by no means least, we are particularly thankful to the communities in India, Nepal, and Bhutan who openly shared their rich knowledge and concerns with us.

Some Key Concepts

Some brief definitions are given below of key concepts used in this book in the context of climate change.

Adaptation: Adaptation to climate change is the adjustment of a system to moderate the impacts of climate change to take advantages of new opportunities or to cope with the consequences (Adger et al. 2003, p 192)

Adaptive capacity: Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damage, to take advantage of opportunities, or to cope with the consequences (IPCC 2007). Adaptive capacity is shaped among others by available resources, institutions, and skills and knowledge.

Climate change: 'Climate change' means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCCC 1994).

Coping strategies: Coping strategies are short-term actions to ward off immediate risk, rather than to adjust to continuous or permanent threats or changes. Coping strategies usually rely on selling or using up assets and reserves and are often the same set of measures that have been used before. When using coping strategies as a response to stress, it is possible that vulnerability will increase in the long term (ICIMOD 2009).

Hazard: A hazard is a potentially damaging physical event, phenomenon, or human activity that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation (ISDR 2004).

Maladaptation: Maladaptation is an action or process that increases vulnerability to climate change-related hazards. Maladaptive actions and processes often include planned development policies and measures that deliver short-term gains or economic benefits but lead to exacerbated vulnerability in the medium to long-term (UNDP 2011).

Mitigation: In the context of climate change, mitigation is a human intervention to reduce the sources or enhance the sinks of greenhouse gases (UNFCCC 2011).

Resilience: Resilience is the ability of a social-ecological system to absorb disturbances without losing its fundamental structure and function (combination of definitions).

Risk: Risk is the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted, environmental damage) resulting from interactions between natural or human-induced hazards and vulnerable conditions. Conventionally risk is expressed by the notation Risk = Hazards x Vulnerability. Some disciplines also include the concept of exposure to refer particularly to the physical aspects of vulnerability (ISDR 2004).

Vulnerability: In the context of climate change, vulnerability is the degree to which a system is susceptible to, and unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change, and the variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC 2007).

Acronyms and Abbreviations

CFUG	community forest user group
DAO	District Agriculture Office
DDC	District Development Committee
DFO	District Forest Office
IFAD	International Fund for Agriculture and Development
LFUG	leasehold forestry group
masl	metres above sea level
NAPA	National Adaptation Programme of Action
NREGA	National Rural Employment Guarantee Act (India)
NTFP	non-timber forest product
VCA	vulnerability and capacity assessment
VDC	village development committee area (Nepal)

Part I

Introduction and Synthesis

1 Introduction

Mountain Communities and Climate Change

Mountain communities in the developing world are often marginalised from political influence and economic opportunities and generally face high levels of poverty. The ecosystems they dwell in are among the Earth's most sensitive. Mountain ecosystems and mountain people are exposed to multiple drivers of change including globalisation, economic policies, and increasing pressure on land and mountain resources resulting from economic growth and changes in population and lifestyle. Climate change is expected to place additional stress on these already challenged ecosystems and livelihoods.

The present study was designed to investigate how climate and socioeconomic change is affecting mountain people's livelihoods, what makes them vulnerable, and how they are coping with and adapting to change. ICIMOD conducted a community-based vulnerability and adaptive capacity assessment in four different areas under the framework of the International for Agricultural Development (IFAD) Technical Assistance Grant (TAG) 1113 on 'Livelihoods and ecosystem services in the Himalayas: Enhancing adaptation capacity and resilience of the poor to climate and socioeconomic changes (AdaptHimal)'. The four study areas from west to east were in Uttarakhand in northwestern India (two districts); Nepal (two districts), Eastern Bhutan (two districts), and North East India (one district in Assam and one in Meghalaya). The general objectives of the assessments were

- to identify people's perceptions of climate variability and change;
- to identify underlying causes of vulnerability of mountain communities;
- to assess existing coping and adaptation mechanisms and their sustainability in view of predicted future climate change; and
- to formulate recommendations on how to improve individual and collective assets.

The overall aim is to contribute to enhancing the resilience of vulnerable mountain communities in the Hindu-Kush Himalayan (HKH) region to change.

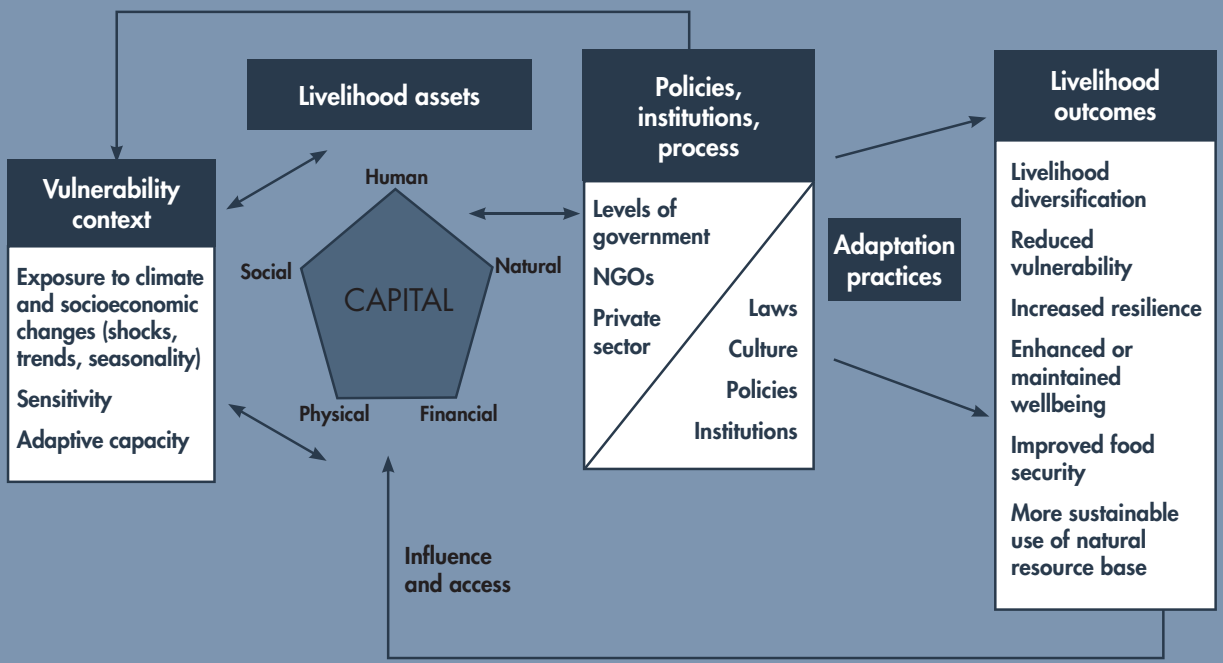
The field studies were conducted between June 2010 and June 2011 and included focus group discussions at the community level and in-depth interviews at the household level. They followed a more extensive participatory rural appraisal exercise undertaken in March to August 2010.

It is important to keep in mind while reading this report, that not all the identified responses should be interpreted as direct responses to climate-related risks. Many may rather be interpreted as responses to the challenging life that mountain communities are already living, which is being aggravated by climate change. The findings demonstrate that the livelihoods of mountain communities are already seriously affected by climate and socioeconomic change and that they have developed a repertoire of response strategies to these changes.

Approach and Methodology

The analytical approach applied for this study was the community-based vulnerability and capacity assessment (VCA) approach described by Macchi (2011) which is based on the sustainable livelihoods approach of the Department for International Development (DFID 1999) (Figure 1). The VCA approach recognises that the ability of a community or an individual to implement adaptation strategies requires livelihood assets including entitlements to financial, social, and physical capital as well as human and natural resources (Brooks and Adger 2005), and depends on different types of institutions (Agrawal and Perrin 2009). In contrast to a classic climate change impact assessment, the VCA approach not only considers impacts driven by climate change, but also impacts driven by non-climatic factors (environmental, economic, social, demographic, technological, and political) that may have beneficial and/or adverse impacts on

Figure 1: **Sustainable livelihoods approach**



Source: Adapted from DFID 1999

communities' livelihoods. Furthermore, it places a special focus on the communities' local knowledge and capacity to adapt. The objective of a VCA is to improve our understanding of how environmental and socioeconomic changes affect the livelihoods of rural, natural resource dependent women and men, what shapes their vulnerabilities, and what livelihood assets they have for coping with and adapting to climate and socioeconomic changes (Macchi 2011). Special attention was paid to potential differences in the vulnerability and adaptive capacity of women and men and of different social groups. The general role of formal and informal institutions in the adaptation process was also considered. ICIMOD is planning further studies focusing specifically on the complex role of institutions under the Himalayan Climate Change Adaptation Programme (HICAP).

The following assumptions were made in the preparation phase of the study: climate change is already happening, it is noticeable to communities in mountain areas, and it is directly affecting their livelihoods and means of production; environmental variability and change are not new phenomena and mountain communities have developed a range of adaptive strategies in response; changes happening in mountain areas are driven by a variety of environmental and non-environmental drivers of change, not only by climate; vulnerability to climate change is unevenly distributed across and within mountain communities.

The findings of a VCA are intended to contribute to informed decision making on how to improve individual and collective assets with the aim of enhancing the resilience of mountain communities in the Himalayas.

The following research questions guided the study:

- How do mountain communities perceive and interpret climate and socioeconomic change?
- What are the major impacts of these changes on their livelihoods?
- How do mountain communities respond to the perceived changes, and are these responses sustainable in view of predicted future climate change?

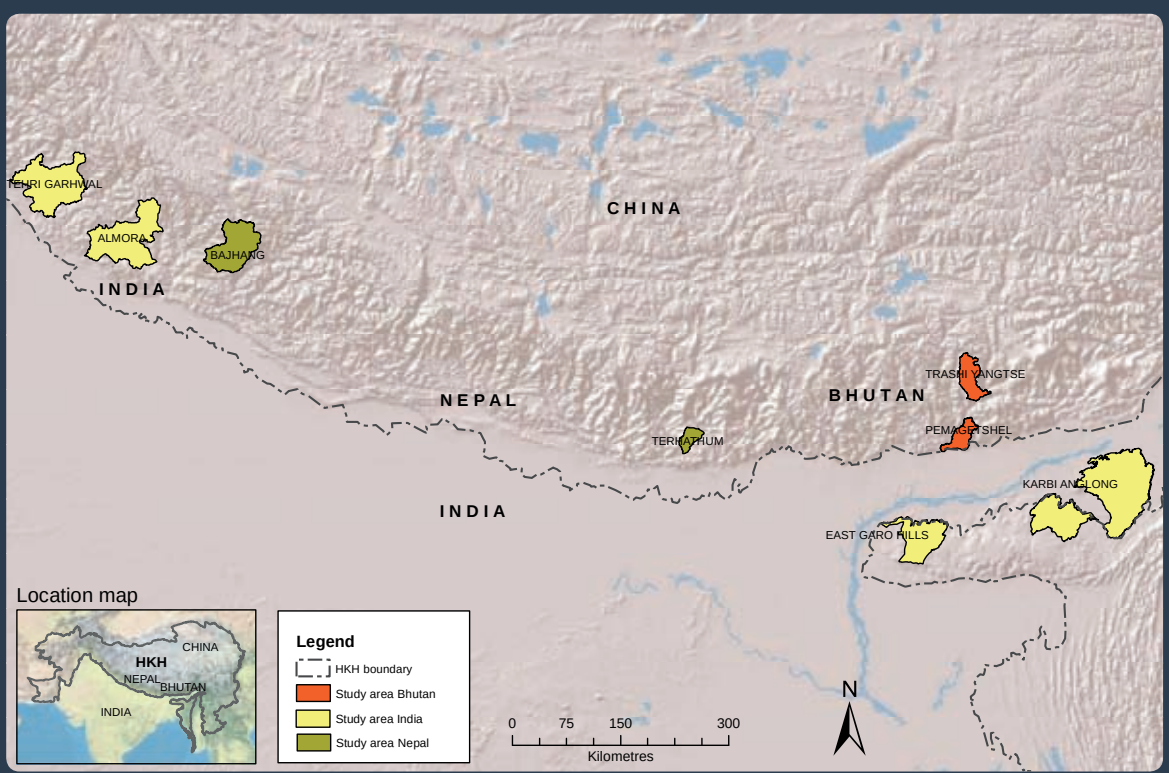
- What are the mountain communities' main assets and needs for coping with, and adapting to, environmental and socioeconomic changes?
- Are there any differences between different social groups (in particular men and women) in terms of their perception of change and its implications, and with regard to their vulnerabilities and adaptive capacities?
- How do different institutional mechanisms and policies influence the capacity of mountain people to adapt?
- What actions are necessary to increase the resilience of mountain communities?

In order to answer these questions, primary data were collected at community and household level through in-depth household interviews and partly gender disaggregated focus group discussions (see guidelines in Annex 1). Representatives of different socioeconomic strata and different ethnic groups and castes were addressed in the in-depth interviews in order to identify potential differences in vulnerability and adaptive capacity. The time frame in which the communities were asked to report perceived changes was between 10 and 20 years or more, depending on the age of the respondent. In Nepal and Bhutan, the communities' perceptions of climate change were compared and validated with trend analyses of observed climate data derived from the closest hydro-meteorological station. No recent climate data were available from India.

Study areas

The field studies were conducted by experienced regional and international consultants at four study areas in the Himalayas in three countries: Almora and Tehri Garhwal in the Indian hill state of Uttarakhand; Bajhang in the far west and Terhathum in the far east of Nepal; Trashi Yangtse and Pemagetshel in Eastern Bhutan; and Karbi Anglong in Assam and the East Garo Hills in Meghalaya both in North East India (Figure 2). The sites were selected on the basis of a number of factors such as altitude, culture, degree of accessibility, and geographic location, and were situated between 400 and 2,400 m above sea level (masl). All the selected sites overlapped with IFAD project areas that had previously been identified as particularly vulnerable.

Figure 2: **The study sites**



The boundaries represented on this map are not political.

Farmers' Perceptions of and Responses to Change: The Regional View

The results were analysed for each of the four areas and are summarised in the case studies which form Part 2 of this report. In the following, we present a summary and synthesis of the findings from across the region.

Perceptions of Change and Trend Analysis Across the Study Area

Water is one of the most important factors in subsistence farming. When water supplies become unreliable, this can threaten the whole basis of people's lives. The study focused on poor rural farmers, mostly without irrigated land, for whom precipitation, and especially the monsoon, was fundamental for an optimum harvest. Changes in the amount, timing, and intensity of rainfall were the primary concern of respondents across the study area. The delay in the onset of the monsoon, observed mainly in the western part of the study area – in Uttarakhand in India and Bajhang in Nepal – had significant consequences for the production of the main food crop. It was leading to delays in the sowing of rice and affected the growth of maize, severely affecting food security. There was a perception that annual rainfall was reduced overall, which reduces the recharge of underground aquifers and the amount of drinking water available from springs for communities and livestock. Winter precipitation and snowfall at higher altitudes were seen to be erratic and decreasing dramatically.

Many respondents, and particularly those living at higher altitudes, thought that temperatures were rising. Mosquitoes have appeared in areas previously too cold for the present level of incidence, and fruit and other crops can be grown at altitudes where it was previously not possible, both of which support this perception.

There had been an unprecedented increase in crop disease and pests, again most marked in the western areas of Uttarakhand and Bajhang, areas that also appear to have become drier and that faced prolonged dry seasons with almost drought-like conditions in 2010.

Windstorms appeared to be the greatest hazard in Eastern Bhutan, and change in all parts of the eastern Himalayas (Terhathum in Nepal, Bhutan, and North East India) appeared to be characterised most by a marked increase in the variability of weather events rather than a specific trend in one direction or another.

The perceived changes are summarised in Table 1.

Table 1: **Summary of main changes perceived across the study area (from west to east)**

Uttarakhand, India	Nepal	Eastern Bhutan	North East India
Overall less rainfall, and more erratic	Overall less rainfall, and more erratic	Erratic precipitation patterns (highly variable rainfall patterns within the study area)	Erratic precipitation patterns
Overall decreased water availability	Overall decreased water availability	Overall decreased water availability (with exceptions)	Overall decreased water availability
Less or absent winter rains	Less or absent winter rains		
Increased frequency of intense rainfall events	Increased frequency of intense rainfall events	Increased frequency of windstorms, more severe hailstorms	More severe storms
Increase in pests and disease	Increase in pests and disease	Increase in pests and disease	Increase in pests and disease
Increasing temperatures	Increasing temperatures	Increasing temperatures	Increasing temperatures
Warmer and shorter winters with less snowfall	Warmer and shorter winters with less snowfall		

Assessing Perceived Changes

Notwithstanding the widespread reports of water and other climate-related changes, it is important to remember that climate change may be only one component, and not necessarily the most important, affecting these events. For example, reduction in the perceived availability of water from a well or spring can result from increased demand as well as reduced flows (as shown, for example, in a study by Merz et al. [2002] in central Nepal). Problems of crop productivity and reduced food security can be related to socioeconomic changes such as lack of labour resulting from outmigration, increased demand resulting from increased population, and the cultivation of more marginal lands, as well as from climate change impacts. Similarly, the increase in pests and disease might also be linked to the increasing use of chemical fertilisers, planting of monoculture crops, use of imported seed, and/or more intensive farming methods.

At the same time, human perception is based on memories that change. Comparisons with actual climate measurements indicated that farmers generally had a good memory of the past. However, perceptions were strongly shaped by their experiences in the most recent years. For example, the delayed onset of the monsoon was perceived as a trend, but in 2011, the year after the survey, the rains began early and in some places were much stronger than usual. In Upper Mustang in Nepal, continuous rainfall was experienced over 48 hours in an area where it had barely rained over the past 30 years, damaging infrastructure and vegetation (Shahi 2011).

Notwithstanding the actual causes, farmers across the region clearly felt that the climate was changing, and – most importantly – that it was much less predictable than previously. The erratic nature of the events experienced and lack of predictability posed the greatest problem for the adaptation processes of the rural poor, who were unable to prepare clearly for the annual agricultural processes, and who needed to be prepared for and able to respond to a range of different climatic conditions.

Local Responses to Climate Change

Climate-related changes are already having severe impacts on people's livelihoods, particularly those that are highly dependent on agriculture and animal husbandry related activities. Water scarcity or overabundance, drastic reductions in yields, increases in crop pests and disease, health issues, and increased workloads – especially for women – are some of the challenges that rural mountain communities are facing.

Agrawal and Perrin (2009: 356-357) note that "Adaptation strategies are viewed by some scholars as being prospective in nature in contrast to coping efforts which are seen as being retrospective and in response to specific experiences of variability". The recurrence of hazards leads to some 'coping' strategies becoming prospective in nature. This study uses the term 'coping strategies' to mean 'short-term actions to ward off immediate risk' (ICIMOD 2009) and 'adaptation' to refer to longer term 'adjustments of a system to moderate the impacts of climate change' (Adger et al. 2003). Responses to change can be planned (usually by interventions of public agencies) or autonomous (usually by individuals or communities) (Brooks and Adger 2005). The coping and adaptive strategies used in the study area were grouped according to these definitions and are summarised in Table 2. Coping strategies are generally autonomous and not planned.

Although more adaptive strategies are listed, these rural communities used coping strategies much more frequently than adaptive strategies. Strategies such as shifting of the agricultural calendar or using stalks of failed crops as fodder are mostly retrospective strategies, employed on a year-by-year basis depending on the actual weather events and requiring few external resources. Such strategies are only effective in the short term; they can buffer the extreme loss of harvests but still result in a decline in yield and cannot prevent damage caused by a consistent lack of rainfall or significant delays in the monsoon. Strategies such as re-sowing after an early season failure, borrowing money, or selling assets may even render people more vulnerable as they are depleting their asset base. In contrast, autonomous adaptation strategies such as non-timber forest product (NTFP) collection or wage labour are a mixture of retrospective and prospective responses. Planned response strategies are mostly prospective and implemented with external assistance, mostly from local institutions, and require resources – financial, human, and technological, including information and knowledge. Except in Bhutan, planned interventions in the study area were mostly single sporadic activities, inaccessible to individual households and too small to reach a critical mass.

Table 2: **Response strategies to climate variability and change in the study area***

Hazard	Coping strategy	Adaptation	
		Autonomous	Planned
Erratic precipitation (too much or too little water)	Adjusting the agricultural calendar (e.g., delayed sowing, early harvesting) [r] Stopping paddy planting [r] Repeat sowing and crop replacement after failure early in the season [r]	Changing to crops that can cope with water and temperature stress (e.g., millet replacing rice, mustard replacing wheat) [r,p] Building canals and ponds for irrigation [p]	Introduction of improved seeds that promise high yields even under dry conditions [p] Starting to cultivate off-season vegetables [p]
Overall reduction in water availability	Using stalks of failed crops as fodder [r] Walking longer distances to collect water, fuelwood, and fodder [r] Performing rituals [r] Changing livestock composition to cope with fodder and water scarcity [r,p]	Mulching to increase soil moisture [r] Moisturising and deep sowing maize seeds to increase chances of germination [r] Rainwater harvesting in tanks to be used for cattle, the household, and vegetable irrigation [p]	Investments in electric water pumps to pull spring water from a nearby stream at a lower elevation [p] Revitalisation of rotational irrigation, a traditional mechanism in northwestern India where water is shared through channels [r,p]
Rising temperatures		Introducing new crops such as ginger and turmeric that fetch higher prices and can better withstand water and temperature stress [p] Growing crops at higher altitudes or cultivating more than one crop per year [r,p]	Polytunnels and polyhouses for higher temperature and humidity for particular vegetables [p]
Increased incidence of pests and diseases	Applying traditional pest management strategies such as scattering ash or cow urine, and setting fires in fields to kill pests [r] Increased use of chemical pesticides [r]	Crop rotation and planting of different crops every season to limit infestations of the same pests as well as provide nutrients to the soil [p]	Kurmula traps to attract and kill white grub (Uttarakhand) [r] Promotion of organic pest control mechanisms (Bhutan) [r,p] Construction of specific storage rooms in households with electrical air circulation systems to reduce post-harvest losses [p]
Physical and socioeconomic stress and shocks (e.g., landslides, heavy precipitation, windstorms, acute food shortages)	Building side drains on sloping fields to divert water when strong rains set in [r] Protecting roofs from windstorms by tying them to the basement of the house or nearby trees [r] Taking loans from stores, moneylenders, or savings groups when cash is short [r] Skipping meals during times of acute food shortage [r] Selling assets such as livestock and jewellery [r]	Mixed cropping of beans with maize to protect the maize plants from strong winds [p] Collection of high value NTFPs such as yarshagumba (*Cordyceps sinensis*) and other medicinal herbs to supplement incomes [r,p] Seeking wage labour in nearby markets or through state/INGO sponsored road-building or construction projects [r,p] Rural-urban migration, both domestic and international [r,p]	Planting oak trees around springs to protect the catchment area [p] Introduction of plants with lower stalks(planned by the Government of Bhutan) [p] Cultivation of *Aloe vera*, which thrives under arid and semi-arid conditions (India)[p]

*p = prospective, r = retrospective

The sustainability of the identified response strategies and their potential to increase mountain communities' resilience are currently unknown, as they will depend on the extent and direction of the changes that will occur. Despite persistent uncertainties, scaling up of successful response strategies and knowledge sharing and transfer will be of the utmost importance. Good practices from the region, effective in limiting damage caused by changing weather patterns, need to be exchanged in order to provide people with as many response options as possible.

Differences in Adaptive Capacity

Essentially, having adaptive capacity means having the assets (including knowledge) needed to implement adaptation strategies. Adaptive capacity is determined by various factors including recognition of the need to adapt, willingness to undertake adaptation, and the availability of, and ability to deploy, resources (Brown 2010). Following this definition, the poorest, with the least ownership and access to financial, technological, and human assets, generally have the lowest adaptive capacity. In the Himalayas, this situation is further aggravated by the fact that the rural poor are mostly involved in subsistence agriculture, and thus directly affected by changing weather patterns. Adaptation in agriculture is very challenging, and even more so for the poor. Essentially, climate change has the capacity to make an already poor household or community poorer.

Poverty itself is strongly influenced by social factors such as gender, caste, and pre-existing human capital. Women in much of India and Nepal have low access to resources and decision-making rights. When harvests fail and alternative incomes are needed, they have few skills and little education and can often only work as wage labourers, usually for lower wages than their male counterparts. Most women must also depend on men for the financial and physical capital needed to develop alternative sources of income. The situation is slightly better for women in Bhutan and parts of North East India, where women have more control over assets. The caste system in much of India and Nepal is also an important element to consider when determining adaptive capacity. Members of Dalit castes (the lowest caste, previously deemed 'untouchable') in Nepal and India have historically been marginalised and are generally poor. Other ethnic and indigenous groups in Nepal and India have also suffered discrimination. These societal beliefs translate into poverty-perpetuating habits. For example, in Bajhang in Nepal, Dalit people were previously prevented from entering the areas where yarshagumba (*Cordyceps sinensis*) is collected as there is a holy temple there; they have only recently been able to participate in this high-income-generating activity. In Terhathum in eastern Nepal, Dalit people reported that untouchability was no longer a problem; however, indigenous groups such as the Tamang and Limbu report discrimination by higher-caste neighbours. The wealthier, high caste farmers are also the local moneylenders, and thus an integral part of the system that traps people in poverty. The problems are compounded by poor people's lack of access to education; indigenous farmers often couldn't read and write, making them even more vulnerable.

Human capital, specifically literacy and higher education, becomes crucial in the search for employment. Older people and women in the study area had lower levels of literacy. Literacy was also one of the most significant factors triggering poverty in Eastern Bhutan. In Nepal, the low caste Dalit groups have comparatively less education (WB and DFID 2006). In one village in Bajhang where almost all the inhabitants were Dalits, only one villager had completed 10th grade (school leaving certificate year). In the words of a woman from the village "I never went to school and now it's like being blind". In contrast, a higher caste (Chettri) woman from Terhathum said, "We don't have to hide from the people. We can speak up in front of them and we know how to read and write a letter and calculate. Without education I could not run this little shop besides working in the fields." These two quotations illustrate the importance of human capital for diversifying livelihoods away from climate sensitive subsistence farming, thus increasing resilience.

In summary, although influenced by social factors, adaptive capacity in the study area was broadly determined by poverty and the reliance on income sources that depend on timely weather patterns. As agricultural yields for subsistence become increasingly at risk, other income sources will become increasingly important. Those who currently depend on off-farm activities or on a variety of livelihood strategies both on and off-farm, and who have comparatively higher educational attainments, are perhaps the ones who will be most able to adapt, as their livelihoods do not entirely focus on professions that are dependent on predictable weather events. It is the poorer farmers in the region, with small marginal landholdings at a distance from markets, who depend solely on agriculture and have few income-generating options, who will find it hardest to adapt.

Institutional Opportunities and Constraints

Institutions can be crucial in determining and influencing the adaptive capacity of any group, particularly by structuring impacts and vulnerability, mediating between individual and collective responses to climate impacts and thereby shaping outcomes of adaptation, and delivering external resources to communities in order to facilitate adaptation (Agrawal and Perrin 2009). Local institutions – the primary bodies in contact with farmers – can play a significant role in limiting vulnerability in mountain areas, where farmers suffer from poor accessibility. However, in most parts of the study area, the outreach services provided by local institutions were insufficient. They did not meet the needs of the people, and did not reach the people in most need. Furthermore, most institutions were unaware of climate-related risks, and thus had no advice or support to offer in coping or adaptation. Bhutan was an exception; in Bhutan local government authorities were highly responsive to problems related to agriculture or animal husbandry and to farmers' needs for information and support.

Across the region, local institutions need to be strengthened in terms of technological, financial, and human resources to enable them to deliver demand driven services where they are most needed. Climate change mainstreaming among these institutions will be vital in order to enable them to disseminate the latest information in a timely manner to help avoid climate-related risks such as crop losses and subsequent food insecurity.

Policy

At the policy level, considerable efforts have been made by all three countries in this study to develop policies and adaptation programmes at the national level to address climate change. These include the development of National Adaptation Programmes of Action (NAPAs) in Nepal and Bhutan and the National Action Plan on Climate Change in India. However, such national policies are still insufficient for the people in mountain areas, as it is crucial to take the local context and the specificities of mountain areas into consideration. Nepal has also formulated Local Adaptation Plans of Action (LAPAs). It remains to be seen whether these will be beneficial for mountain people. However, if they are shown to deliver tangible benefits, other countries with mountainous areas should consider formulating similar plans in a participatory manner.

The Way Forward

Despite the challenges, there are possibilities for addressing the problems that will arise as a result of climate change and assisting communities to adapt and mitigate the impacts. It will also be important to exploit the opportunities emerging from climate change, for example growing crops at higher altitudes. The key is to consider the ground reality and develop specific strategies that acknowledge or build upon existing autonomous adaptation strategies and counter climate-related risks.

Some of the approaches that should be considered are summarised below.

Approaches in Support of Adaptation

Planning for climate uncertainty

Mountain areas are characterised by high topographic and climatic variability. The resolution of the present-day climate models is insufficient to capture this topographic variation. Equally, there are very few hydro-meteorological stations in the mountainous parts of the Himalayas, and the amount, quality, and historical availability of data records are mostly inadequate for climate trend analysis. The most consistent perception among respondents was that precipitation patterns were becoming increasingly erratic. Thus there is a high degree of uncertainty about the future direction and magnitude of change, and this needs to be taken into account when planning for adaptation. Sustainable livelihoods in the Himalayas depend on being able to live with uncertainty, above all with erratic precipitation. Over the short and medium term, so called 'no-regret' strategies are needed regardless of the direction or magnitude of change. The focus should be on 'climate resilient development', which includes three components: reducing vulnerability by minimising risk without depending on a p articular climate future, increasing resilience so that the unexpected can be overcome, and enhancing adaptive capacity so that communities can take informed control over their future (Ensor 2009). Over the medium and longer term, the existing knowledge base needs to be enhanced through coordinated research in order to reduce uncertainty and enable development of adaptation measures that tackle specific climate risks that are outside historic climate variability.

Reducing poverty and social inequality

Poverty was identified by the communities as the key driver of vulnerability and low adaptive capacity to climate change. Livelihood assets are required to adapt to change, and many respondents stated that being poor limits their options to cope with or adapt to changing conditions. For example, financial capital is needed to buy a second batch of seeds or to buy food from markets when crops fail. Financial and social capital are needed for migration; it is rarely the most disadvantaged who migrate (Black et al. 2005). Lack of human capital also prevents people from taking up skilled labour in sectors that are less climate sensitive. Limited accessibility was another factor that reduced people's possibilities for escaping from poverty and limited their adaptive capacity. Vulnerability is particularly high where poverty intersects with discrimination, be it because of gender, caste, or ethnicity. This is especially true for women and lower caste people (as seen in the Nepal and Uttarakhand case studies). Thus, poverty and social inequality need to be addressed when aiming to enhance the resilience of rural communities. There should also be a special emphasis on the role of women in adaptation, as many of the coping and adaptive responses they implement add to their already heavy workloads. Interventions to reduce poverty and social inequality are very important in addressing vulnerability to climate change.

Raising awareness

Responses to climate change can be prospective or retrospective (Agrawal and Perrin 2009). Most strategies observed in the study area were retrospective rather than prospective. This may be linked to the fact that many people were

Many communities have adopted short-term coping strategies such as shifts in the agricultural calendar, re-sowing after an early season crop failure, or use of failed crops as hay – but longer-term adaptation strategies are needed

not aware that, or unclear about the reasons why, the weather patterns were changing and thus could not anticipate climate-related risks. Many of them believed that the changes were the result of their own mistaken behaviour, or of deforestation and other evils that had enraged the Gods who were punishing them through adverse climatic conditions. As one farmer (aged 72) from Terhathum in Nepal said, "Earlier, everything was balanced. These days, the earth is upside down and the Gods are rude with us. Maybe it is because men don't believe in God anymore and this is why they are punishing us. So we need to keep being faithful". Since adaptive capacity is partly determined by knowledge (including indigenous knowledge) and the awareness of climate change risks, it will be crucial to raise communities' awareness of potential climate-related risks, as well as of appropriate mechanisms to address such risks. It will also be important to raise awareness within local and government institutions.

Moving from coping to adaptation

Many of the observed community-based responses in the study areas were short-term coping strategies. Examples include shifts in the agricultural calendar in response to varying annual precipitation patterns, re-sowing after an early season failure, use of failed crops as hay, borrowing money and selling assets, and even migrating due to a complete lack of drinking water (as observed in one village in Terhathum). Many of these coping strategies deplete the household's livelihood asset base and may actually render it more vulnerable if another shock occurs. Adaptation strategies are longer-term and sustainable. The examples observed include the introduction of new crops; maintaining multiple cropping systems; growing more than one crop per year; construction of water harvesting systems; and livelihood diversification. In order to increase the resilience of mountain communities, appropriate longer-term strategies that build on mountain communities' traditional knowledge need to be developed, rather than focusing on short-term responses which may reinforce vulnerability in the longer term.

Supporting livelihood diversification to spread risk

Livelihood diversification is already one of the key strategies used by the studied communities to adapt to change. Communities across the study area increasingly engage in the collection of NTFPs such as yarshagumba (*Cordyceps sinensis*), a high value product in Asian medicine; in wage labour (both on and off-farm) and other non-farm employment; and in migration for work. Given the uncertainty with regard to future climate scenarios, livelihood diversification is likely to remain among the most important strategies for adapting to change. Livelihood diversification means having more than one source of income; if one source fails there is still another to rely on. This spreading of risk helps people to be more resilient to shocks. However, the study also showed that not all groups are equally successful in diversifying their livelihoods. The main reasons are lack of assets and restrictive institutions and policies. Thus conducive and inclusive policies and institutions are necessary to foster pathways to livelihood diversification and the associated improved access to employment opportunities for everybody. This could mean, for example, the promotion of high value products that can be transported across rough terrain with limited road access, or skill development in non-climate-sensitive trades targeting disadvantaged groups.

Conducive policies, institutions, and processes for enhancing the adaptive capacity of mountain communities

Given the high degree of uncertainty about how climate change will affect mountain areas and people, policy interventions should focus primarily on addressing the underlying causes of vulnerability and the limited adaptive capacity of mountain communities, including their high dependence on natural resources, persistent poverty, inaccessibility linked with limited access to markets and outreach services, and inadequate education and employment opportunities. Such policies need to be adapted to the local context and integrated into broader development policies at different scales. Strengthening local public and private institutions and raising awareness among them about climate-related risks will be key, since local institutions play a major role in supporting or hindering communities in their process of adapting to change (Agrawal and Perrin 2009). Furthermore, it will be important to bridge the gap between local institutional mechanisms and external institutions (public and private), given that the adaptation process will be influenced to a great extent by information, technology, and knowledge provided by external institutions and facilitated through local institutions.

Improved delivery mechanisms for support services

With the exception of Bhutan, communities generally lacked access to support services across the study area (extension services, access to subsidised food, energy, education and healthcare, micro-credit, crop insurance, off-farm income opportunities). Furthermore, even where services did exist, they were often not responsive to the increasingly erratic weather patterns affecting mountain communities and ecosystems. Thus, there is a need to increase coverage of and improve quality of and access to services that are responsive to climate change related risks. A special focus is needed on disadvantaged groups, such as lower caste people and women, well as those living in remote places.

Seizing emerging opportunities

Climate change can also have positive impacts on mountain people's livelihoods. For example, with rising temperatures the growing seasons are lengthening, and certain crops are maturing early, providing an additional cropping season that can help improve food security and provide higher incomes (as observed, for example, in Uttarakhand). Climatic conditions are also becoming more favourable for certain crops such as cereals, vegetables, and tropical fruit at altitudes where they previously did not thrive (as observed in Uttarakhand and Nepal). Thus, climate change should not only be associated with negative impacts; rather ways should be actively sought for capitalising on emerging opportunities.

Besides opportunities in the agricultural sector, new opportunities might also emerge for the tourism sector, which need to be seized. With increasing temperatures, cool mountain resorts in the tropics and subtropics may become attractive for people who wish to escape the heat during the hot season, thus providing important new livelihood opportunities,

as long as the revenues remain with the local people. This has already happened in Uttarakhand, where tourism is on the increase thanks to a prolonged summer 'tourist season' in the mountains, providing income opportunities of longer duration.

Labour migration is a vital livelihood strategy for rural mountain communities in the Hindu Kush-Himalayan region and was found to be increasing in most of the villages studied, mainly because of lack of opportunities for gainful employment closer by, now accentuated by climate change. Improving access to and enhancing efficiency in the use of both social and financial remittances could be a promising way of increasing the resilience of mountain communities, since access to remittances can act as a social safety net in times of shock.

Finally, rewards for ecosystem services may grow to be more important as certain resources, in particular water, become scarcer. Community-based REDD (reduced emissions from deforestation and forest degradation) projects could be another promising way of attracting funds for mountain communities.

Part II

Case Studies

Poverty and Climate Change: How the Rural Poor Tackle Water and Temperature Stress in Uttarakhand

"It does not rain when it should and it will rain when it should not."

– 43-year-old man from Uttarakhand

Introduction

Uttarakhand, formerly Uttaranchal, is a scenic but poor mountainous state in northwestern India, formed on 9 November 2000 after separating from Uttar Pradesh. Almost half of Uttarakhand's population live below the poverty line; the majority in hill areas where they depend on agriculture for their livelihoods. As agriculture is highly weather dependent, communities in the state are strongly affected by climate-related variability and change. The vulnerability of Uttarakhand's rural population to climate and socioeconomic change stems from a number of factors, especially dependence on ecosystem services, high levels of persistent poverty, marginalisation, and social inequality. In the 3 years from 2008 to 2010, Uttarakhand received less-than-normal rainfall which affected harvests and adversely affected the livelihoods of the majority of the state's population (WFP 2010).

Study Area

Focus group discussions and interviews were carried out in June/July 2010 in four villages situated at different altitudes and of varying accessibility in each of two districts – Almora and Tehri Garhwal (Table 3). The people in these districts still follow a predominantly traditional lifestyle mainly dependent on agriculture, animal husbandry, and seasonal processing of forest products, and are guardians of a vast body of local knowledge. Besides climate variability and change, they are exposed to rapid socioeconomic changes that impact on their livelihoods, including increasing rates of male outmigration and the associated feminisation of agriculture.

Table 3: **Villages surveyed in Uttarakhand**

District /Village	Altitude (masl)	No. of HHs*	Distance to road (minutes)	No. of respondents interviewed in each wealth category				
				1	2	3	4	Total
Almora								
Natadol	2,100	209	75	4	4	4	4	16
Naikena	1,800	37	60	4	4	4	4	16
Gud Gadoli	1,200	27	120	5	4	4	3	16
Udiyari	1,100	42	15	1	7	4	4	16
Tehri Garhwal								
Kurn	1,850	203	180	4	4	4	4	16
Karn	1,300	37	120	4	5	6	1	16
Pali	700	60	15	4	4	4	4	16
Srikot	400	48	15	4	4	4	4	16

masl = metres above sea level; HHs = households
*Source: GOI 2001

Table 4: **Sources of income of respondents in different wealth groups**

Source of income	Household wealth category								
	1 – Extremely poor		2 – Poor		3 – Marginally poor		4 – Other		Average
	A	TG	A	TG	A	TG	A	TG	
Agriculture alone	14.3	0.0	21.1	5.9	25.0	5.6	6.7	0.0	10.2
Remittances	0.0	6.3	0.0	17.7	25.0	44.4	33.3	69.2	23.4
Other (e.g., salary, business)	0.0	0.0	5.3	5.9	0.0	0.0	20.0	0.0	3.9
Agriculture and labour	85.7	93.8	73.7	70.6	50.0	50.0	40.0	30.8	62.5

A = Almora; TG = Tehri Garhwal

Analysis of data from the India National Sample Survey 2003 showed that poverty in Uttarakhand was much higher than the Indian Himalayan region average (Hunzai et al. 2011) . Close to half of both rural and urban households in Uttarakhand were below the poverty line of USD 1 per day as compared to 17% in the remainder of the rural Indian Himalayan region; half of household heads were uneducated; and 34% of household members were illiterate. Close to 85% of the population was involved in agriculture

The residents of the two districts classified themselves into four categories of economic status using their own criteria: Category 1 – extremely poor, Category 2 – poor, Category 3 – marginally poor, and Category 4 – other. The numbers interviewed in each wealth category are shown in Table 3. The sources of income identified by the different wealth groups are summarised in Table 4. Of the poorest families, 86% of households in Almora and 94% in Tehri Garhwal were dependent on a combination of agriculture and labour as their main source of income, but only 40% and 31% of the wealthiest households. The better off households thus appear to be comparatively less vulnerable as they depend on more diversified sources of income such as businesses, salaries, and remittances.

Communities' Perceptions of Change

"Sometimes it is difficult to distinguish between the various seasons. Even October is as warm as June."

– a resident of Almora

Information on perceptions of change was obtained from the detailed interviews and also in larger focus group discussions. Regardless of the socioeconomic status of the households, water was seen as the most important resource required in agriculture. Given that arable land, and especially irrigated land, is a scarce resource in mountains, it is not surprising that in a society characterised by caste and class differentiation, the proportion of poor households with access to irrigated land was extremely low. Farmers without irrigated land depend solely on annual rains. In the past, some communities had adapted their agricultural activities to make use of the small amounts of rainfall falling in the non-monsoon months, but according to the communities, this phenomenon had now ceased almost completely. The winter precipitation is crucial for recharging groundwater. Some springs had dried up completely, affecting the availability of water for people, livestock, and irrigation. Overall rainfall was thought to have declined, but at the same time, there were more periods of high intensity rainfall, which can lead to floods, landslides, and soil erosion, as well as being associated with high surface run-off and limited infiltration of water to underground aquifers. The major observations are summarised in Table 5 and discussed in the following.

Winter precipitation has become extremely erratic and unpredictable. Instead of winter rains, some communities reported that it now rained in March/April when the winter crop is ready for harvest, causing the cereals to rot. Villages at high altitude used to have moderate to heavy snowfall in December to March, with up to 1 metre (several feet) of snow that would lie for a long time. Currently, it only snows for 1 to 2 months and with low intensity. It has not snowed in Almora for 3 to 4 years. Medium altitude villages that were accustomed to moderate to low snowfall now receive very little, if any. Snowmelt used to be an important source of water for agriculture as it extends the availability of water from precipitation for long after the precipitation event.

Table 5: **Perceptions of change in Uttarakhand**

Aspect	Almora	Tehri Garhwal
Annual precipitation	Significant reduction in duration; severe decline in amount; erratic, more intense events	Extreme reduction in duration; severe decline in amount; erratic, more intense events
Monsoon	Significant delay in onset and early completion	Significant delay in onset and early completion
Winter precipitation	Severe reduction in amount and delay in onset; erratic and unpredictable; severe reduction in snowfall (complete absence over the past 3–4 years)	Severe reduction in amount and delay in onset; erratic and unpredictable; high reduction in snowfall (now almost nonexistent)
Dry season	Severe extension of duration; high increase in intensity	Severe extension in duration; high increase in intensity
Temperature	Higher in winter and summer; more warm months	Higher in winter and summer; more warm months
Frost	Decline in duration and intensity	Decline in duration and intensity
Hailstorms	Decrease in incidence	Decrease in incidence
Crop disease and pests	Unprecedented increase	Unprecedented increase

The dry season has become longer, in line with the lack of precipitation. In 2006/07 and 2008/09 there was almost no winter rain and farmers in Uttarakhand experienced drought-like conditions. This could explain the strong perception of the communities that dry spells that usually lasted less than 2 months had now extended to more than 7 (Tehri) or 8 (Almora) months long. Farmers also attributed an increase in incidence of forest fires to the prolonged dry spells; fires are degrading the forests near villages and preventing natural regeneration by damaging the germination and growth of seedlings.

There was a significant perception that the temperature had increased with warmer summers and milder winters. People in all the communities studied felt that the warm season had been prolonged by several months and observed an overall increase in the intensity and frequency of hot days.

Impacts of Change on Livelihoods and Community Wellbeing

The communities ranked prolonged dry spells and increase in temperature as having the most significant negative impact on their livelihoods. Increased attacks by insects and pests, forest fires, and landslides were identified as the major weather-induced hazards. Widespread crop damage by wild animals (wild boars, monkeys, porcupines, and other herbivores) was also attributed to forest degradation, partly associated with changes in the climate.

Positive impacts associated with changes in weather patterns included a decline in the duration and intensity of frost, less damage by hailstorms, and, in some communities, an overall decrease in the frequency and intensity of storms.

Agriculture is dependent on a proper combination of weather and associated factors, and is thus highly vulnerable to climate change – any slight change can have a severe impact on the yield of staple and cash crops. Close to 85% of the population of Uttarakhand is directly or indirectly dependent on agriculture for subsistence and income (Hunzai et al. 2011); the reduction in harvests greatly impacts food security and the ultimate source of income for these households.

Anything affects a harvest

Lack of sufficient water immediately decreases the agricultural harvest. Similarly, the timing of rainfall is important – a delay in the monsoon forces farmers to delay the sowing of rice, especially on rainfed fields, and the yield declines considerably. Conversely, incidences of intense rainfall erode the nutritious topsoil, cause landslides that destroy farmland, interrupt roads and thus access to markets, and lead to loss of life and property. Changes in precipitation can also affect the incidence of pests. Farmers reported a significant increase in kurmula (white grub) over the past 5 to 7 years, damaging major cash crops such as potato, other tubers, kidney beans, pulses, and vegetables, and reducing cash income. Lack of snow was thought to be the cause because heavy snowfall kills the eggs; warmer

temperatures might also be conducive to the growth of this pest. As harvests fail, communities are becoming dependent on external markets. Previously, households could rely on two types of cereals to fulfil their basic needs for at least 11 months of the year, but now some respondents said that they only had enough food to last for 2 to 3 months of the year. However, this should not only be attributed to climate change. Among others, high rates of male outmigration and the associated reduction in workforce had led to widespread fallowing of land.

A new phenomenon observed in Uttarakhand was double flowering of apple and Malta orange trees, leading to two harvests in a year. This adversely affected fruit quality; fruits were smaller and less tasty (and not fit for sale). "Over the past few years the climate has changed drastically. There is very little snowfall and the weather has become quite warm and it seems that this is affecting the flowering pattern of apple and Malta trees here", reasoned a villager. Horticulturalists are concerned that the double fruiting could result in crop losses and impair the overall health of the orchard, as it prevents the trees from recuperating between crops and makes them weaker.

Women work more

Nearly two-thirds of respondents (61%) thought that an increase in male migration rates was leading to increased feminisation of agriculture, which was increasing women's workloads. Around 80% believed that they have to travel longer distances to fetch fodder – the burden of fetching fuel and fodder falls solely on women. Similarly, drinking water has to be carried from the nearest springs (some of which are drying up) or someone has to wait in a queue of 2–3 (or more) hours at the tap, another responsibility adding to the workload. Measures to counter the impacts of climate change – for example, repeat sowing in the event of crop failures; spreading traditional and chemical fertilisers and pesticides; walking longer distances to fetch water and fodder – are all activities implemented by women and adding to their regular workload. The limited number of oxen available for ploughing in the villages (and the inability to afford to rent these animals) is compelling women to use shovels to plough their fields. However, land is increasingly left uncultivated as a result of both high levels of outmigration and decreasing productivity. Changes in animal husbandry practices (moving from bigger to smaller ruminants) have reduced the time required to tend them from the previous 3–4 hours to 1.5 hours a day, relieving some of the workload for women.

Conversely, as household food production is becoming insufficient, more food needs to be purchased from the market, and men, as the main cash income earners, are driven to seek wage labour wherever possible, adding to their workloads.

Health and nutrition suffer

Occurrence of disease and illness is perceived to have increased. Common ailments include colds, fever, jaundice, typhoid, and kidney stones. Elders believe that the warmer temperature is conducive to germs. Unused to purchasing market food, communities do not trust bought grain and suspect that chemicals used in the production process could also be causing illness. Traditional knowledge of medicinal herbs to treat sickness is fading, and the plants are also being lost as a result of forest degradation and overexploitation. The drying up of springs adds pressure to the remaining springs and this could be leading to water pollution, explaining the increase in water-borne diseases. Women suffer the most when households lack adequate quantities of food – they consume food after serving the men and children and might have to sleep hungry. Accidents are also becoming more common as women travel farther to fetch fuelwood and fodder, and have to climb steep slopes and slippery ridges.

Community-Based Responses to Change

Mountain agriculture has traditionally been highly dynamic, with farmers continuously having to adjust to extreme environmental and climatic conditions over time. However, farmers have been unable to adjust agricultural processes to the fast pace of change in weather patterns experienced in recent years. They are mainly adopting short-term measures to cope with climate stresses; adaptive measures are difficult to introduce in agriculture without extensive financial and physical resources.

The main responses to climate and socioeconomic change in the study area are summarised in Table 6 and discussed in more detail in the following paragraphs.

Table 6: **Community response to perceived change in Uttarakhand**

Perceived change	Experienced impact on livelihood systems	Response
Erratic precipitation	Decline in agricultural productivity	Changes to agricultural calendar: delayed or early sowing and harvesting of crops Changes in crop varieties and types Increased engagement in wage labour Labour migration
	Crop failure	Re-sowing of crops Buying food from market Reduced meals Barter
Overall decreased water availability	Less flow in springs and streams; drying up of springs; lowering of groundwater levels	Re-adoption of traditional water management systems Catchment area protection Replacing large livestock with smaller species Less land area under cultivation Walking longer distances to fetch water
	Reduced soil moisture	Mulching
	Decline in agricultural productivity	As above
Decreased or absent winter rains	Decreased yield from winter crops (decline in agricultural productivity)	As above
Increased frequency of intense rainfall events	Soil erosion and landslides	Watershed management: afforestation
Increase in pests and disease	Reduced production	Traditional pest management strategies (spreading cow urine, salt, or ashes; crop rotation; setting fields on fire) Setting up 'kurmula' (white grub) traps Increased use of pesticides
Increasing temperatures	Health issues (increased incidence of vector-borne diseases)	Use of medicinal plants if available Increased reliance on western medicine
	Beneficial conditions for crops	More than one or shorter cropping cycle Introduction of new crops at higher altitudes (e.g., peanuts, mango, banana)
	Double flowering of orange and apple trees diminishing fruit quality	None
Warmer and shorter winters with less snowfall	Beneficial conditions for certain crops	As above
	Increased incidence of pests and disease	As above
Reduction in available workforce	Increased workload for those left behind	Less land under cultivation Move from big ruminants to smaller livestock

Responses to erratic rainfall and reduced water availability

In response to erratic rainfall patterns, farmers were adjusting their agricultural calendar on a yearly basis by delaying or advancing the sowing of rice and other crops that depend on the monsoon precipitation. Winter crops such as potatoes and wheat were also planted earlier or later in some places depending on the arrival of the winter rains. Farmers reported that in 2009/10 they had planted their winter crops up to 30 days late in expectation of rain. As a result, the harvesting of these crops also had to be delayed to allow for maturing. When there was an early season crop failure because of inadequate rainfall, households that could afford a second batch of seeds either re-sowed the crop or replaced it. Rice was replaced with soybean, mustard, pulses, or madira (fodder grass); maize with soybean or vegetables; and mandua (millet) with pulses, soybean, or potato.

In the past, communities in Almora had had a traditional irrigation system with water sharing rules and regulations using guhls (water channels), but this mechanism had fallen out of use. Following the lack of rainfall and prolonged dry spells, this traditional rotational irrigation system has now been revived. The system fulfils everyone's needs and eliminates conflict over shared water. However, farmers situated at the end of the ghuls, mainly from the lowest economic strata, reported that they had to postpone sowing of rice by between 15 and 30 days while waiting for their turn for water, and this adversely affected their harvest. Another response to decreased water availability was protection of catchment areas by planting oak trees around spring catchments near villages.

Aajeevika (an IFAD funded project) distributed improved seeds of numerous vegetables such as eggplant, tomato, and capsicum, which are tolerant to water stress and germinate well giving a high yield despite dry conditions and lack of water. Unfortunately, other seeds provided for millets, pulses, and beans gave only mediocre results. The same project also provided *Aloe vera* plants, which thrive in arid and semi-arid conditions.

Living with rising temperatures

As a result of rising temperatures, potatoes were found to mature faster and could be harvested in 3 to 3.5 months instead of the traditional 5 to 6 months. This additional time offers new opportunities to farmers and was successfully used to grow cauliflower and peas as cash crops for a higher income. Other new crops introduced included ginger and turmeric, both because they withstand water and temperature stress better, and because they are popular cash crops which fetch a good price in the market. In addition, prolonged growing seasons now allow for more than one crop cycle per year and rising temperatures were found to be suitable for new crops, such as ground nuts and fruits such as mango and banana, which were described as being larger and better tasting and even fit for sale.

Combating the increased incidence of pests and disease

Traditionally, ash, cow urine, and salt have been used as pesticides but their effectiveness appears to be decreasing as illustrated by the drastic increase in pests. Fires are lit post-harvest to kill insects and pests but can also kill earthworms and other microorganisms beneficial to the soil. "Earlier, traditional methods of pest control like spraying of salt or ash were effective in controlling the pests, but now, because of the increase in pest infestation, these methods have become ineffective," said Ram Singh from Gud Gadoli village in Almora. Chemical pesticides have been more effective in reducing crop pests and damage, but according to the farmers, their effectiveness is also reduced after 2 to 3 years of use. Uttarakhand Parvatiya Aajeevika Sanvardhan Company (UPASaC), created to implement Aajeevika, is providing ingeniously designed traps that have been used successfully to attract and kill kurmula (white grub).

Dealing with environmental and socioeconomic change

Cornhusks and leaves are being used as alternative fuels to reduce the hard work of collecting fuelwood as this resource becomes increasingly scarce. Farmers reported that medicinal plants were also rarer, possibly as a result of a combination of overexploitation and forest degradation, and thus people have become more dependent on more costly western medicine.

Changes in livestock composition had also been made in order to cope with fodder and water scarcity and the reduced workforce resulting from the high levels of outmigration. Households were reducing the number of large ruminants and focusing on rearing goats, which require less labour, fodder, and stall feeding; goats also have more than one offspring per litter and offer increased gains for farmers.

When agricultural yields were insufficient for household needs, small/marginal farmers traditionally supplemented their incomes through wage labour on other farms or by rearing other people's livestock. With decreasing agricultural productivity, the number of people in search of wage labour is increasing, while the demand for wage labour has fallen, and farmers have to look for work in nearby markets or towns. Decreasing agricultural productivity is also an important push factor for seasonal and rural/urban migration. At the same time, the tourist season appears to have lengthened with the lengthening of the summer in the Uttarakhand mountain areas, providing more income-generating opportunities. Young people in particular are shifting to non-farm activities – roadside eateries near tourist circuits,

Excessive dependence on agriculture influences the vulnerability of poor households

taxi driving, and other small businesses – disillusioned by agriculture and attaching little value to it. This phenomenon appears to be mainly due to changes in norms and values, but climate change is an aggravating factor.

Differences in Vulnerability and Adaptive Capacity

Socioeconomic and sociopolitical factors also play a role, in addition to the geophysical environment, in determining the vulnerability and adaptive capacity of communities.

The poorest households' excessive dependence on agriculture predetermines their vulnerability. Literacy and an educational background are also crucial in seeking other professions or income opportunities in the endeavour to adapt to changing conditions. Among the four income categories, only 35% of the respondents in the extremely poor category were literate, compared to 51% in the wealthiest category. Wage labour was seen as the only livelihood option apart from agriculture for the non-literate. The relationship between poverty and literacy is a vicious cycle: Poor households do not have access to higher education or vocational training (or even basic education in some cases) since they cannot pay the costs, whereas the wealthy can afford to send their children to nearby towns or cities for higher education. In addition, the poorest households had the fewest migrants and thus the least access to financial remittances as well as to new skills, knowledge, and other strategies for improving wellbeing.

The low incomes of the poor also resulted in low savings. In Tehri Garhwal, the average monthly income of people in Category 1, the poorest, was INR 969 (approximately USD 20) compared to INR 13,000 (around USD 265) for those in Category 4, the wealthiest. With this income, it is difficult to even meet daily requirements and savings are

practically non-existent. The lack of financial capital also makes it difficult for the poorest to diversify their livelihoods, for example by setting up a small business. Poor farmers do not have enough collateral for a bank loan, and farmers are anyway hesitant to apply for loans because of the volatility of their income. The main asset base was landholdings, and these were small and unviable for both Category 1 and Category 2 respondents. Households in Category 1 had average landholdings of 0.13 hectares, of which only 0.005 hectares were irrigated. In terms of their adaptive capacity, the poorest were unable to risk diversifying crops, for example by growing cash crops instead of staples, for fear they would lose their food security, and they also could not afford some of the coping strategies; for example, a second batch of seeds was too expensive for repeat sowing.

Socially discriminated groups like women and Dalits (the lowest caste group, previously considered untouchable) are more vulnerable to the impacts of climate change. Patriarchy is still widespread, and women are economically poorer and also have limited access to resources. Within households, in terms of nutrition, women are the last to eat and the first to be affected by food deficiency; they have greater responsibility for activities such as fetching fodder, fuel, and drinking water, and are also more prone to accidents while involved in these activities. Coping strategies require labour that is usually provided by women – repeat sowing, spreading pesticides and fertilisers, and ploughing with shovels. The Dalit groups have smaller landholdings and are dependent on wage labour in other people's fields, thus they suffer the most as agricultural productivity, the main source of income, declines.

The lack of access of the rural poor to markets and institutions is a major constraint in tackling the impacts of climate change. Health centres and veterinary hospitals were on average 15 kilometres away, agriculture and allied departments more than 35 kilometres away. As a resident of Bageshwar said, "It takes one full day to go to the government offices and get home, so we approach them very rarely". Many villages are not connected by motorable roads and others do not have regular transport facilities, further limiting accessibility. Thus access to social safety nets, another key determinant of adaptive capacity, is also limited, particularly for more remote communities and marginalised groups.

Institutional Opportunities and Constraints

Institutions can be crucial in determining and influencing the adaptive capacity of any group, particularly by structuring impacts and vulnerability, mediating between individual and collective responses to climate impacts and thereby shaping outcomes of adaptation, and delivering external resources to communities in order to facilitate adaptation (Agrawal and Perrin 2009). Some of the more important formal and informal institutions active in the study area are listed below together with the associated opportunities and constraints.

Traditional institutions (formal and informal)

Traditional water harvesting systems – In Almora, indigenous water harvesting systems were set up to counter the frequent water shortages and make use of the high surface runoff in the hills. Some of these traditional structures are still in use today, but many are on the verge of decline. Revitalising these structures and combining their use with the traditional institutional mechanisms for water sharing could be an important way of adapting to increasing water stress of the type faced by the communities in the years preceding this study.

Van panchayats – Van panchayats are autonomous democratic local institutions characteristic of the state of Uttarakhand. They are an institutionalised form of resource management through state community partnerships which regulate the utilisation and protection of forests and forest products. Each van panchayat functions according to specific rules and regulations which are based upon the traditional knowledge of the communities (Mukherjee 2003). Strengthening the existing 12,000 or so van panchayats in Uttarakhand and increasing their awareness of climate change related risks could be an effective strategy for guaranteeing the sustainable use of forest products and forest regeneration, as well as for sustainable water management.

Formal institutions

Gram panchayats – The gram panchayat, headed by a gram pradhan, is the lowest rung of the three-tiered local self-governance system. The gram panchayat oversees a cluster of 3–4 villages. It channels government funds for small-

scale development and is responsible for the 'public distribution system' (PDS) as well as for issuing the 'below poverty line' (BPL) cards that determine subsidised rations and work allowances under the Mahatma Gandhi National Rural Employment Guarantee Act (NREGA). Unfortunately, the lack of transparency in the use of these funds and corruption in the issuance of BPL cards has damaged the credibility of these institutions and limits their effectiveness in assisting the coping and adaptive strategies of the most disadvantaged.

Fair price shops – The government ensures the supply of essential commodities under the public distribution system through networks of fair price shops that ensure affordable prices. With the shortfall in household food production and the need to purchase food, fair price shops have an important role to play in food security protection, but they need to enhance the quantity and quality and ensure the regular supply of food products.

Agriculture and other departments – The state departments for agriculture, fisheries, animal husbandry, and horticulture were set up to provide agricultural extension services. Unfortunately, the officials in these departments lack awareness of climate change and believed that "there is no need to worry unnecessarily", which was reflected in the complete lack of funds for climate change awareness or adaptation programmes, and limits their role in assisting rural farmers in tackling the impacts of climate change. These departments are perceived by the communities to be poorly managed and to distribute untimely and inadequate outreach services. Making these departments aware of the challenges that rural communities are already facing, partly as a result of climate change, strengthening their human and financial resources, and ensuring transparency will be very important.

Revenue Department – Some compensation for crop damage due to drought was provided by the state through the revenue department, but communities claimed that the compensation provided was insufficient and distributed inequitably. Introduction of crop insurance is one way to strengthen the social safety net for rural communities, and could be another important step in enhancing the resilience of the rural poor.

Climate Change Policy

India's National Action Plan on Climate Change (NAPCC), released in June 2008, outlines current and future policies and implementation mechanisms addressing both climate mitigation and adaptation (C2ES 2008). Under the NAPCC, the Federal Government of India identified nine missions, and requested line ministries to lead them. Two of these missions are directly relevant for mountain communities. One focuses on sustaining the Himalayan glaciers and mountain ecosystem. It suggests continuing and enhancing monitoring of the Himalayan ecosystem in order to preserve important ecosystem services, in particular freshwater reserves. The mission further stresses the importance of building the capacity of local communities to preserve the Himalayan ecosystems. This mission is complemented by the National Mission for Sustainable Agriculture, which focuses on improving the productivity of rainfed agriculture, taking the traditional knowledge of people into account. However, mountain farmers and their concerns need to be addressed at the local/state level as a national plan cannot hope to accommodate the diversity of needs. When implementing these missions, it will be crucial to acknowledge the specific needs of mountain communities and their local knowledge, possibly through the formulation of Local Adaptation Programmes of Action (LAPAs), rather than depleting their assets, for example by establishing exclusionary protected areas.

Conclusion

Poor farmers not only face rapidly changing socioeconomic conditions, they have also been coping to the best of their ability and resources with water and temperature stresses resulting from climate variability and change. These stresses are expected to continue and increase, and the constant coping will have consequences, eventually depleting the asset base of the rural communities if new measures are not taken. Young people are already disillusioned, and most try to leave if they can. The trend of seeing agriculture as an unviable livelihood option and leaving has implications for household and food security. Assisting farmers in adding value and productivity to agriculture will be of the utmost importance, for example through the development of value chains for high value products. But other livelihood options and associated human capital development will also have to be promoted, by involving actors from state government, local institutions, non-governmental organisations, and primarily the stakeholders. Persistent poverty and social inequality needs to be addressed, in particular supporting women and members of the lower castes.

It Doesn't Rain on Time: Climate Change and Its Impacts in Eastern and Western Nepal

"I am very poor, I don't own land or a house. I work on other people's land and receive half of the total annual production as compensation. During last year's drought, I cultivated everything in small amounts but the seeds germinated and then dried up. They did not bear any fruit and not even the cattle wanted to eat the stalks. So I was forced take a loan to buy food."

– 70-year-old man from Terhathum, August 2011

Introduction

The study looked at the perceptions of, and responses to, change in rural villages in two different parts of Nepal. Over 80% of Nepal's population is rural (IM undated); the great majority involved in subsistence agriculture. Nearly one quarter of the population lives on less than USD 1 per day, and more than half of the 75 districts are food deficient (FAO 2010). There is a clear connection between poverty, food security, and worsening agricultural productivity, which is at least in part a result of climate change. For farmers, changes in water availability and timing have become the crucial symptom and effect of climate change.

Study Area

The studied was carried out in three village development committee areas (VDCs) in Bajhang district in the far west and five VDCs in Terhathum district in the East (Table 7). Bajhang is one of the most underdeveloped districts in the

Table 7: **Villages surveyed in Nepal**

District/VDC	Altitude (masl)	No. of HHs*	Population*			In-depth HH interviews
			Male	Female	Total	
Bajhang						
Surma	2,400	453	1,309	1,296	2,605	8
Chainpur (Mayana village)	1,950	925	2,594	2,547	5,141	8
Chainpur (Khalapata village)	1,100					8
Rayal	950	1,011	2,904	3,187	6,091	8
Terhathum						
Solma	2,000	842	2,206	2,389	4,595	4
Oyakjung	1,870	937	NA			8
Myaglung	1,670	1,279	NA			8
Sabla	1,550	467	NA			12
Panchakanya Pokhari	750	438	NA			11

masl = metres above sea level; HHs = households; NA = not available

*Source: CBS 2002

country; 75% of the residents have insufficient food for half the year. Food security is very poor in Bajhang, which has an 'extremely alarming' global hunger index value (the worst category on a five-point scale), and only slightly less so in Terhathum, which has an 'alarming' global hunger index value (NPC 2010). The study was carried out in July/August 2010, in a year when Nepal was affected by an extreme drought. Terhathum was revisited in August 2011 in order to validate the data gathered in the previous year under extreme conditions.

The primary occupation in both districts was agriculture; approximately 10% of women and 20% of men in the study areas had non-agricultural occupations (production of goods and wage labour). In Bajhang, there was a growing trend towards involvement in the collection of high-value NTFPs, which was seen to be very profitable. Less than 15% of the agricultural land in Bajhang, and 21% in Terhathum, was irrigated. Agriculture was considered to be more profitable in Terhathum than in Bajhang as farmers had high yields of ginger and cardamom.

In the past, education has had a low priority and the literacy rate of adults in rural areas, particularly women, is low. The literacy rate was 71% for men and 48% for women in Terhathum and 60% for men and 18% for women in Bajhang. Life expectancy was 42 years in Bajhang and 55 years in Terhathum (DAO 2010).

Communities' Perceptions of Change

"Betime-ma pani aucha, ke garnu." (It doesn't rain on time, what to do.)

The monsoon is the most important seasonal phenomenon for rainfed agriculture. Major food crops such as rice and maize, grown in the summer, depend completely on this annual precipitation. The most significant observation was a trend towards delayed onset of the monsoon, noticed over the last 10 years, but with differences in the delay. People also noted increasing numbers of dry spells during the monsoon period, lasting up to 15 days and damaging crops. Associated with this was a perception that the dry season was longer and more severe.

Living in Terhathum

A Dalit couple aged 51 and 48 from Sabla, Terhathum described how weather patterns have become increasingly erratic and how this is challenging their livelihoods.

"People may say what they want, but I have 41 years experience. These days when it rains it rains heavily and uncontrollably and even the earth cannot hold the water, but sometimes it doesn't rain at all", explained the husband.

"There used to be sunny days and rainfall like we wanted, but these days God is not in the mood to give us all that, he doesn't like to see us happy…", his wife continued. "Even if there is a drought and food shortage we need to eat. With a half full stomach it is impossible for us to work. Taking loans has become quite normal. Of course we will pay them off someday but if we don't we will run away from this place, not in the daytime but during full moon so that we don't get hurt", she added smiling.

In contrast to 2010, the monsoon rains started early in 2011, and in August 2011 the communities in Terhathum were hopeful for their crops. Nevertheless, they confirmed the perception expressed a year earlier that the annual total precipitation had decreased and rainfall patterns had become more erratic. Further, they said that there used to be at least some rainfall in almost 11 months of the year, even if it was only once in a month, with 2 to 5 months of heavier precipitation. This low intensity rainfall had disappeared almost completely, with rain falling only in the monsoon months. Winter precipitation – snowfall at higher altitudes and rain at lower altitudes – was thought to have decreased at both study sites. Some communities, accustomed to snow 5 to 6 months a year, with 1 month of high intensity snowfall, claimed that it was snowing less and snow was lasting for a shorter period. Winter rainfall is crucial for recharging of groundwater and replenishing springs, and some springs had already dried up.

Hailstorms appeared to be less frequent, resulting in less hail damage. Communities in the east noted that the incidence of floods and landslides had decreased with the reduced precipitation, whereas respondents in the west perceived an increase (partly due to high intensity rainfall in 2009 which had caused severe landslides and loss of life and property).

Perceptions regarding changes in temperature were mixed, although communities had noticed that both winters and summers were warmer. An increased variability in temperature had been observed particularly at higher altitudes, and there was a sense that the temperature was diverging from regular patterns, but the change itself was hard to pinpoint. One respondent in Terhathum claimed that food would spoil in three days instead of seven in the summer. Mosquitoes had been observed at higher altitudes than previously and during months when it used to be too cold, but this could have been due in part to the recent construction of unpaved roads in the study areas, which had resulted in deep tracks being left by heavy vehicles that were now filled with stagnant water.

Apart from issues related to water and precipitation, respondents were most concerned about the increase in crop pests and disease. With crops already negatively affected by the changing weather, the increased incidence of pests and disease had exacerbated the food security situation in the areas studied. Not only had there been a significant increase in known diseases and pests, but newer afflictions were also being observed. 'Ranke' (blight), which had devastated the maize harvest in 2009, appeared to be affecting other crops as well. 'Thaulya' was a new disease; it prevents grain formation in millet and paddy and had affected the millet harvest drastically in 2009 and continued to damage harvests. Communities speculated that the white grub 'khurkulo' thrives in the absence of rain, as both grub size and population seemed to be increasing. Other pests affecting yields included 'sindure', 'bet', and black beetle. Although there was a potential link to climate change, farmers in Terhathum also linked the unprecedented incidence of crop pests with monoculture crops and the increasing use of chemical fertilisers.

The perceptions of change are summarised in Table 8.

Table 8: **Perceptions of change in Bajhang and Terhathum**

Aspect	Bajhang	Terhathum
Onset of monsoon	Delayed, more unpredictable	Delayed, more unpredictable
Annual precipitation	Significant reduction in amount and duration, increase in high intensity events that caused damage, erratic	Significant reduction in amount and duration, erratic
Winter precipitation	Severe decrease in amount, intensity and duration of snowfall; reduced or no winter rain	Slight decrease in amount and intensity of snowfall (at high altitudes), significant decrease in amount of winter rain
Dry season	Significantly longer	Longer, more intense
Hailstorms	Decrease	Decrease
Frost	Slight decrease in some areas	Slight decrease in some areas
Temperature	Warmer at higher altitudes, increased variability	Warmer at higher and lower altitudes, increased variability
Crop disease and pests	Significant increase and new pests observed	Significant increase and new pests observed

Comparison of Perceptions of Change with Climate Records

There is marked topographical and altitudinal variation within small areas in Nepal (as in the Himalayas in general) and data collected at individual stations provide only an indicative idea to compare with local perceptions in villages located some distance away. Nevertheless it is interesting to make the comparison, bearing the limitations in mind. Data were available from two hydro-meteorological stations in Bajhang from 1956 onwards – Chainpur at 1,304 masl and Pipalkot at 1,456 masl – and from one station in Terhathum at 1,633 masl from 1971 onwards. Detailed meteorological data are given in Annex 2; the results are summarised briefly below.

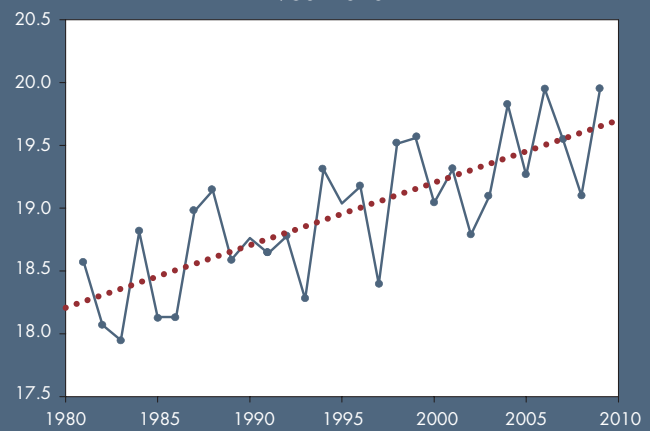
Precipitation

Data from the two stations in Bajhang showed clear differences; overall the results indicated the marked interannual variability and localised nature of rainfall, more than any clear trend. Both stations showed a slight increase in average annual precipitation over the whole 50 year period, but there had been a slight decrease in Pipalkot over the 30 years before the survey and a more marked decrease over the 10 years preceding it, while no significant change was identified in Chainpur over the 30 years. Winter rain was highly variable at both stations, but with an indication of a decreasing trend. Pipalkot had had almost no winter rain in the 2 years leading up to the survey. In 2009, the annual rainfall was the lowest in 30 years, considerably less than half that of 1999/2000. In Bajhang the number of rainy days appeared to be decreasing, and the number of extreme rainfall days slightly increasing. Terhathum also showed a slight increase in average annual rainfall over the whole period, but a decrease over the last 20 years. Recent years had shown marked variation with, for example, twice as much precipitation in 2005/06 as in 2004/05. Winter rain was highly variable, with almost none falling in the 2 years before the survey. Overall, the marked variability, and recent dryer trend, matches the local perceptions.

Temperature

Temperature data were only available from Chainpur station in Bajhang from 1980. The mean annual maximum and minimum temperatures over the preceding 30 years (between 1980 and 2009) were 25.8 °C and 12.1 °C. There was a marked increase in mean annual air temperature during that period in line with local perceptions (Figure 3), with a rate of increase of 0.05 °C/year in the mean maximum temperature and 0.03 °C/year in the mean minimum temperature.

Figure 3: **Mean annual air temperature at Chainpur, 1980–2010**



Source: Data from the Department of Hydrology and Meteorology, Ministry of Environment, Government of Nepal

Impacts of Change on Livelihoods and Community Wellbeing

Food security

Climate variability and change affected livelihoods most markedly through impacts on food production. None of the individual farmers interviewed could sustain their households for more than 6 months from their harvest, and some could do so only for 1 month. Respondents claimed that harvests had decreased drastically due to lack of or untimely rainfall, although farmers in Terhathum felt that thanks to chemical fertilisers, when the rains did come on time, overall productivity had increased. Somfarmers had stopped planting rice and switched to maize, a crop that is less water intensive, or left the land fallow. The World Food Programme (WFP) issued a press release related to this issue in May 2009 claiming that the winter drought of 2008/09 had destroyed crops across Nepal, and wheat and barley production had dropped by 14 and 17%, respectively. Some districts had received less than half the average winter rainfall and had crop yields reduced by more than half (WFP 2009).

Livelihoods

Man from Bajhang showing his yield of yarshagumba (*Cordyseps sinensis*), valued for medicinal uses

Cash crops such as black cardamom, ginger, and broom grass have proliferated in Terhathum, but the decrease in water availability had reduced harvests and thus income. Most communities depend on nearby forests for fuelwood and fodder, as well as for NTFPs that provide an additional source of income. Higher altitude villages across Nepal and particularly in Bajhang depend on the collection of yarshagumba (*Cordyceps sinensis*, also known as caterpillar fungus) which is of extremely high value in eastern medicine. Up to 70% of household income in one village was from yarshagumba. These communities claim that with warmer temperatures and early spring, the caterpillar that hosts the fungus has a shortened life cycle, and it is turning into a moth before the fungus can mature – a threat to this main source of income. However, overharvesting may also be contributing to the problem. Livestock and dairy also provide a crucial supplement to household income, and are affected by the reduction in fodder availability and drinking water for animals. Communities close to markets regularly sold milk, but claimed that milk production decreased when livestock could not be fed fresh fodder due to the lack of rain. Poultry is another insurance mechanism, as both eggs and meat can be sold in times of hardship, but with foxes and illness (jhokraune) plaguing the chickens, even this income was reduced.

Daily life

Climate change also affects other aspects of daily life. Paddy is planted at the beginning of the monsoon, and millet somewhat later. Any delay in the monsoon delays rice planting to the time when millet needs to be planted – and farmers then have to work doubly hard to plant both at the same time. Households that can afford it and are connected to roads can pay for tractors to fetch loads of grass and wood. But most people have to walk several hours to gather these essentials, which increases the workload for women, who are mainly responsible for these activities. Nevertheless, people mentioned that thanks to new technologies such as chemical fertilisers, water taps in villages, and electrification, as well as the construction of roads, overall their workloads had decreased greatly.

With reduced groundwater recharge, springs for drinking water are drying up. Some families in Terhathum have had to migrate due to a complete lack of drinking water. The Food and Agriculture Organization of the United Nations (FAO) has attempted to improve the diets of the rural poor by distributing vegetable seeds, but the lack of water has reduced production.

Residents claimed that stress and other mental tension had increased. With food security already precarious, the reduction in harvest, attributed mainly to climate variability and change, was difficult to bear. Mothers had to worry about being able to feed their children. Alternate livelihoods, whether through wage labour or migration, had to be considered, involving prospects that carry many responsibilities and difficult decisions.

Community-Based Responses to Change

The changes perceived by farmers were not necessarily happening for the first time. However, in the past, floods, landslides, and lack of rainfall would be brief and rare occurrences. Coping strategies were developed for the occasional years in which harvests failed. The changes perceived now seem to be more lasting, and also highly unpredictable. The existing coping strategies are mainly effective in the short term, but climate change will require adaptation through long-term adjustment of livelihood activities.

Erratic rainfall, including delayed monsoon onset, is a challenge for timely planting of millet in Terhathum

The main responses to climate and socioeconomic change in the study area are summarised in Table 9 and discussed in more detail in the following paragraphs.

Responses to erratic rainfall and decreased water availability

Farmers with unirrigated land wait until the rains have started before transplanting rice, as the fields need to be flooded. If the monsoon arrives late, planting of the major summer crops is delayed. When the winter crops fail due to lack of winter precipitation, the summer crops are planted early if there is sufficient rain by then. Maize and other crops that do not produce grain are used as fodder. Millet will not produce grain if there is an extended delay in sowing. However, farmers still planted millet late in the hope of obtaining some yield, and used the stalks as animal feed if there was none. If the harvest seemed threatened, farmers would sometimes sow again, but this depended on the availability and affordability of a second batch of seed and was not a viable coping mechanism for the very poor. Respondents from several villages in Bajhang and Terhathum had stopped planting paddy, due to the lack of water, and either left their fields fallow or planted maize. This was still the case in August 2011. One farmer said that in spite of the good rains in 2011 he had ceased planting paddy, as the spring he used to irrigate his fields had dried out. Farmers in Bajhang had replaced the krisi dhan variety of rice provided by the district agriculture office with ghaiya dhan, an old variety that does not need to be transplanted and requires less water.

Mulching is a traditional way of spreading organic fertiliser composed of dung, leaves, and grass over fields to increase soil moisture and add nutrition to the soil. In order to address the problem of reduced soil moisture, farmers ploughed the fertiliser into the soil immediately after dispersing. They also covered millet seedlings with mulch to prevent them from drying out, and farmers in Bajhang dampened maize seeds before dibbling them deeper into the ground than normal at a depth where moisture is higher.

Table 9: **Community responses to perceived change in Nepal**

Perceived change	Experienced impacts on livelihood systems	Response
Erratic precipitation patterns	Decline in agricultural productivity	Changes to agricultural calendar: delayed or early sowing and harvesting of crops Changes in crop varieties and types Burning forest to gain more land for cultivation (Bajhang) Increased engagement in wage labour Collection of NTFPs (e.g., yarshagumba) Labour migration
	Crop failure	Re-sowing of crops Feed stalks to livestock Buying food from market Sell off assets Take loans
Overall decreased water availability	Less flow in springs and streams, drying up of springs	Stopping paddy planting
	Reduced soil moisture	Mulching Moisturising maize seeds and deep dibble
	Decline in agricultural productivity	As above
Decreased amount or absence of winter rains	Decreased yields from winter crops (decline in agricultural productivity)	As above
Increased frequency of intense rainfall events	Soil erosion and landslides	Building canals to divert water (Terhathum)
Increase in pests and disease	Reduced production	Traditional pest management strategies (spreading cow urine, salt, or ashes; crop rotation and intercropping) Increased use of pesticides
Increasing temperatures	Health issues (increased incidence of heat stroke and vector borne diseases; mental tension)	Collection of medicinal plants
	Beneficial conditions for crops	More than one or shorter cropping cycle Introduction of new crops at higher altitudes (e.g., lychees, mangos)
Warmer and shorter winters with less snowfall	Beneficial conditions for certain crops	As above
	Loss of yields of yarshagumba and thus off-farm income	Increased engagement in wage labour and labour migration
	Increased incidence of pests and disease	As above

Reinforcing traditional farming practices

Farmers in mountainous environments have always had to adapt to variable environmental conditions and have developed many traditional farming practices which can be effective even when conditions are changing fast. Intercropping is one such strategy, with several crops, for example millet or soybean and maize, planted in the same field. Climbing beans are frequently planted in maize fields as the bean roots fix nitrogen and act as a natural fertiliser, while the beans themselves protect the maize to a certain extent during storms. Soybean plants are grown along the ridges of paddy terraces; the roots support the ridges, preventing erosion while providing an additional crop. Another

example is crop rotation. Farmers in Bajhang traditionally plant three different crops – gahat (lentil), mas (black bean used as daal), and til (sesame) – in the same field. They alternate the crops each year to minimise pests and disease, as the crops are affected by different pests, and to improve soil nutrition.

Living with rising temperatures

The rising temperatures are a cause for concern. However, in some areas, the receding snowline and rising temperatures provide an opportunity for agriculture at higher altitudes, and previously unusable areas are now becoming arable land. Residents of high-altitude villages in Bajhang are now able to grow millet in areas where it was too cold to do so before. In Terhathum, it is now possible to grow fruits such as lychee (*Litchi chinensis*) and mango (*Mangifera indica*) that require warmer temperatures and were previously unsuitable for these altitudes.

Dealing with pests and disease

The increased incidence of khurkulo (white grub) was thought to be a result of the lack of rainfall, but was also attributed to mixing of rice husks with the compost fertiliser. With the increase of khurkulo, residents of Bajhang had stopped mixing rice husks with the fertiliser. Thaulya had appeared in millet in the previous 2 years in one village in Bajhang. The disease was observed to spread after weeding, so this practice was stopped to prevent the disease from spreading. Chemical pesticides are also being used to a certain extent, but the high cost deters widespread use. The communities claimed that spraying vegetables with chemicals compromised the taste, so they would use them primarily for cash crops. In order to counteract the increasing use of chemical fertilisers, the district agriculture office in Bajhang had been training farmers to make organic pesticides and promoting their use over chemical pesticides.

Coping with food insecurity

Most households were unable to sustain themselves for the entire year from their harvests and supplemented their income with wage labour and by selling livestock and forest products. When this was still insufficient, they took loans from local moneylenders, generally paying extremely high interest rates. Loans were also taken in the form of credit from stores, and in some places community members could take loans from local saving groups.

The last resort when harvests fail is to start selling off assets, ranging from livestock to property. Unfortunately, this reinforces the cycle of poverty as it reduces future livelihood options. This is the ultimate option, and farmers prefer to take loans than to sell assets. However, in some cases selling off may be unavoidable.

The Public Works Programme of the World Food Programme (WFP) offers an extra source of food and/or income for farmers in far-western Nepal. Roads, irrigation canals, and schools are constructed with local labour, and the workers are paid in rice or cash through WFP's food or cash-for-work programmes. One day of labour is paid in rice, with lentils given monthly.

When the available land is not productive enough, residents of Mayana (Bajhang) sometimes start forest fires to clear new land for agriculture. However, this practice may not be sustainable and could increase vulnerability in the long term.

Diversifying livelihoods

Farmers in Terhathum have replaced maize with different types of cash crops including ginger, cardamom, and broom grass, which can raise a high income if the weather conditions are appropriate. In Bajhang, farmers rely on collecting yarshagumba (*Cordyceps sinensis*) in order to supplement their small incomes from farming or wage labour. In both districts, farmers collected medicinal herbs from forests and sold them to traders. Residents in Bajhang also used to grow marijuana and sell hemp and other products; this was then declared illegal, but some products continued to be sold. In Terhathum, residents from areas near markets sold dairy products, and some farmers engaged in trades such as carpentry to earn additional income. Some better-off families had bought small tea gardens to generate income.

Every community gave wage labour as the first option for an alternative livelihood. As one male farmer (aged 35) from Bajhang noted, "If we don't work for wages, there will be nothing to eat, no fire in the stove". Labour can be in nearby markets or in other countries. The trend of migration to the Gulf and Southeast Asian countries has been escalating. People from Bajhang traditionally migrated to India seasonally to work as labourers. More than 50% of men and close to 50% of the women in one village in Bajhang migrated to support their families. Seasonal migrants travel after the harvest. If the harvest is late they will leave later than usual. If the harvest looks as though it will fail due to lack of water, they will leave earlier.

Differences in Vulnerability and Adaptive Capacity

Socioeconomic and sociopolitical factors also play a role, in addition to the geophysical environment, in determining the vulnerability and adaptive capacity of communities.

The most important factor influencing vulnerability and subsequent adaptive capacity is poverty, which is itself strongly influenced by socioeconomic and political structures such as caste discrimination, lack of education (especially for girls), and lack of decision-making power and economic autonomy for women. These problems reinforce each other, further hindering the escape from poverty (the poverty trap). As the climate changes, subsistence farming becomes less productive, and people become more reliant on finding new sources of livelihood. Women generally lack education and financial assets and must work as wage labourers, but their rates of pay are lower than those of men. Thus the adaptive capacity of women as a group is lower than that of men.

People belonging to the Dalit castes also tend to have a lower adaptive capacity as a group. Traditionally, these people were considered to be 'untouchable' and were limited to low paying professions, for example, tailors, cobblers, blacksmiths, and tanners. They generally have lower rates of education and poorer access to water when the resource is limited. A few are involved in subsistence agriculture, but their landholdings are generally smaller than average. With a smaller resource base, coping and adapting to changes in the climate is more difficult. Furthermore, the reliance on income from services to farmers means that they are affected by farmers' loss of income.

Female farmer from the Dalit group, aged 30 – Khalapata (Bajhang)

"I never went to school and now it's like being blind. We're poor because we do not have enough land. We don't get money from anything except wage labour. My husband has been working in Tamil Nadu for 14 years as a security guard. He sends 3,000–4,000 rupees (NPR) (approximately USD 40–55) every 2 to 3 months. It is never enough for myself, our two small children, and my husband's second wife. We have taken many loans. Whatever we earn is either spent on food or to pay back some of the loans. We sell some vegetables when we can but it is very infrequent. We mainly do wage labour for about NPR 200–250 (USD 3) a day, in addition to working in our field. Harvests have decreased; insects eat the wheat and rice. Mostly there's no water and when it does come it's too intense and our rice rots. What we get from the land is only enough to feed us for a month."

Institutional Opportunities and Constraints

The main institutions operating in the study areas were formal ones, including government institutions and government-aligned and international organisations, and community based institutions such as community forest user groups (CFUGs), leasehold forest user groups (LFUGs), and community savings groups. Unfortunately communities, particularly in the far west, have become dependent on external resources and on initiatives of formal institutions, which are perceived to be endowed with resources. The actions of government bodies are often not demand driven; they are not accountable for their services, and they do not possess the technological, financial, and human resources to inform and support climate change adaptation approaches. Furthermore, processes are lengthy and corruption often limits effectiveness. Effective support to rural communities in tackling the impacts of climate change will require all possible

resources to be mobilised (both human and financial) to raise awareness within institutions of climate change risks and adaptation approaches. Some of the more important formal and informal institutions active in the study area are listed below, together with the associated opportunities and constraints.

Community-based organisations

Community Forest User Groups (CFUGs) and Leasehold Forest User Groups (LFUGs) – These groups have been created so that communities can utilise and protect selected areas of forest and have been quite successful. Such groups could be used as an entry point to raise awareness on climate change among local people.

Community savings groups – These groups had been set up in the study areas in order to help local people become less dependent on moneylenders, who charge exorbitant interest rates. The groups act as social safety nets for farmers and others in times of need and could become even more important if harvest failures become more common.

Government institutions

District development committee (DDC) – The DDC operates government grant programmes for building infrastructure such as bridges, irrigation canals, and drinking water taps. The DDC has allotted grants for tree planting through the community forest user groups.

District agriculture office (DAO) – The district agriculture offices provide information and advice for agriculture, and are especially important in the adaptation process. Farmers currently approach the DAO when problems such as pest infestation and crop failure occur. The DAO supports agroforestry and provides fruit trees so that farmers can grow fruit to supplement income. The DAO has the capacity and resources to gather information and test varieties of crops best suited to the climate.

District forest office (DFO) – The district forest offices assist CFUGs and LFUGs in planting herbs and other income-generating products, and developing plans for forest use. Grass and fodder collected from forests are essential for livestock, which are a key insurance mechanism and livelihood asset.

Government-aligned and international organisations

The Western Uplands Poverty Alleviation Programme (WUPAP) and Environment, Culture, Agriculture, Research, and Development Society, Nepal (ECARDS) – WUPAP operates in the western districts of Nepal as a collaboration between the International Fund for Agricultural Development (IFAD) and the national government and is aimed at strengthening the livelihood systems of the rural poor. ECARDS is WUPAP's counterpart in the eastern districts. These programmes interact with communities on a regular basis, and can play a vital role in communicating the needs of communities to government and non-governmental institutions that have the resources to assist in climate change adaption.

World Food Programme (WFP) and Food and Agriculture Organization of the United Nations (FAO) – The mandate of both of these United Nations organisations is to ensure food security. The approach includes humanitarian relief, support for alternative livelihoods, seed distribution, and farmer training. Activities are helping to buffer the food security situation, which has been compromised by various factors, including climate change. These activities might need to be scaled up as climate change reduces crop yields.

Climate Change Policy

Nepal submitted its National Adaptation Programme of Action (NAPA) in September 2010 (MoE 2010) and the government approved a national climate change policy in early 2011. Local Adaptation Plans of Action (LAPAs) have been drafted to take into account Nepal's wide diversity of ecosystems, micro-climates, cultures, and socioeconomic circumstances (MoE undated) The NAPA recognises that water security is a priority and focuses on broad projects that are likely to reduce vulnerability to climate change. If the measures proposed in the NAPA are implemented successfully,

they could greatly assist farmers in dealing with some of their concerns. However, the NAPA is a relatively short-term project-based approach to climate change adaptation and it will be necessary to consider how to scale up these projects to make them relevant for long-term adaptation. Related services should be provided by the DAOs and DDCs. The proposed activities would require investment and efficiency in government offices.

Conclusion

The main climate-related challenges faced by the communities in Nepal were erratic rainfall, increasing temperatures, and an unprecedented increase in crop pests and disease. The changes were perceived as stronger in the west (Bajhang) than in the east. This may also be related to the fact that the far-western part of Nepal is comparatively less developed and has higher levels of poverty and food insecurity, and thus more limited adaptive capacity. Climate change is aggravating this already precarious situation and may therefore be perceived more strongly by these communities.

Weather patterns in Nepal are extremely variable, and it is difficult to differentiate between normal short-term fluctuations and long-term trends. Nevertheless, there is a clear indication that the variability is itself increasing, that changes are taking place in rain and snowfall and temperature, and that it is increasingly difficult to predict the weather events that affect agriculture and harvests. Thus, diversifying livelihoods and moving away from a reliance on natural resource dependent activities will be unavoidable.

Social inequality is still widespread in the study areas and discrimination of people belonging to lower caste and indigenous groups and women is prevalent. It will be important to overcome this in order to address the problems of the most vulnerable in responding to climate change.


LEKHO

Impacts of and Vulnerability to Climate Change in Eastern Bhutan

"Even the lamas cannot make it start or stop raining."

Introduction

Bhutan is an entirely mountainous country. It is culturally and geographically distinct from its neighbouring Himalayan states, and was isolated from the outside world to a great extent up to the 1960s. The total population is 690,000 (WB 2009) and society is predominantly matrilineal. The rural economy has been transformed from a purely subsistence to a semi-subsistence cash economy as a result of the high priority placed by the government on the agricultural sector. The special characteristics of Bhutan can be used to generate a more comprehensive understanding of climate change and its impacts in the Himalayan mountains.

Study Area

Three villages were studied in each of two districts (dzongkhags) – Pemagetshel and Trashi Yangtse – in Eastern Bhutan, the poorest part of the country (Table 10). More than 85% of the households in Eastern Bhutan are agrarian; they are particularly disadvantaged in terms of connectivity (Hunzai 2011), an important factor in determining poverty and vulnerability. The villages are at different elevations and differ in access to markets and roads and especially in access to water.

Bhutanese women have the presumptive right of land ownership in a matrilineal system with property controlled by an 'anchor mother' and passed on to female family members. The government provides free education and health services as well as an entitlement of agricultural land given for subsistence purposes. Nevertheless, 38% of the population in Pemagetshel lives below the poverty line (USD 1.08 per day), and 24% in Trashi Yangtse (RGOB 2007). The lower poverty in Trashi Yangtse may result from productive yields from more fertile land, as well as from widespread collection of yarshagumba (*Cordyceps sinensis*), a high value NTFP.

Table 10: **Villages surveyed in Eastern Bhutan**

District/Village	Altitude (masl)	No. of HHs*	Distance to next market (walking minutes)	No. of in-depth HH interviews
Trashi Yangtse				
Tarphe (with Cheng and Drongney)	2,350	24	360	9
Tsaling	1,900	45	15	9
Khamdang	1,500	155	0	9
Pemagetshel				
Gompasingma	2,000	20	30	9
Shali	1,200	60	20	9
Khangma	1,100	100	180	9

masl – metres above sea level; HHs = households
*Number of households estimated by local informants; the houses are scattered over a wide area and numbers are not exact

Communities' Perceptions of Change

Windstorms were seen as the greatest weather-related hazard by farmers in Eastern Bhutan. Storms are particularly destructive to maize – one of the primary food crops in the study area. Respondents felt that storms had increased over the past years, causing increasing damage to property and crops. Storms generally start in March and are extremely unpredictable, frequent, and intense. Almost every community in the study area experienced this as the greatest threat to farmers.

The villages studied in Pemagetshel suffered chronic water shortages as they lie far from sources of water such as rivers or streams and are highly dependent on the monsoon, which brings 60–90% of annual precipitation. Villagers thought that rainfall had greatly decreased, severely affecting the rain-fed agricultural systems. "We used to have plenty of rain in the off-monsoon seasons and now even the monsoon rain has decreased to half the usual amount", claimed one respondent. Of the villages studied in Trashi Yangtse, two received ample rainfall throughout the year whereas one, Khamdang, faced an acute shortage. Khamdang is located in a rain-shadow area and used to limited precipitation, but even there the general feeling was that precipitation over the last decade had become scarcer and that winter precipitation had disappeared. The other two villages were at higher altitudes than most of the villages in the study and had experienced increasing rainfall. This would match findings of previous studies on climate change in the eastern Himalayas (Sharma et al. 2009) which observed increasing rainfall at higher altitude.

The most observable change seemed to be the increased unpredictability and variability of weather patterns. The monsoon onset was late in some areas, and early in others. "There is no rainfall by the time it would usually come. The young maize plants in the field keep drying up and we have to plant them over and over again!" exclaimed one respondent. Some communities in Trashi Yangtse noted variable monsoon rains and sudden heavy showers interrupted by dry periods, which hampered the growth of crops requiring continuous precipitation. The magnitude of hailstorms and hailstones appeared to have increased, but the incidence had decreased.

Farmers thought that temperatures were rising, particularly in winter. Older inhabitants speculated, "We often wonder what is going on, is the sun falling down towards the Earth or is the heat in the house caused by the metal roof?" Snowfall was less in the high altitude villages in Trashi Yangtse, which might also indicate warmer temperatures.

Comparison of perceptions of change with climate records

Aggregated climate and precipitation records were obtained from two hydro-meteorological stations, one in Trashi Yangtse at 1,830 masl and one in Pemagtshel at 1,618 masl. Data were only available from 1996, too recent for any climate trend analysis; the temperature and precipitation graphs are given in Annex 2. The data show the overall interannual variability of rainfall and temperature in both districts. There had been slightly less rainfall in the 3 years before the survey than immediately before that, but there was no clear overall trend. There is some indication of an increase in temperature in Trashi Yangtse between 2002 and 2010 and Pemagetshel from 2002 to 2007, but higher temperatures were recorded in both places before this period.

Without weather data from the actual village sites, longer-term data, or analysis of intra-annual differences, it is not possible to make a proper comparison of villagers' observations with climate records. But there is some indication that participants' responses mainly reflect comparisons with the most recent years, rather than long-term observations.

Impacts of Change on Livelihoods and Community Wellbeing

Unpredictable harvests

The variability of weather patterns has led to unpredictable harvests. Although households are mostly food sufficient, yields are affected by changes in rain patterns, temperature, and storms; disturbances from wildlife; and lack of labour. Wind and hailstorms are a big hazard and can destroy harvests such as maize. The communities studied did not have access to river water and were dependent on rainfall. Most fields were not irrigated, which limited production when rains did not arrive in the expected amounts at the expected times.

Pests and disease

More exotic plants (weeds) are appearing in fields and suppressing plants that could be used as fodder. Pests and disease in crops are of increasing concern to farmers. Blight in potato and chilli, which are major food crops, affected a large area of production, possibly a result of longer than usual rains increasing the chances of infestation. Citrus greening, transmitted by psyllid bugs ('jumping plant lice'), was affecting orange trees, leaving the fruits small and green and killing the trees. Numbers of wildlife, particularly wild boar but also porcupines and monkeys, have increased owing to a ban on hunting of wild animals, as well as a ban on shifting cultivation (as animals used to get scared by the fires and now have more places to hide with vegetation growing back); wild animals are causing increasing damage to maize and potato crops. Although human health statistics have improved with government services and outreach clinics, respondents reported more headaches and stomach aches. Increasing numbers of mosquitoes have also been observed over the last 5 years.

Workloads and labour

Most farming activities were conducted on time, but with some slight variation depending on the specific rain pattern. Farmers in Pemagetshel were sowing early, with early rainfall, and harvesting early. Harvesting was also preponed at times to prevent the crop rotting. Wage labour often complements farm work in the off-season when less labour is required for agriculture, especially for poor households that need income to purchase food. Some respondents remarked that they have less leisure time than before. Rural-urban migration is also an increasing trend. In 2004, nearly one-quarter of Pemagetshel's population, and at least one member from more than half of all rural households, had migrated to urban areas (mostly Thimphu) (RGOB 2004).

Emerging opportunities

Higher temperatures and increased precipitation in the high altitude villages of Trashi Yangtse had led to better crop yields. Orange trees flower earlier and are growing at higher elevations (almost 1,000 m higher), providing more opportunities for farmers. There was a similar altitudinal shift in exotic flora, previously found only at lower elevations and in the southern region.

Community-Based Responses to Change

Spirituality and religion are very important in the districts studied as in other parts of Bhutan. Local deities are invoked when rain is delayed or limited, when hazards affect crops and livestock, and for human health. Variability is difficult to prepare for and adjust to. However, farmers do use certain strategies to the best of their abilities.

The main responses to climate and socioeconomic change in the study area are summarised in Table 11 and discussed in more detail in the following paragraphs.

Religious coping mechanisms

Praying and performing rituals for local deities was the most common coping strategy reported by almost all the farmers interviewed. Rituals could include walking naked with painted faces, walking to nearby villages for three nights, or simple pujas (ceremonies) requesting local deities to bring rain. Most villagers felt completely helpless when there was too much rain, whereas rites were reported to be helpful in the case of too little rain. "Not even the lama can stop the rain", commented a 70-year-old resident of Pemagetshel. In the belief that trespassing on certain sacred forest areas angers deities, residents were banned from accessing these areas to prevent storms.

"We have no coping mechanisms as such, but we perform religious rituals to protect our crops and livestock if there is too little water, extreme temperatures, or hail or windstorms, and if we get sick. This traditional measure is sometimes sufficient. If pests or disease attack crops, we spread ash after we perform rituals. The head of the household usually takes the initiative to perform the rituals and each household deals with its problems individually. Often the community as a whole performs the rituals for the local deities. If the trouble concerns many households then we report it to the local agriculture or livestock extension office and ask for help."

– Tawrang, aged 48

Table 11: **Community response to perceived change in East Bhutan**

Perceived change	Experienced impact on livelihood systems	Response to change
Erratic precipitation patterns	Decline in agricultural productivity	Religious rituals Changes to agricultural calendar: delayed or early sowing and harvesting of crops Changes in crop varieties and types Introduction of new crops Increased engagement in wage labour Collection of NTFPs (e.g., yarshagumba)
	Crop failure	Re-sowing of crops (seeds provided by the government) Consuming food distributed by government Buying food from market Take loans
Overall decreased water availability	Decline in agricultural productivity	Religious rituals Pumping water from nearby springs Rainwater harvesting Afforestation of catchment areas
Too much water	Loss of harvests	Construction of side drains to divert water
Increased frequency of windstorms	Destruction of crops Damage to houses	Ban on trespassing in sacred forests Mixed cropping, for example beans and maize Tying roofs to the basement of the house or to trees
Increase in pests and disease	Reduced production	Traditional pest management strategies (spreading cow urine and ashes, crop rotation, and intercropping) Early planting and harvesting of crops to escape attacks Introduction of organic pesticides such as *Artemisia* Increased use of chemical pesticides Introduction of resistant varieties Introduction of post-harvest management technologies to avoid insect attacks
Increasing temperatures	Health issues (headache stomach ache, more mosquitoes)	None
	Beneficial conditions for crops	More than one crop or shorter cropping cycles Introduction of off-season vegetables
	Orange trees flower early	Orange trees grown at higher altitudes (up to 1,000 m higher)

Changes in agricultural practices

Communities have been found to adapt the agricultural calendar annually in response to the increasingly erratic precipitation patterns. Sowing and harvesting times are adjusted according to the onset of precipitation as well as to prevent rotting. Seedlings dry out when rain is insufficient, and crops are sometimes destroyed by natural calamities. Maize and other cereals (barley, wheat, buckwheat, and millet) and vegetables are re-sown if there is enough time for a crop to ripen. The seeds for re-sowing are usually distributed by the government.

In Bhutan, government institutions are strong and reliable partners for farmers and regularly provide them with services. These institutions are making considerable efforts to improve rural people's livelihoods and support them in adapting to changing conditions. For example, new crops have been introduced in particular areas to assess their adaptability and yield potential. Upland rice from Nepal has been introduced in high-altitude areas of Trashi Yangtse and communities are now food-sufficient year-round. Cash crop production – ginger, cardamom, oranges, potato – has been

encouraged in areas with potential for such crops, particularly focusing on poorer households. Also, a new concept of off-season vegetable cultivation has been introduced in order to increase farmers' income.

The Ministry of Agriculture supports application of chemical spray pesticides if crops are damaged by epidemic pests. When this is unsuccessful, seeds are replaced with resistant varieties. The government also strongly supports organic fertilisers and pesticides such as manure and *Artemisia* spp.

Traditional and new cropping technologies are taught by agricultural extension officers including early planting to escape pest/disease infection and subsequent rotting. Crop rotation (alternating different types of crops on the same piece of land on a yearly basis) has also been revived.

Specific strategies for storing produce have also been promoted in order to prevent destruction by insects (potato in Pemagetshel). Households have been helped to build structures with electric air circulation systems. Training on crop storage emphasising hygiene and proper aeration is provided to farmers. Farmers now prefer to dry chilli crops with electrical dryer systems as the quality is higher than with traditional methods – drying is uniform and the colour is retained.

Responses to too little water

Various approaches have been used to address problems of too little water. Where possible, trees have been planted around water sources. Local administrations have promoted a number of activities to protect catchment areas, including fencing and running awareness programmes on the effects of deforestation. The government also introduced rainwater harvesting in schools in 2007 and in communities in 2009. Rainwater is collected in a big tank and used for cattle, washing clothes, and to water vegetables in kitchen gardens.

Although the government has provided taps and water supply schemes, some users still face problems as a result of house location or the number of taps from a single source. One group in Pemagetshel had invested in an electric water pump to pull water from a nearby stream at a lower elevation, and now has sufficient water.

This roof has been tied to a tree with a rope to protect it from windstorms

Livelihood diversification

Collection of NTFPs such as yarshagumba (*Cordyceps sinensis*) is a lucrative activity and households that have procured trade licences for these products are becoming wealthy. There is strict monitoring of the trade and collection of such products. The government issues special permits for these activities to ensure sustainability of harvests. Wage labour in off-farm activities is also widespread, for example in gypsum mining, road construction, production of cultural and religious items, and hand weaving.

Responses to natural and economic stress

Side drains have been built on sloping fields to divert water when strong rains set in. As a reaction to the increase of strong windstorms, people protect roofs from being blown away by tying them to the basement of the house or to nearby trees. Some crops, such as maize, are protected through mixed cropping – beans are planted next to maize so the climbers provide additional support to help the maize withstand wind

and the roots make soils more fertile by fixing nitrogen. During food shortages, respondents reported that they would take loans in the form of cash or credit from wealthy neighbours or stores.

Differences in Vulnerability and Adaptive Capacity

Bhutan's unique geography and social structure are the main factors determining poverty and vulnerability to climate change. Gender, ethnicity, class, and literacy play a role, but somewhat differently than in other parts of the Himalayas.

Bhutan's Buddhist traditions and values consider men and women to be equal. In 1981, at its inauguration, the National Women's Foundation declared that the women of Bhutan had already come to enjoy "equal status with men, politically, economically and socially" (Savada 1991). But there is a differentiation in roles, for example more women than men are involved in agriculture (68% and 36%, respectively, in Pemagetshel). Eastern Bhutan has a high poverty rate compared to the rest of the country, which appears to be mainly influenced by social status, as indicated by literacy rates (Hunzai et al. 2011). Women's literacy rates in the study area were lower than men's (31% compared to 61% in Pemagetshel, and 45% compared to 64% in Trashi Yangtse). Literacy is important in the search for off-farm opportunities (aside from wage labour). With climate change and the reduction in harvests, other opportunities will have to be sought and the lower literacy rates for women in Eastern Bhutan will eventually affect their adaptive capacity.

Assets and lack of access to basic facilities also determine poverty in Eastern Bhutan. Although the government provides free basic education, the rural poor cannot always afford school uniforms or textbooks, or the cost of losing children's labour, and are thus less likely to be educated. Financial, physical, and social assets are crucial in adapting to climate change, for example in changing professions or introducing new seeds and improved agricultural technologies. Richer households can purchase more fertile land as well as fertiliser. Land belonging to poorer households is comparatively less fertile and the poor cannot afford either fertilisers or labour to collect leaf litter and forest topsoil to enrich their fields. Poor households also have less livestock to provide manure. Thus the resilience and adaptive capacity of poor farmers is limited.

Eastern Bhutan is also disadvantaged in terms of connectivity, especially to the centres of administration and commerce. Greater proximity to roads is generally associated with lower incidence of poverty and improved access to infrastructural services, which mainly exist in urban centres (Hunzai et al. 2011). The government has invested heavily in infrastructure and outreach services and is specifically targeting the poorest districts, but the rugged terrain, remoteness, sparse population, and lack of reliable communication facilities hinder the delivery of services (e.g., health services) in rural areas. Of the six villages studied, only one was located in a market area; farmers from the others had to walk between 15 minutes and 6 hours to reach the nearest market. Road and market access are crucial for farmers to be able to sell products to supplement their incomes.

Institutional Opportunities and Constraints

Informal institutions

Informal institutions such as monasteries and nunneries are important structures for the Bhutanese in terms of coping strategies, providing spiritual support. Rituals to please local deities are the primary coping mechanism and are performed by monks. Assistance from external institutions is only sought if the rites and donations to monasteries fail to rectify the situation.

Government institutions

The Government of Bhutan has been proactive in providing services to its citizens, investing in health care, agriculture, infrastructure, and others. The Ministry of Agriculture offers concrete support to improve agronomic practices including pest and disease management, planting techniques, and post harvest management. The government also offers direct support for crop damage – replacement seeds if the crop fails around planting time, food if the crop fails later. Farmers deal with their problems individually unless the problem is a community concern, at which time the local administration will be informed and the message passed on to regional and national level agencies. Respondents felt that their

workloads had decreased drastically with the provision of electricity and water. The government's campaign to ensure road access to every mid-level administrative centre (Geog) by 2013 will ease transportation problems and help in the sale of agricultural and other products, which will help livelihood diversification. The provision of meals at schools for students also ensures food security for children.

There are still weaknesses, however. The agricultural sector has been promised free water supply, including the labour and equipment to provide it; however, in practice, poor households located at the end of a water source may receive little or no water. The government has introduced new seeds and has had some successes, for example, maize plants were shorter and more storm resistant. However, some seeds have proven more prone to pests. Further, there may still be some discrimination; some community members believed that "only rich householders get good material to replace their roofs after a storm has blown them away, while poor famers like us get simple plastic sheets". Equitable access and provisions, with priority given to poor households, is fundamental to build trust and reduce conflict.

Climate Change Policy

Bhutan was one of the first countries to develop a NAPA, completed in 2006, and has recognised the need to integrate climate change concerns and adaptation strategies into national and sectoral development plans such as the Tenth Five-Year Plan (2008–2013). Most of the nine identified priorities in the NAPA focus on disaster risk reduction. The projects target disaster management, GLOFs, floods, landslides, and forest fire management; few address long-term strategies for adaptation, but there is strong emphasis on climate change adaptation within the Tenth Five-Year Plan. Bhutan recognises the importance of managing the natural resource base for sustainable socioeconomic development. It has integrated policies and strategies aimed at managing the fragile mountain ecosystem and developing an economy based on niche products through approaches such as engaging communities through cooperatives, recognising traditional knowledge systems and agricultural practices, and enacting strong environmental protection laws.

Conclusion

Residents of the eastern districts of Bhutan have yet to experience any severe climate-related changes, and the changes there are relate more to variation and lack of predictability than to any clear trend. This might explain why relatively few coping and adaptation mechanisms were identified. Furthermore, with a small population and a strong and stable government, even people living in the remotest areas of the country can count on government support. This may reduce the need for communities to develop individual responses. Nevertheless, Bhutan will not be exempt from the impacts of climate change, and international and national research institutions need to monitor, document, analyse, and disseminate climate data so that appropriate adaptation measures can be proposed. Awareness raising on climate change will be essential at every level – from local households to national officials – in order to develop a common understanding on causes, impacts, and strategies. Finally, Eastern Bhutan is particularly vulnerable as a result of the high rates of poverty, low human capital, high dependence on agriculture, and low accessibility, and the government will need to continue to target this region.

Climate Change and Its Impacts in North East India

"The rains have been delayed every year for the last few years; while the delayed rains are of concern, what really worries us is the change in rainfall – earlier, when the rains started, they would go on for days; nowadays, the rains don't last for long, and there are long periods of hot, dry days in between. Moreover, when the rains do come, they are so heavy, it is as if the heavens have opened up!"

– Garo elder from Samanda village near Williamnagar, East Garo Hills

Introduction

The study looked at the perceptions of, and responses to, change in rural villages in two districts in North East India. The region lies in the far northeast of the country and comprises the eight states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. It is known for its heavy monsoons, commencing in early April and lasting to October or November; Mawsynram in Meghalaya – 'the abode of the clouds' – holds the distinction of having the heaviest rainfall in the world. The monsoon period is typically cloudy, with heavy and continuous rainfall broken by short spells of up to 10 dry days. Dry, sunny days are rare.

The heavy monsoon and high humidity gives rise to a rich and diverse vegetation; the region has extremely high biological diversity, with some of the most dense rainforests outside the Amazon. North East India is culturally distinct from the rest of the country with a rich ethnic diversity and strong cultural affinities that can be traced to the Tibeto-Burman communities of China and Southeast Asia. The Government of India has provided special constitutional protection (through the Sixth Schedule of the Constitution of India) which confers on the ethnic communities the right of ownership and management of their natural resources in accordance with the traditional customary norms of each community, governed by their respective traditional institutions within the framework of the constitution. The North East is also one of the least developed areas of India.

Study Area

The study was carried out in five villages in two districts – Karbi Anglong in Assam and the East Garo Hills in Meghalaya (Table 12) using a participatory rural assessment (PRA) approach. Karbi Anglong is predominantly inhabited by Karbis, and the Garo Hills by Garos. Both communities are agrarian, predominantly shifting cultivators with a strong dependence on forest and other natural resources. Despite government efforts to replace shifting cultivation with settled agriculture, both communities continue with this practice. Landholdings and access regimes among both groups were traditionally within a common property framework, and largely remain so. In the past few decades, private holdings have slowly emerged, inadvertently encouraged by different government programmes promoting the conversion of shifting cultivation into settled agriculture. Where shifting cultivation prevails, the common property regimes still apply. Access to common land – village land in the case

Table 12: **Villages surveyed in North East India**

District/Village	Altitude (masl)
Karbi Anglong	
Umphu	576
Borphu	478
Uzandonka	406
East Garo Hills	
Bolmoram A Dapgre	519
Kalak Songgital	435

masl – metres above sea level

A young woman picks spring onions grown under shifting cultivation

of Karbis and 'akhing' land among Garos – is still controlled by traditional institutions, although the tenurial rights to shifting cultivation plots for each household within a village remains a hereditary right. The Karbis are patriarchal while the Garos are matrilineal; tenurial rights are inherited by sons among Karbis, and by daughters among Garos.

The Garos have strong indigenous roots and continue to depend on the traditional practice of shifting cultivation, collection of forest products, and to a lesser extent poultry and piggery for their livelihoods. A gradual 'comodification' of shifting cultivation has emerged, and it is common to see surplus agricultural and forest products sold in nearby markets. Income from produce is supplemented by wage labour. Among others, the National Rural Employment Guarantee Act (NREGA) provides a legal guarantee of 100 days of employment every financial year for a household. Animal husbandry is an important investment for households since animals can be sold at times of need. The sale of animals during festivals – particularly Christmas and marriages – is an important source of income.

The Karbis are also dependent on agriculture and practice shifting cultivation, clearing small plots for cultivation each year in a rotation system. Market towns are close by and communities are able to sell vegetables, wild edibles, and fruit such as banana, pineapple, jackfruit, mango, and guava, grown in their shifting cultivation fields and home gardens or collected from the regenerating shifting cultivation fallows. Ginger and turmeric are important primary cash crops; trade in these is primarily through commission agents engaged by outside traders for markets outside the region.

Communities' Perceptions of Change

The primary concern of communities appeared to be erratic, rather than delayed or reduced, rainfall. The extremely hot and humid weather during the spells between rainy days was also a recent and unwelcome phenomenon.

Farmers in the East Garo Hills had noticed a delay in the onset of the monsoon, which was also observable but less significant in Assam. Local variations in climate complicate the perceptions. Overall appraisals in several villages in Assam indicated a lengthening in the duration of precipitation, whereas some of the individuals interviewed had experienced the opposite, with a decrease in overall precipitation. Farmers in both Meghalaya and Assam found that the monsoon is no longer predictable, and the sowing and harvesting calendars have had to shift. There were longer dry spells between the rain, but the rain was heavier when it did fall, severely affecting crops and ultimately yields from their fields. The dry season was thought to be lengthening and more severe, with long periods of hot, dry days associated with a drying up of springs and drinking water shortages. Overall, farmers across the study area thought that both summers and winters were warmer.

Hailstorms were thought to be less frequent, except in one community, although their severity appeared to have increased dramatically. Flash floods were noted to have decreased in one district of Meghalaya.

Crop pests and disease were thought to have increased moderately or severely across the study area. Farmers thought this might be a result of the change in monsoon onset and of changes in temperature. Rhizome rot disease was affecting ginger and reducing the income from this crop in parts of both Meghalaya and Assam.

Impacts of Change on Livelihoods and Community Wellbeing

Food security

Communities in both districts expressed concern about the change in precipitation patterns leading to a drying up of water sources – rivers, streams, wells, and springs – for drinking water and irrigation.

The dry season appeared to be lengthening, which "delays sowing and transplantation, particularly of rice as most of upland agriculture is rainfed". Furthermore, the increased severity of hailstorms was causing damage to standing crops in September, sometimes completely destroying the year's standing paddy crop. Hailstorms earlier in the year also damaged flowers, preventing fruit set, and resulted in early fruit fall among horticultural crops such as citrus, mangoes, lychees, and other fruit.

The erratic nature of precipitation had a serious negative impact on harvests. A woman from Assam explained, "These grains are not ripe for harvest yet, but instead of being sunny and helping the crop to ripen, it has been raining, so we cannot harvest the crops and probably they will go bad in the field". Others from Meghalaya remarked that "for the past few years, there has been an increased incidence of dry spells between rainy days, resulting in the wilting of germinated crops. The dry spell is followed by sudden heavy rains often resulting in the erosion of soil around roots, exposing them to drying during the dry days that invariably follow – this cycle of drying and heavy rains is destroying our crops". The reduction in soil moisture was also affecting production of staples (rice, millet) in Meghalaya. Overall, the impact was inducing and perpetuating food insecurity in the region.

Daily life

As springs and other sources close to villages dry up, women's workloads are increasing as they have to travel further to fetch water. The changes in the weather also encouraged weed growth; farmers noted that it takes twice as long to weed as in the past. Moreover, as the productivity of agriculture declines, men search for wage labour opportunities, adding both to their workloads and to the workloads of their wives. Conversely, the warmer temperature in the winter has reduced the need for fuelwood and the time taken to collect it.

Community-Based Responses to Change

The major difficulty for villagers was coping with the uncertainty of climate variability. As one farmer from the East Garo Hills explained, "We knew how to deal with delays in rainfall or with heavy rainfall – at least there was a known pattern; how do you deal with situations when the rains are delayed for weeks, and then when it comes, you have the heaviest downpour as if it is the height of monsoon! Then the rains don't last for long and you have days when it is dry and hot instead of continuous rain. We don't know how to deal with this erratic climate!" People also claimed that following their conversion to Christianity, they had lost the traditional knowledge from their ancestors which would have helped them to deal with such situations. The church generally perceives traditional practices as primitive and to be replaced by 'modern/scientific' approaches – thus indigenous knowledge and traditional practices are not being passed down the generations. Nevertheless some strategies – both new and traditional – have been adopted by the communities to cope with the stresses resulting from climate and socioeconomic change, although with the growing variability in weather patterns, some of these mechanisms may not be effective in limiting damage in the longer term. The community responses are summarised in Table 13 and discussed in more detail in the following paragraphs.

Responding to erratic rainfall patterns and too little water

Farming communities have adjusted the timing of sowing and harvesting of cereals and vegetables to cope with the changes in the timing of precipitation and temperature. New varieties of seeds have been introduced which require less water and can be harvested earlier, for example methungja, a local variety of rice, and alikha, a variety of millet, which are drought resistant and have better productivity. Crop varieties that withstand strong winds and storms have also been planted.

With soils becoming dry as a result of delayed rainfall, farmers dibble seeds, particularly maize, deeper into the soil where soil moisture is higher, increasing the chance of the seeds sprouting and taking root. Elsewhere, farmers select sites with shade and higher soil moisture for seed beds. In order to retain what soil moisture is available and prevent further evaporation, farmers use crop residues and weeds as mulch, or add organic compost and manure around emerging seedlings to ensure their survival.

In extreme cases, when seeds fail to sprout or sprouted seedlings wilt, farmers re-sow the field with different crops. When cereals fail, farmers replace them with sesame, soybeans, or ricebeans (*Vigna umbellata*), crops that are suited for harsher conditions and tolerate stress. Fruit crops such as banana trees are intercropped with lychee and areca nut (*Areca catechu*) trees, combined with mulching to spread risks from moisture loss and other stresses.

Table 13: **Community response to perceived change in North East India**

Perceived change	Experienced impact on livelihood systems	Response
Erratic precipitation patterns	Decline in agricultural productivity/crop failure	Changes to agricultural calendar: delayed or early sowing and harvesting of crops Introduction of water stress tolerant varieties Borrowing grain from self-help groups (SHGs) Introduction of new cash crops such as ginger, turmeric, cardamom, and chillies Collection of NTFPs Increased engagement in wage labour Participation of a household member in the NREGA programme
Overall decreased water availability	Reduced soil moisture/decline in agricultural productivity	Dibbling maize seeds deeper into the soil Cultivating crops in shady locations with higher soil moisture Mulching with organic compost and manure
Too much water	Loss of harvests and property	Use of bamboo matting to protect terraces from flash floods
More severe storms	Loss of harvests and property	Introduction of varieties that can withstand strong winds
Increase in pests and disease	Reduced production	Traditional pest management strategies (e.g. dead crabs and sour bamboo shoot extract)
Increasing temperatures	Beneficial conditions for some crops	Introduction of off-season vegetables

Dealing with too much water

Flash floods often deluge terraced plots, destroying standing crops and damaging the terraces with the debris carried by the flood water. An innovative coping strategy practiced by upland farmers in the Garo Hills is the use of bamboo matting across inlet channels to trap the silt and debris brought by the floodwater. The bamboo matting allows the water to flow in while the silt and debris are trapped. This reduces the workload of farmers in repairing the fields, while strengthening the bunds along which the matting is laid.

Combating crop pests and disease

Traditional organic pesticides such as pomelo skin, dead crabs, and sour bamboo shoot extract are used to ward off pests. Samsnung (smelly leaves), bamboo leaves, and magrit (grass) are also applied to repel pests on wet terraces. These measures are effective with low levels of pest infestation, but less so when pest infestation is severe. Chemical pesticides are also used, but to a much lower extent than in other areas.

Livelihood diversification

In times of food insecurity, wild or forest sourced indigenous foods such as game, fruit, tubers, ferns, mushrooms, and honey are collected for household consumption and sale. Fish are also raised to enrich the diet and as a source of income; a pond built in East Garo by the state to store water was converted into a fish pond by a self-help group.

Agriculture is increasingly focused on cash crops, especially ginger, turmeric, cardamom, chillies, leafy vegetables, and tomatoes. North Eastern Region Community Resource Management (NERCOMP), an IFAD project, has introduced home gardens to produce seasonal vegetables for local markets in villages at higher elevations to diversify incomes.

With productivity declining and yields becoming insufficient, many households look for wage earning opportunities outside the village. Although wage labour through NREGA is assured for 100 days within the village, many people leave the village to look for seasonal earning opportunities in plantations, road building, or mines. Many women use handicrafts and weaving to supplement household income.


Livelihood diversification is making households more resilient to shocks: Weaving traditional cloth and chillies for sale on the local market

Social safety nets as important fall back mechanisms in times of need

Social safety nets, particularly those extended by the family and traditional institutions, are extremely important both among the Karbis and the Garos. The church and church initiated groups are also significant support groups in times of need. The self-help groups promoted by the IFAD projects have also emerged as important mechanisms that provide a safety net in difficult times. Self-help groups not only provide micro-credit, they also have food banks which help people to borrow grain at times of food shortage.

The government NREGA programme aims to enhance livelihood security in rural areas by guaranteeing 100 days of unskilled wage employment per year to households that fall below the poverty line. This government system is much used by the communities in the study area.

Differences in Vulnerability and Adaptive Capacity

There is no caste system in North East India and thus no discrimination based on caste. Similarly, upland communities make little distinction between rich and poor. Educational attainment does have an influence on vulnerability, however, since the better educated usually enter into the bureaucracy or politics and are less reliant on climate sensitive occupations.

The matrilineal culture in Meghalaya has enabled women to play a major role in decision-making. Men also assist in household chores, and women frequently trade in markets. Women in Assam are less active, but with the establishment of self-help and other affinity groups, this is changing rapidly.

Institutional Opportunities and Constraints

Community-based institutions play an important role In North East India, particularly in times of environmental and socioeconomic stress. Some of the more important formal and informal institutions active in the study area are listed below, together with the associated opportunities and constraints.

Local institutions

Village headman – Each village has a headman, called the gaonbura in Assam and nokma among the Garos in Meghalaya. The headman is more a custodian than an authoritative head. The gaonbura is assisted by clan elders in taking decisions; the nokma takes decisions in consultation with the maharis or maternal uncles of the nokni (heiress), particularly with regard to access and control of resources, and executes the decisions.

Self-help groups – Assisted by local organisations, these groups have started micro-credit activities, helping communities start small income-generating activities such as pig and poultry raising, as well as vegetable gardens. They also provide physical support.

Kinship (relatives, clans) – Relatives and the clan are extremely important in times of need. Households generally turn to close relatives within or outside the village for immediate relief; for greater relief, the clan is of paramount importance. Clan members, as a body, will contribute towards the needs of a family belonging to the same clan. The help extended could range from cash support, grain, and shelter, to access to common property resources as well as access to formal support institutions.

Church and church bodies – The church and church-promoted social bodies play a prominent role in times of need. The support extended to needy families is confined to members of the same denomination; it does not extend to non-Christians and is not universally available.

Government institutions

Block development office – The block development office is responsible for implementing and overseeing various projects and schemes instituted by the government. In Meghalaya, this office has provided support for areca nut plantations, construction of ring-wells, low cost houses, schools, and roads.

Horticulture/agriculture departments – These departments have been assisting communities with the supply and plantation of saplings of cash crops such as rubber, coffee, tea, ginger, turmeric, and pineapple.

Soil and conservation departments – These departments have made efforts to increase irrigation potential in the study area and bring more land under cultivation. They have also provided land development activities for wet terraces and orange plantations.

National Rural Employment Guarantee Act (NREGA) – This scheme guarantees 100 days of employment per fiscal year to anyone with a 'below poverty line' (BPL) card. The NREGA is crucial in providing a source of income for low-income households. Activities include repairing water harvesting structures, fisheries, footpaths, and labour on rubber plantations.

Climate Change Policy

The relevant policy in India is summarised in the case study on Uttarakhand.

Conclusion

Although communities possess autonomous mechanisms for responding to change, it is clear that there is a strong need for support from the government support services. It will be very important to strengthen delivery mechanisms, particularly with regard to access to information and technical services. Options for income diversification need to be explored as cash generation is critical at times of stress. Risk management also requires attention. Mixed cropping, seed exchange, and related traditional practices that spread risk need to be encouraged at the local level, complemented with formal risk insurance mechanisms.

References

Adger, WN; Huq, S, Brown, K; Conway, D; Hulme, M (2003) 'Adaptation to climate change in the developing world.' *Progress in Development Studies* 3(3): 179–195. www.uea.ac.uk/env/people/adgerwn/ProgDevStudies2003.pdf (accessed 29 November 2011)

Agrawal, A; Perrin, N (2009) 'Climate adaptation, local institutions, and rural livelihoods.' In Adger, WN; Lorenzoni, I; O'Brien, KL (eds), *Adapting to climate change: Thresholds, values, governance*, pp 350–367. Cambridge, UK: Cambridge University Press

Black, R; Natali, C; Skinner, J (2005) *Migration and inequality*, Equity and Development: World Development Report 2006, background papers. Brighton, UK: Development Research Centre on Migration, Globalisation, and Poverty, University of Sussex

Brooks, N; Adger, WN (2005) 'Assessing and enhancing adaptive capacity.' In Adger, WN; Lorenzoni, I; O'Brien, KL (eds), *Adaptation policy frameworks for climate change: Developing strategies, policies and measures*, pp 165–181. Cambridge, UK: Cambridge University Press

Brown, K (2010) *Climate change and development short course: Resilience and adaptive capacity* (Power Point presentation). Norwich, UK: International Development, University of East Anglia

C2ES (2008) *Summary: India's National Action Plan on Climate Change*. Arlington, VA, USA: Center for Climate and Energy Solutions. www.c2es.org/international/country-policies/india-climate-plan-summary/06-2008 (accessed 25 November 2011)

CBS (2002) *Population census results in a gender perspective: Population census 2001*, Volumes I and II. Kathmandu, Nepal: National Planning Commission Secretariat, Central Bureau of Statistics

DAO (2010) *Annual Agriculture Development Program 2065/66*. Terhathum, Nepal: District Agriculture Office

DFID (1999) *Sustainable livelihoods guidance sheets*. London, UK: Department for International Development. www.eldis.org/vfile/upload/1/document/0901/section1.pdf (accessed 22 March 2011)

Ensor, J (2009) *Adaptation to climate change: The role of adaptive capacity and resilience*. Lima, Peru: Teconolgiay Sociedad (Soluciones Practicas)

FAO (2010) *Nepal Humanitarian Transition Appeal 2010*. Rome, Italy: Food and Agriculture Organization of the United Nations. www.fao.org/emergencies/tce-appfund/en

GOI (2001) *Uttarakhand statistics*. New Delhi, India: Government of India. http://censusindia.gov.in/PopulationFinder/Population_Finder.aspx (accessed: 25 November 2011)

Hunzai, K; Gerlitz, JY; Hoermann, B (2011) *Understanding mountain poverty in the Hindu Kush-Himalayas: Regional report for Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan*. Kathmandu, Nepal: ICIMOD

ICIMOD (2009) *Local responses to too much and too little water in the greater Himalayan region*. Kathmandu, Nepal: ICIMOD

ISDR (2004) *Living with risk: A global review of disaster reduction initiatives*, Vol 1, p16. Geneva, Switzerland: United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UN/ISDR). www.unisdr.org/files/657_lwr1.pdf (accessed 28 November 2011)

IM (undated) *Nepal – rural population (1960–2009)*. Index Mundi, internet resource. www.indexmundi.com/facts/nepal/rural-population

IPCC (2007) *Climate change 2007: Impacts, adaptation and vulnerability*, Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report. Cambridge, UK: Cambridge University Press

ISDR (2004) *Living with risk: A global review of disaster reduction initiatives*, Vol 1, p16. Geneva, Switzerland: United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UN/ISDR). www.unisdr.org/files/657_lwr1.pdf (accessed 28 November 2011)

Macchi, M (2011) *Framework for community-based climate vulnerability and capacity assessment in mountain areas*. Kathmandu, Nepal: ICIMOD

Merz, J; Nakarmi, G; Shrestha, S; Shrestha, B; Shah, PB; Weingartner, R (2002) *Water and erosion studies of PARDYP Nepal: Water demand and supply survey*. Kathmandu, Nepal: ICIMOD

MoE (2010) *National adaptation programme of action (NAPA) to climate change*. Kathmandu, Nepal: Ministry of Environment. www.napanepal.gov.np/pdf_reports/NAPA_Report.pdf (accessed: 28 November 2011)

MoE (undated) *Nepal climate change and development portal*. Kathmandu, Nepal: Ministry of Environment. www.climatenepal.org.np/main/ (accessed: 28 November 2011)

Mukherjee, P (2003) *Community forest management in India: The van panchayats of Uttranchal*. Rome, Italy: FAO. www.fao.org/DOCREP/ARTICLE/WFC/XII/0108-C1.HTM (accessed 5 September 11)

NPC (2010) *The food security atlas of Nepal*. Kathmandu, Nepal: Food Security Monitoring Task Force, National Planning Commission, Government of Nepal (in collaboration with Nepal Development Research Institute and World Food Programme). http://documents.wfp.org/stellent/groups/public/documents/ena/wfp223377.pdf (accessed 28 November 2010)

RGOB (2004) *Rural-urban migration in Bhutan*. Thimphu, Bhutan: Royal Government of Bhutan, Ministry of Agriculture

RGOB (2007) *Poverty analysis report*. Thimphu, Bhutan: National Statistics Bureau, Royal Government of Bhutan.

Savada, AM (ed) (1991) *Bhutan: A country study – climate*. Washington DC, USA: GPO for the Library of Congress. http://countrystudies.us/bhutan/15.htm (accessed 29 November 2011)

Shahi, P (2011) 'Upper Mustang's rain spell has weather experts scratching their heads.' *The Kathmandu Post* 28 July 2011

Sharma, E; Chettri, N; Tse-ring, K; Shrestha, AB; Mool, PK; Eriksson, M (2009) *Climate change impacts and vulnerability in the Eastern Himalayas*. Kathmandu, Nepal: ICIMOD

UNDP (2011) *Adaptation to climate change. Adaptation definitions and levels*. New York, USA: UNDP. www.undp.org/climatechange/adapt/definitions.html#15 (accessed 24 January 2011)

UNFCCC (1994) *The United Nations Framework Convention on Climate Change*. Bonn, Germany: UNFCCC. http://unfccc.int/essential_background/convention/items/2627.php (accessed 24 January 2011)

UNFCCC (2011) *Glossary of climate change acronyms*. Bonn, Germany: UNFCCC. http://unfccc.int/essential_background/glossary/items/3666.php#M (accessed 24 January 2011)

WB; DFID (2006) *Unequal citizens: Gender, caste and ethnic exclusion in Nepal – Summary*. Kathmandu, Nepal: World Bank and Department for International Development

WB (2009) *Data – countries and economies*. Washington DC, USA: World Bank (online only). http://data.worldbank.org/country (accessed 10 January 2011)

WFP (2009) *Winter drought worsens food insecurity in Nepal*. Kathmandu, Nepal: World Food Programme. www.wfp.org/news/news-release/winter-drought-worsens-food-insecurity-nepal (accessed 9 May 2009)

WFP (2010) *WFP partners with Uttarakhand Government to combat climate change and strengthen food security*. Rome, Italy: World Food Programme. www.wfp.org/news/news-release/wfp-partners-uttarakhand-government-combat-climate-change-and-strengthen-food-security (accessed 25 November 2011)

Annexes

Annex 1: **Interview guidelines for focus group discussions and household interviews***

General information about village and respondent(s):

Interview/FGD ID: _____

Date of interview: _____day _____ month _____ year

Name of interviewer: _____

Country: _____

Name of district: _____

Name of village: _____

Climatic conditions: _____ mean annual rainfall

Altitude: _____ m above sea level

Coordinates: _____

No. of households: _____

Types of households: ☐ mostly poor ☐ some poor, some above average

☐ mostly above average

Access to electricity: ☐ mostly yes ☐ mostly no

Access to improved source of drinking water: ☐ mostly yes ☐ mostly no

Distance to paved road: _____ minutes walking time

For household interviews only

Name of respondent: _____

Age of respondent: _____

Sex of respondent: ☐ male ☐ female

Ethnicity of respondent: _____

Education: ☐ no formal education ☐ primary ☐ secondary ☐ higher

Head of respondent's household is: ☐ male ☐ female

Household status: ☐ very poor ☐ poor ☐ not poor ☐ above average

* Source: Macchi 2011

Guidelines for Interviews

Please note: The following interview guidelines can be used for interviews with individual resource persons, or to guide focus group discussions (FGDs) in combination with different PRA tools. Some sections (especially those on perception of changes and coping strategies) are probably better discussed in FGDs. The appropriate PRA tools to accompany the questions are indicated in each section. Women and men should be interviewed separately in individual interviews; in general focus groups should also be composed of all women or all men, but this can depend on the topic.

The timeframe for questions (10 to 20 years) depends on the age of the interviewees. Younger interviewees may only remember what happened 10 years ago or less, whereas older respondents may have a longer memory.

Activities profile

- Could you please describe your daily activities? What are your main activities from the morning when you get up until the evening when you go to bed?
- Which activities in the house and in farm production are performed by women? Which are performed by men? Which are performed by both women and men and to what extent?
  - Do these activities change over the course of the year? In what way?
  - How much time is needed to carry out each of these activities?
- When you think back, have there been any major changes between now and 10/20 years ago in terms of activities and workload?
  - Are there any different or new activities you are carrying out now (e.g., production of cash-yielding crops, off-farm activities)? Why? Who in the household takes responsibility for these activities?
  - Are there any activities you used to carry out that you are not carrying out any more? Why?
  - Does it take more or less time to complete your daily activities today? Why?
  - Do you find your activities easier or more difficult to perform now than it was for your mother/father? Why?
  - Are there activities that used to be performed by men and are now performed by women, or vice versa? What caused these changes?
- In which activities performed by the community are men involved? In which are women involved? In which activities are both men and women involved?

Resource, access and control profile

☞PRA tools: These questions can be linked to a transect walk.

- What kind of natural resources do you depend on for your daily activities?
  - Which natural resources do men mainly use? For what purpose?
  - Which natural resources do women mainly use? For what purpose?
  - Which decisions concerning the management of natural resources are taken by men, which by women, which by men and women together, and which by the community?
- Are there any resources that you used to use, but can no longer access (e.g., water, firewood, plants, animals)? Which ones? Why?
- Has the seasonal availability and abundance of any resources you are dependent on changed? Which ones? In what way? How does this influence your activities and your wellbeing?
- Are there any new resources that have appeared and that you have started to use (e.g., plants, animals, materials for energy production, and so forth)? Which ones? For what purposes?
  - Why did you start using these new resources?

- To which types of land do women mainly have access? To which types of land do men mainly have access (homestead, irrigated land, rainfed agricultural land, pasture land, rangeland, or other)?
  - What are the main activities women/men are carrying out on this land?
  - Who decides what to grow/how to use the different types of land?
- Which decisions within the household related to the management of small livestock/big livestock are taken by women, which by men, and which by men and women together?
- Which decisions within the household related to the management of crops are taken by women, which by men, and which by men and women together?
- Are there any traditional institutional arrangements within the community for the management of, or decision making about, common resources (e.g., pasture land, water bodies, forest products, and so on)?
  - What is the role of women and men in these institutional arrangements?
- Mobility: What are the daily, seasonal, or yearly migration patterns you follow in pursuing your daily and seasonal activities?
  - Have these migration patterns changed? If so, why?
  - Have members of your household migrated to larger cities or even abroad? Who has migrated and where? Why? When? Do they send money home?
- Do you have access to off-farm income and loans? How do you use the income and loans?
  - Which decisions within the household related to the use of income and loans are taken by women, which by men, and which by women and men together?

Perception of changes

☞PRA tools: The following questions can be combined with the seasonal calendar, the livelihood seasonal monitoring calendar, and the historical timeline. Do not mention the idea of 'climate change' as this might bias the answers.

- Please describe the **main weather events** that happen during the year (e.g., rainy season, dry season, snowfall, hailstorms, cloudbursts, and so forth).
  - When do these events usually occur? How long do they last?
  - Have you observed any changes in the past 10/20 years? What kind of changes (timing, duration, intensity, frequency)?
  - How do these changes influence your activities and workload?
  - What do you think are the reasons for these changes?
- Have you experienced any major **hazards** over the past 10/20 years (e.g., floods, droughts, landslides, avalanches)?
  - If yes, what kind? When did they occur?
  - How did they affect you and your family?
  - Have these hazards become more frequent or more intense over the past years?
- Have you noticed any changes in the size of **glaciers**? If yes in what way?
  (☞ only ask this question if there are glaciers in proximity to the study site)
- Have you noticed any difference in **temperature** over the past 10/20 years?
  - If yes, in which way did the temperature change?
  - What do you think is the reason for this change?

- In your perception, has the **availability of water** from rain, snowfall, and water in water bodies (lakes, streams, springs and so on) changed over the past 10/20 years?
  - How has it changed (e.g., less or more rainfall, snowfall, glaciers are melting, lower water levels in rivers, lakes)?
  - What do you think are the reasons for these changes?
  - Does this have any influence on your daily activities/your workload?
- Do you know of any **traditional ways of predicting the weather** (e.g., when the monsoon starts, when the first snow will fall, and so forth)?
  - If yes, please describe these methods.
  - Are these methods to predict the weather still reliable today? If not, why not, and what are the implications for your lives?
- Have you noticed that some **species** (plants, animals) are **appearing earlier or later in the season** or in places where they did not appear before?
- Have any **species** (plants, animals) **disappeared** or become less/more abundant? If yes, which ones?
- Have you observed any **new diseases** affecting your livestock and crops over the past 10/20 years? Which ones? When did they occur for the first time? Do they occur every year? Why do you think they occur?
- Have you observed any **new pests** affecting your livestock and crops? Which ones? When did you notice them for the first time? Do they occur every year? Why do you think they are occurring?
- Have you observed any new **health problems** that have affected you and your family? Which ones? Are there any health problems which have diminished or disappeard? Which ones and why do you think they have diminished or disappeard?
- Are there any **positive changes** you can think of that make things easier (e.g., prolonged cropping season, warmer winters with lower energy consumption, warmer streams for washing, hygiene, modern technologies, remittances, health posts? and so forth)?

☞The following questions should only be asked at the household level

- Do the changes you have mentioned impact on the availability of food for your household throughout the year?
  - If yes, in what way?

  ☐ less food ☐ more food ☐ no change ☐ uncertain
- Has your overall food production changed? If yes in what way and why?

  ☐ less harvest output ☐ more harvest output ☐ no change ☐ uncertain
- For how many months a year does your family have enough food?

  ☐ 0-3 months ☐ 3-6 months ☐ 6-9 months ☐ 9-12 months
- Has this changed over the last 10/20 years? If yes, how and why?
- How is the food diversity (multiple response possible)?

  ☐ Sufficient grains (rice, cereals, bread, pasta) and/or legumes ☐ Sufficient roots and/or tubers

  ☐ Sufficient meat and/or fish and /or dairy ☐ Sufficient vegetables and/or fruits and/or nuts
- Has there been any change in terms of food diversity?

  ☐ less diverse ☐ more diverse ☐ no change ☐ uncertain
- What are your main sources of income? (multiple response possible)

  ☐ mostly agriculture ☐ mostly industry ☐ mostly remittances ☐ mostly services

  ☐ combination of different sources

- Do the changes you have mentioned impact on your income opportunities (on-farm and off-farm)?
  If yes in what way?
  - Are there any income opportunities you no longer have?
  - Are there any new income opportunities that have arisen over the past 10/20 years?

- Has your overall income changed, and, if yes, in which way?
  ☐ less ☐ more ☐ no change ☐ uncertain
- What are the reasons for these changes?
- Is your income sufficient to cover your basic needs (food, clothing, schooling, healthcare)?
  Income is ☐ more than sufficient ☐ less than sufficient ☐ sufficient

Capacity analysis: Coping and adaptation mechanisms

☞The questions in this section need to relate to the answers given in the previous section on perception of changes. The interviewer should refer to the specific examples of changes mentioned by the respondents during the interview or FGD (e.g., less rainfall, more rainfall, floods, landslides, longer dry seasons, diseases, pests, food shortages, and so forth). The interviewer should only ask questions about the examples of changes that the respondents have actually experienced. For example, the interviewer should not ask questions about crop pests if the respondents have not experienced any changes in crop pests. Sample questions are listed below.

☞PRA tools: These questions can be asked when the seasonal calendar and the livelihood seasonal monitoring calendar are being merged together (see Figure 3 in section on Data Collection).

- What do you do when there is **too little rain/water** or there is an unusually long dry period?
  - What do you do with your crops (e.g., do you change varieties, timing of sowing/planting or harvesting, irrigate the land)?
  - What do you do with your animals?
  - What do you do in your household/in the community? Who is dealing with this problem (you, your husband/wife, other family members, or the community as a whole)?
  - Are these strategies still useful today? Or what, in your view, needs to be done? Who could help you?
- What do you do when there is **too much rain/water**?
  - Ask same sub-questions as above
- What do you do when the **weather** is extremely **hot** over a long period of time?
  - Ask same sub-questions as above.
- What do you do when it is extremely **cold** over a long period of time?
  - Ask same sub-questions as above.
- What do you do when there is a **flood**?
  - How do you protect your crops, your animals, your children, and your houses and personal belongings?
  - Are these measures still sufficient today? Or what, in your view, needs to be done?
  - How long does it take you to get back to normal life after a flood?
  - Who is responsible for which measures? Do you help each other out within the community? Do you get support from outside? What kind of support would you need?
- What exactly do you do when there is a **landslide**?
  - Ask same sub-questions as with flood.
- What do you do when there is a **hailstorm**?
  - Ask same sub-questions as with flood.

- What do you do if there is **a lot of snow**?
  - Ask same sub-questions as with flood.
- Have you **introduced** any **new crops** or **given up** planting some crops?
  - If yes, which ones and why?
- What do you do when your **crops are affected by pests/diseases**?
  - Do you have any remedies for this? Are these remedies still useful?
  - Who is dealing with this problem (you, your husband/wife, or the community as a whole)? Can you get any support from the community, from outside (e.g., extension services)? What kind of support would you need?
- What do you do when your **livestock are sick**?
  - Ask same questions as with pests.
- What do you do when **members of your family get sick**?
  - Do you have any traditional remedies?
  - Can you go and see a doctor/ health worker?
  - Who is taking care of those who are sick? Do you get assistance (also in monetary terms) from other members of the community or from outsiders?
- What do you do if there is a prolonged period of **food shortage**?
  - Do you have to go to a moneylender?
  - Do you engage in off-farm activities?
  - Do you sell any personal goods?
  - Do some of your household members migrate? If yes, where to and for how long?
  - Do you get assistance from other members of the community or from outside?
  - What kind of support would you need?
- What do you do if there is a **shortage of fuel** for cooking or heating?

Social safety nets

☞ PRA tools: The following questions can be linked to the Venn diagram on institutions

- When you try to resolve these problems, are there any specific community groups or arrangements from which you receive help (e.g., when your crops are affected by pests, when there is a water shortage, when you need assistance because of food shortage, or you need money for a veterinarian or to see a doctor)?
  - Could you please describe these groups/arrangements?
  - Who participates in these groups/arrangements?
  - Do you also help others if they have any problems? How?
- When you and your family/community are trying to resolve these problems can you get help from outside (e.g., from local government representatives, IOs, NGOs)?
  - If yes, from whom exactly? What is their role? What kind of help do you receive and for what problems?
  - Who within the community can get help from these organisations/sources? For whom is it particularly difficult to gain access to these organisations/sources?
- Do you know what other communities/villages are doing to resolve the problems you mentioned? Do they take the same measures as you/your community? If different than yours, have you tried some of their practices in your community? Which ones? Why or why not?

Needs assessment

- Of the changes, problems, and challenges you have mentioned, which ones are the most important ones that you are facing in your daily lives at present?
- Do these difficulties differ from the ones you were facing 10/20 years ago, or from the ones that your parents were facing? In what way? What do you think the reasons are for these changes?
- Which strategies and mechanisms (including technologies, information, infrastructure, livelihood options, and institutional mechanisms), in addition to the ones you have already mentioned, do you think would help you most to alleviate the current difficulties you are facing?
- Who could help you to overcome these challenges?
- What do you think about the interventions that have already happened in your village (if any)? Which ones worked and which ones did not? Why?
- What would help you most to improve your life?

Institutional constraints and opportunities analysis

☞ The following questions should be asked to representatives of civic, public, and private organisations active in the study area.

- What are the most important climatic and socioeconomic changes observed in the region?
- In your view, how do climate change related hazards affect the livelihoods of the people living here?
- What impacts do climate and socioeconomic change have on daily activities and living conditions?
- What do the communities do in response to these changes?
- What concrete role does your organisation play in supporting the local people in their efforts to adapt to, or cope with, climate and socioeconomic change?
- What kind of concrete support do you offer (extension services, knowledge transfer, technological support, income opportunities, loans, and so on)?
- Who is directly benefitting from your organisation's services? Who participates in your initiatives? How do they benefit from your initiatives? Do women and men benefit equally?
- Do you think that there are any differences between the needs of women and men, and different social groups, with regard to climate change adaptation? If yes, what do you think these different needs are?
- What is your opinion about the importance of informal traditional institutions (safety nets) within mountain communities in the adaptation process to climate change?
  - What role do informal traditional institutions within communities play in the adaptation process to climate change?
  - Are there any linkages between your organisation and traditional informal institutional arrangements within the communities? Please explain these linkages.
- Does your institution have any linkages to other institutions active in the area (civic, public, private)?
  - Could you please explain the way you are collaborating with these other institutions?
- In your opinion, what is the biggest challenge facing local communities at present?
  - Have these challenges changed from the ones that they faced in the past?
  - What should be done first to overcome these challenges?
- How could particularly women and other vulnerable groups be supported in their struggle to cope with, or adapt to, climate and socioeconomic change?
- How can your organisation support these communities?
- In what way would your organisation need external support to help local communities to overcome these challenges?

Thank you!

Annex 2: **Meteorological Data**

Nepal

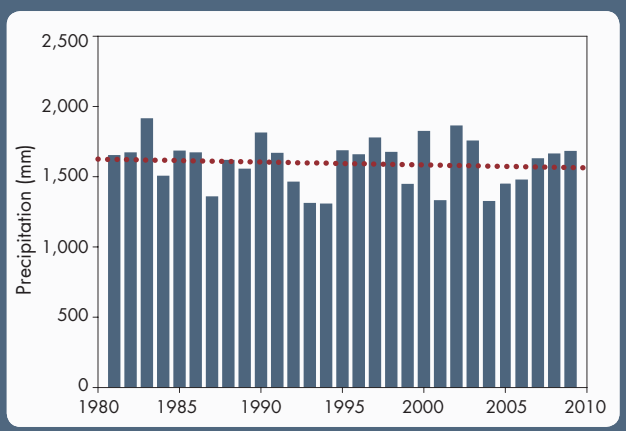
Data were obtained from three stations in Bajhang and Terhathum as shown in Table A1.

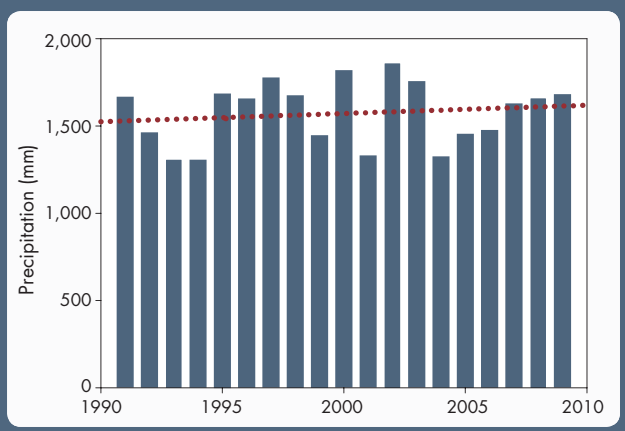
Overall the results at all three stations reflect the marked interannual variability and highly localised rainfall patterns rather than clearly showing any trends. Some gaps in the data also affected the interpretation of trends. However, some general observations can be made as follows.

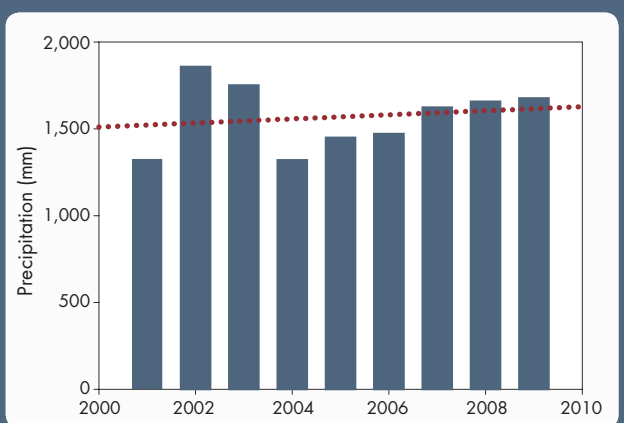
Table A1: **Hydro-meteorological stations in Bajhang and Terhathum**

Station	District	Position			Data availability	Average annual precipitation (mm)
		Lat. °N	Long. °E	Elevation (m)		
Pipalkot	Bajhang	29.62	80.87	1,456	1956–2008 (53 years)	2,189
Chainpur	Bajhang	29.55	81.22	1,304	1956–2009 (54 years)	1,519
Terhathum	Terhathum	27.13	87.55	1,633	1971–2009 (39 years)	1,009

Figure A1: **Total annual precipitation in Chainpur and regression analysis over 10, 20, and 30 years**







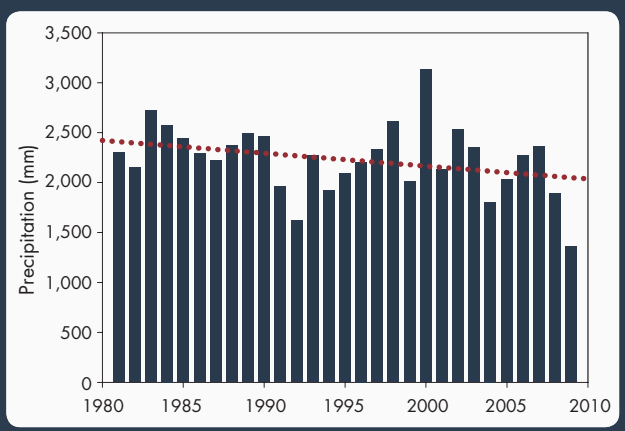
Source: Data from the Department of Hydrology and Meteorology, Ministry of Environment, Government of Nepal

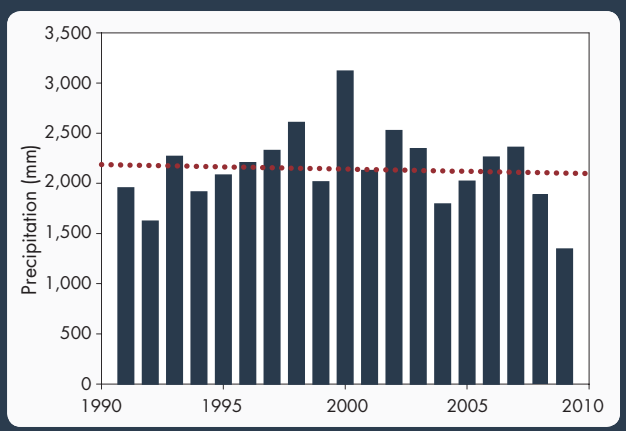
The data from the two stations in Bajhang (Pipalkot and Chainpur) showed considerable differences (Figures A2 to A4). In Chainpur, there appeared to be a slight increase in total annual precipitation over the period 1956–2009, but in Pipalkot there was little or no change. More differences were apparent over the shorter periods of 10, 20, and 30 years, the time frame discussed with respondents. There was no overall change in precipitation over 30 years in Chainpur, but a slight increase on average over 10 years and 20 years (Figure A1). The average increase reflects heavy rainfall in 1999/2000, 2001/02 and 2002/03, but also well below average rainfall in 2000/01 and 2003/04. In Pipalkot, the total annual precipitation decreased slightly over 10 years and 30 years, but was constant over 20 years (Figure A2). Again the average values were influenced by very high rainfall in 1999/2000 and well below average rainfall in 2003/04, and 2008/09.

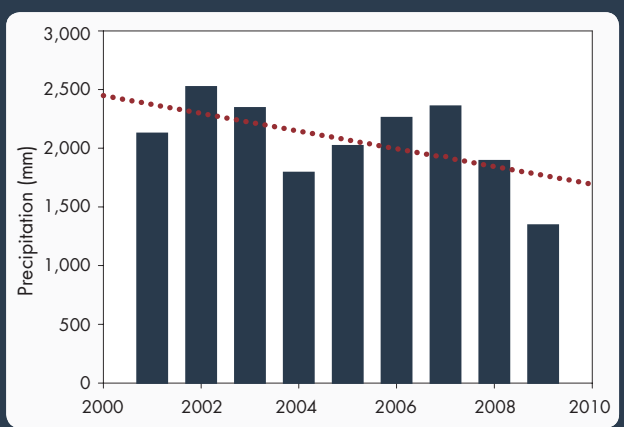
Summer (monsoon) rain (June, July, August, September) showed a slightly increasing trend in Chainpur and slightly decreasing trend in Pipalkot over 30 years (Figures A3 and A4). Winter precipitation was highly variable at both stations, but with some indication of a decreasing trend, and with almost no winter rain in Pipalkot in 2007/08 and 2008/09, the latter year having the lowest annual rainfall in Pipalkot in 30 years, which may explain in part the strong perception that rainfall was decreasing. There was some indication that in Bajhang the number of rainy days was decreasing, whereas the number of extreme rainfall days (>50 mm rainfall in 24 hours) was increasing slightly, which matches with local perceptions.

In Terhathum, there was a slight increase in annual rainfall between the years 1980 and 2009, but a decrease on average over 10 years and 20 years (Figure A5), in line with people's perceptions. However, data were missing for the (heavy rainfall) year 1999/2000. Precipitation in 2004/05, 2007/08 and 2008/09 was particularly low, although well above average in 2005/06 and 2006/07. Monsoon rains had shown an increasing trend over the whole period and over 30 years, but a slightly decreasing trend over the past 10 and 20 years (Figure A6); winter rain was highly variable with almost none falling in 2004/05, 2005/06, 2007/08, and 2008/09.

Figure A2: **Total annual precipitation in Pipalkot and regression analysis over 10, 20, and 30 years**

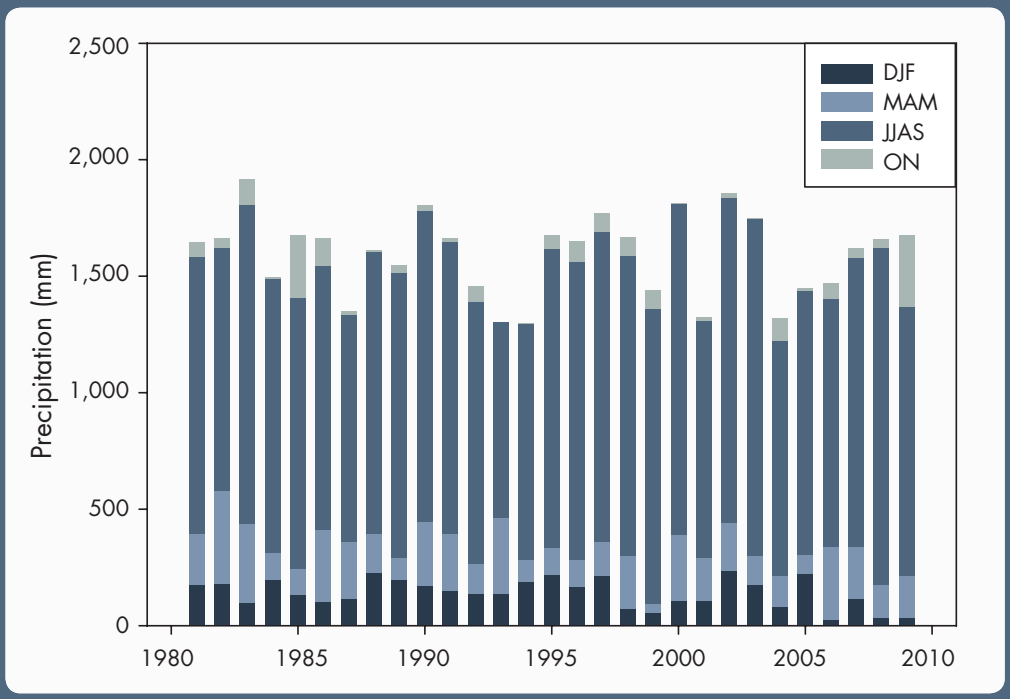






Source: Data from the Department of Hydrology and Meteorology, Ministry of Environment, Government of Nepal

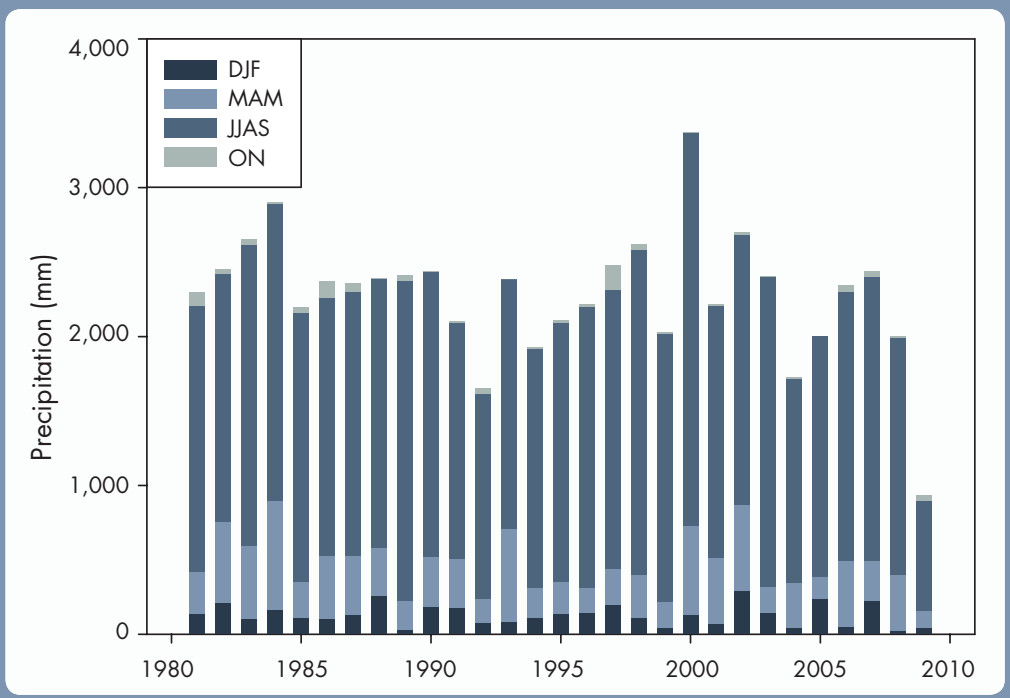
Figure A3: **Seasonal differentiation of total annual rainfall in Chainpur over the last 30 years**



DJF = January, February, March (winter or dry season); MAM = March, April, May (pre-monsoon);
JJAS = June, July, August, September (summer or monsoon season); ON = October, November (post-monsoon)

Source: Data from the Department of Hydrology and Meteorology, Ministry of Environment, Government of Nepal

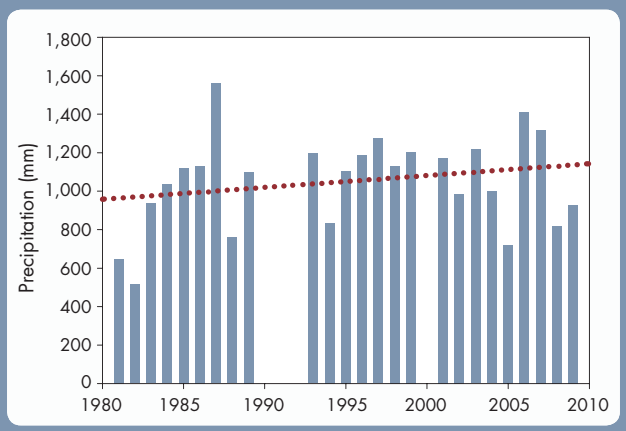
Figure A4: **Seasonal differentiation of total annual rainfall in Pipalkot over the last 30 years**

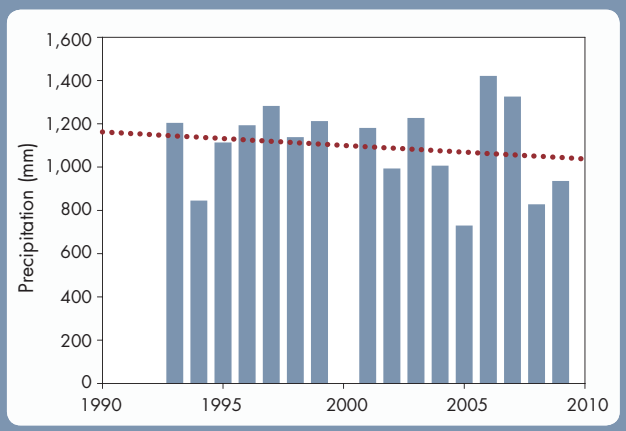


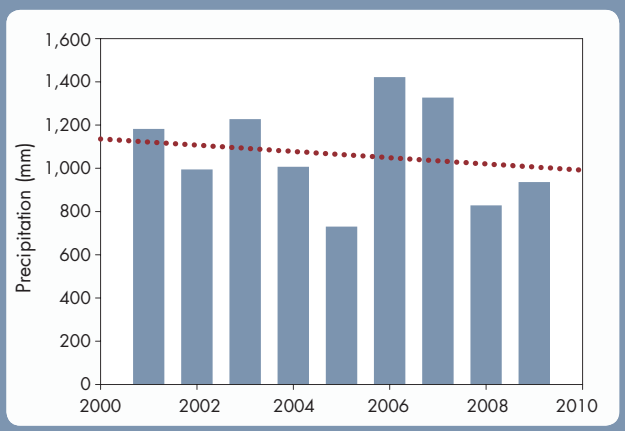
DJF = January, February, March (winter or dry season); MAM = March, April, May (pre-monsoon);
JJAS = June, July, August, September (summer or monsoon season); ON = October, November (post-monsoon)

Source: Data from the Department of Hydrology and Meteorology, Ministry of Environment, Government of Nepal

Figure A5: **Total annual precipitation in Terhathum and regression analysis over 10, 20, and 30 years**

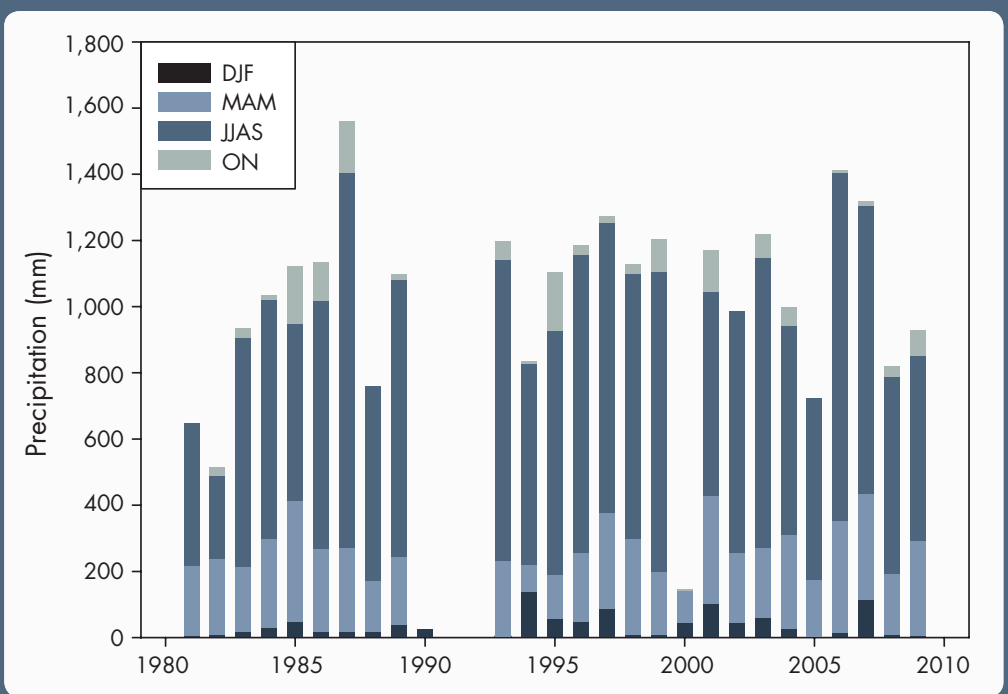






Source: Data from the Department of Hydrology and Meteorology, Ministry of Environment, Government of Nepal

Figure A6: **Seasonal differentiation of total annual rainfall in Terhathum over the last 30 years**



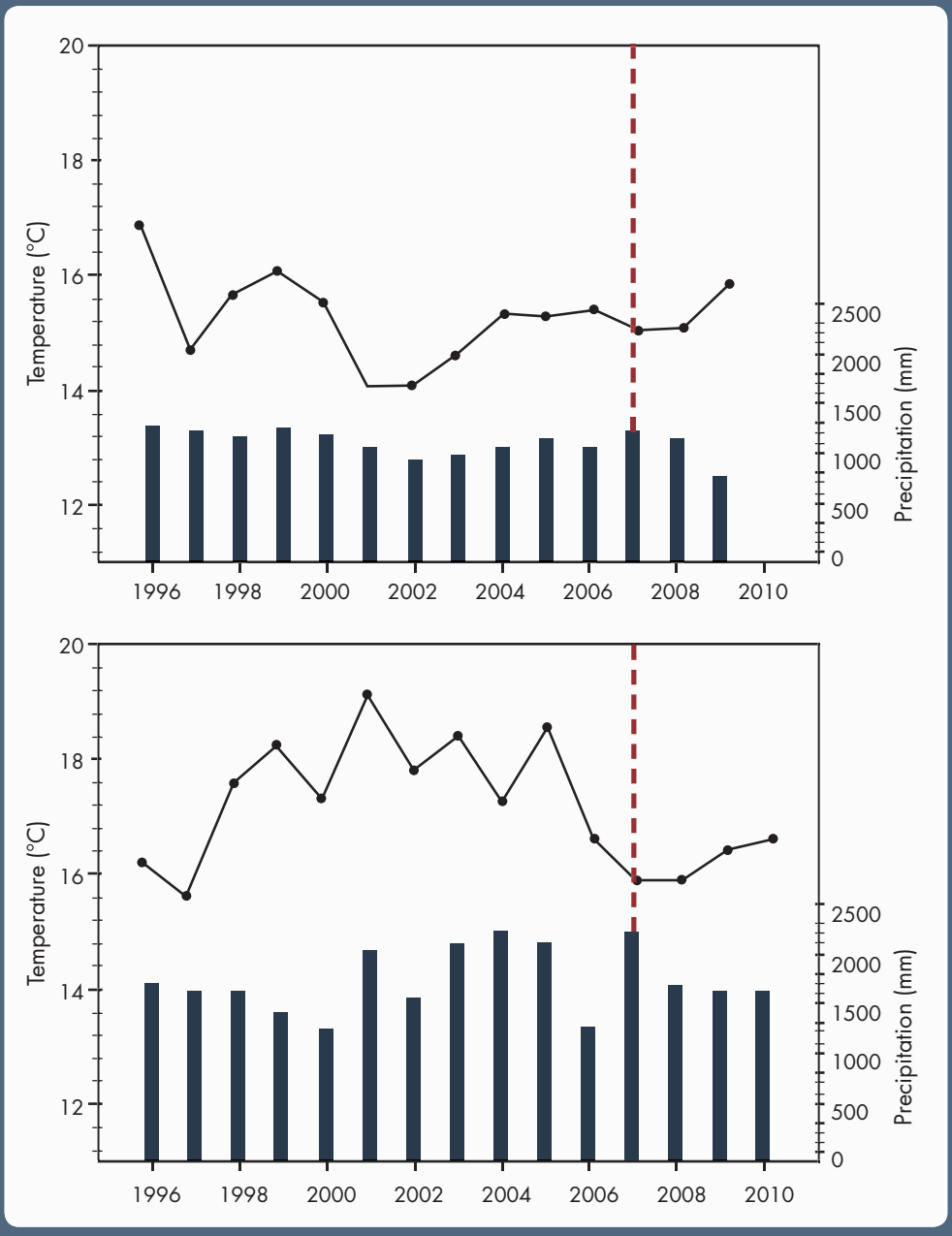
DJF = January, February, March (winter or dry season); MAM = March, April, May (pre-monsoon); JJAS = June, July, August, September (summer or monsoon season); ON = October, November (post-monsoon)

Source: Data from the Department of Hydrology and Meteorology, Ministry of Environment, Government of Nepal

Bhutan

Aggregated climate and precipitation records were obtained from two hydro-meteorological stations in Eastern Bhutan, one in Trashi Yangtse at 1,830 masl at (27.6 °N, 91.5 °E) and one in Pemagtshel at 1618 masl (27.03 °N, 91.42 °E) (Figure A7). There was a marked variability in values over the 15 years and no marked similarity in the fluctuations at the two stations. Both stations showed lower rainfall in the immediate years preceding the survey (from 2006/07, marked with a red line in the figure).

Figure A7: **Mean annual air temperature (black line) and total annual precipitation in Trashi Yangtse (above) and Pemagtshel (below)**



Source: Data from the Meteorology Section, Hydromet Services Division, Department of Energy, Ministry of Trade and Industry, Royal Government of Bhutan

About ICIMOD

The International Centre for Integrated Mountain Development, ICIMOD, is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush-Himalayas – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Globalisation and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues. We support regional transboundary programmes through partnership with regional partner institutions, facilitate the exchange of experience, and serve as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now, and for the future.

International Centre for Integrated Mountain Development
GPO Box 3226, Kathmandu, Nepal
Tel +977-1-5003222 **email** info@icimod.org www.icimod.org

ISBN 978 92 9115 226 1