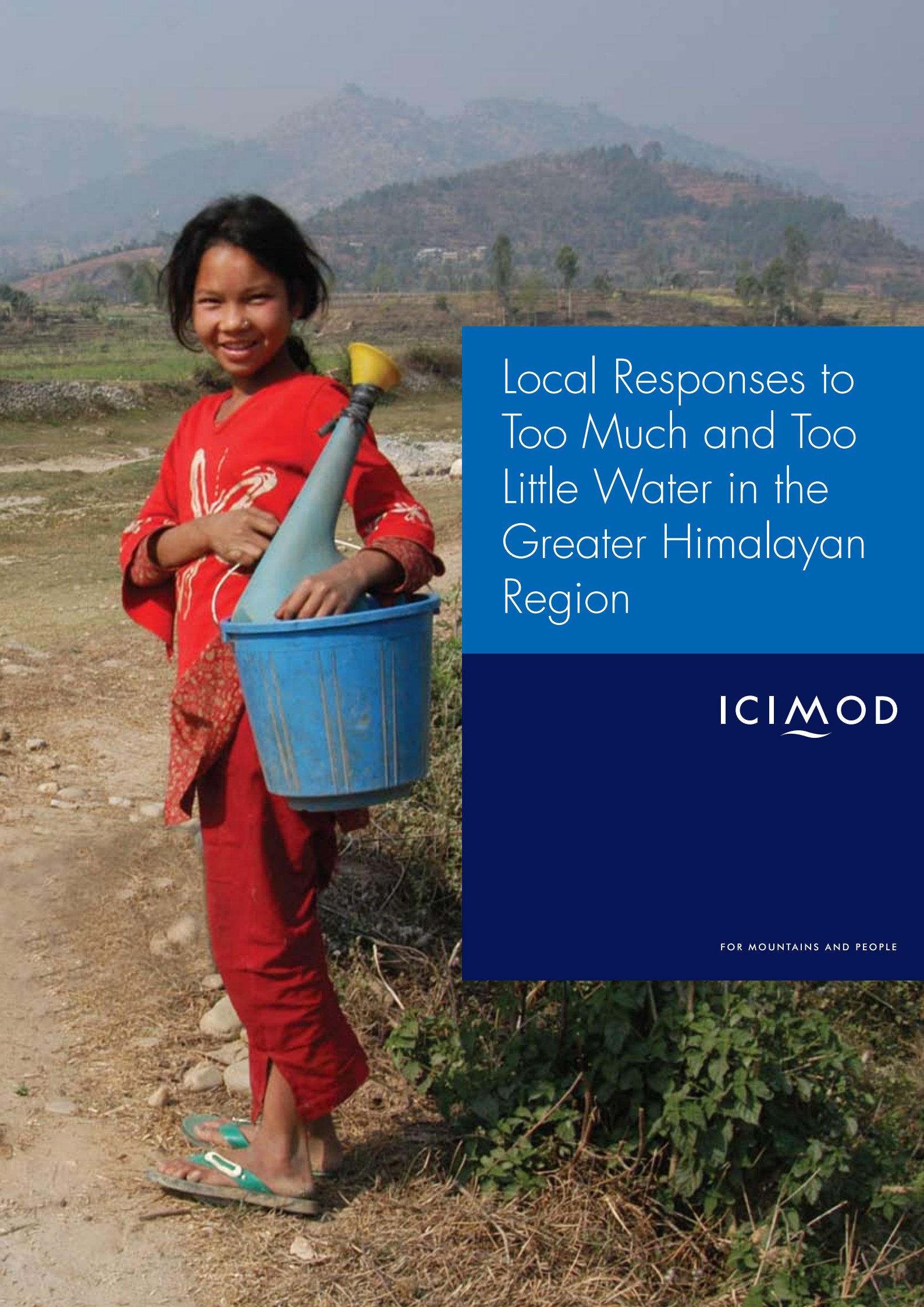

Local Responses to Too Much and Too Little Water in the Greater Himalayan Region

ICIMOD

FOR MOUNTAINS AND PEOPLE

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.

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International Centre for Integrated Mountain Development, Kathmandu, Nepal, 2009

Published by

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

ISBN 978 92 9115 129 5 (electronic)
978 92 9115 128 8 (printed)

Library of Congress Control Number 2009-341525

Photos: Front page, 2, 14, 23, 24, 26, 62 Mats Eriksson; 17, 18, 19 AKRSP; 28, 29 Deep Raj Rai; 32, 35, 37, 39, WII; 42, Dinesh Deokota; 45, 48, Partha Das; 47, 49, Julie Dekens; 50, Alex Treadway; 55, 56 (top), Yao Fu; 56 (bottom), 57, Qiaohong Li

Printed and bound in Nepal by

Hill Side Press (P.) Ltd.

Kathmandu

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This publication is also available at http://books.icimod.org.

Contents

Foreword

Over the last few years, ICIMOD's long-term work towards its vision – that the mountain population of the greater Himalayas enjoys improved well-being in a sustainable global environment – has increasingly incorporated activities with a bearing on the impact of climate change. As this impact affects people's livelihoods in the mountains and downstream, it becomes necessary to seek ways to support people's ability to adapt to the current and forthcoming changes – some related to changes in climate and some related to changes in society.

To this end, changes are not new to people of the greater Himalayan region. People have been living with challenges related to large seasonal differences in the climate, particularly water availability, for generations. Similarly, the region has seen many changes in society over time. The question is whether the resilience that people have developed over time is sufficient in the current world of rapid change. The pace of ongoing climate change is probably unprecedented, and globalisation makes the world smaller, as local markets, once isolated from the outside world, are suddenly linked to global market prices.

To be able to answer this question, we believe that there is a need for better first hand information. We need to document current local adaptation strategies to be able to assess whether these will be functional in a world of accelerated changes. The findings presented in this report indicate that people rely on a range of responses when exposed to floods and water stress, some responses are merely short-term coping and not sustainable in the long term. Other responses actually prove to be robust in a longer time perspective.

It is important that governments in the region and other key actors in climate change adaptation have access to improved knowledge regarding which responses to floods and droughts are successful. They can then support appropriate responses and develop them into sustainable strategies for adaptation to change.

ICIMOD's work towards improved knowledge of the impact of climate change and of communities' adaptation to these changes is best done through national partners in the region and recognised international knowledge centres. The current study is the result of such a consortium of national, regional, and global institutions, that has enabled us to reach a level of understanding considerably higher than if each had undertaken the study on their own.

We think that the findings in this report provide a sound beginning for a comprehensive, more full scale understanding of climate change impact and adaptation in the greater Himalayan region, which encompasses water availability, disasters, biodiversity, human health and wellbeing, and livelihoods at large.

Andreas Schild
Director General, ICIMOD

Acknowledgements

This report synthesises the main findings from five studies of local responses to climate-related water stress and floods. The case studies were carried out between June 2008 and September 2009 as part of the two projects 'Too much water, too little water – adaptation strategies to climate-induced water stress and hazards in the greater Himalayan region', funded by the Swedish International Development Cooperation Agency (Sida), and 'Himalayan climate change impact and adaptation assessment' (HICIA), funded by the Norwegian Ministry of Foreign Affairs. This financial support from Sweden and Norway, which enabled important field work leading to findings on climate change and adaptation based on evidence, is gratefully acknowledged.

The five case studies were carried out in: i) Yunnan province, China, by the Kunming Institute of Botany (KIB) in collaboration with the World Agroforestry Centre (ICRAF); ii) Assam state, India, by Aaranyak; iii) Bihar state, India, by Winrock International, India (WII); iv) the Koshi basin, Nepal, by the Institute for Social and Environmental Transition – Nepal (ISET-N); and v) Chitral District, Pakistan, by the Aga Khan Rural Support Programme (AKRSP).

Overall coordination of the study was provided by ICIMOD with support and guidance from a team from the Centre for International Climate and Environmental Research, Oslo (CICERO), UNEP-GRID Arendal, Stockholm Environment Institute (SEI), International Institute for Environment and Development (IIED), and Institute for Social and Environmental Transition (ISET).

The case studies are accompanied by studies of policies influencing local people's ability to adapt. This work is ongoing by ISET, ICRAF, and the National Institute for Disaster Management (NIDM), India, and only provisional findings have been incorporated in this report.

We are most thankful to the excellent editing, text processing, and layout work provided by Julian Gonsalves, Frances Klatzel, Dharma Ratna Maharajan, Joyce Mendez, A Beatrice Murray, Greta Rana, and Asha Kaji Thaku.

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- IIED: Simon Anderson, Tighe Geoghegan
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- AKRSP: Shahid Nadeem, Imran Elahi, Abdul Hadi, Ihsan Uddin,
- ICRAF: Jianchu Xu, Andreas Wilkes
- ISET: Fawad Khan
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Part 1

Synthesis

Local Responses to Too Much and Too Little Water – Synthesis

Introduction

The greater Himalayan region spans from the Pamir, Hindu Kush, and Karakoram ranges in the west, along the main Himalayan range in the centre, to the Hengduan Shan and other ranges in the east. The region is a vast area with many different climatic and geographical environments.

The region has always had either too much or too little water. Water availability has always been markedly seasonal, varying greatly over short distances whether located in the south Asian monsoon regime areas in the central and eastern Himalayas or in the climate regimes dominated by winter precipitation from the north-westerlies in the Pamir, Hindu Kush, and Karakoram.

For example, about 80% of the precipitation in Nepal falls within four months of the year; and much of this falls during a few extremely intense rainfall events. The result is too much water during a very short time period, making it very difficult for both humans and plants to benefit from it. Most of it flows quickly through the watersheds and basins of the high mountains and middle hills, causing floods and havoc without much replenishment of groundwater and other natural reservoirs. During the rest of the year, the population struggles to support household needs, agriculture, and industrial demands with too little water.

Since these natural climatic regimes and environments date back to geological time scales, people living in this region have, of necessity, adapted their livelihoods and agricultural and cultural practices to these situations. The seasonal changes in climate and subsequent water availability determine the calendar for sowing and harvesting; other livelihood activities, such as herding, brick making, trade, or house construction; and the cultural calendar for religious and other festivities.

The region and the world at large, however, are currently experiencing a range of changes. Growing populations are putting ever-increasing constraints on available resources, including water. As livelihood options dwindle, seasonal and permanent migrations are increasing in order to seek new and more prosperous opportunities. The price of food and other commodities at local levels is affected by improved infrastructure, and globalisation and regionalisation of markets. Political turmoil influences all of the above.

The current, and much debated, changes and variability in climate overlay this wide range of drivers. These subsequent changes are exacerbating the already constrained access to water in a sustainable and equitable way. Climate change will have an impact on the hydrological cycle in its entirety, starting with a reduction in snow cover and glaciers and, gradually, availability of water downstream (Eriksson et al. 2009).

The predicted – and to some extent extant – changes in rainfall patterns might be even more important as the frequency and magnitude of high intensity rainfall events increase and dry geographical areas and dry periods become even drier. Monsoon patterns might shift, thereby increasing the uncertainty about when rains will commence and diminish. Climate change will bring increased uncertainty to water availability in time and space. The changes are hardly new, but challenges arise from the rate at which they are occurring, in combination with pressure on land, water, and other resources from a constantly growing population, particularly in the greater Himalayan region. These challenges are pressing the same population to respond and adapt to the changes at a more rapid pace and in more innovative ways than before.

This report presents people's efforts to respond, cope, and adapt to the current rapid changes, focusing in particular on the impact of climate-induced changes on water availability, which overlays other drivers of change.

Over the last couple of years, the global climate change debate has made a noteworthy shift from

focussing on mitigation of greenhouse gas emissions to increasing awareness of the importance of adaptation to unfavourable impacts from changes in climate and its variability (Schipper and Burton 2009). Simultaneously, numerous studies contributed to building awareness that the least developed countries will suffer the most negative impacts from climate change. These countries have contributed the least to global warming and at the same time are most vulnerable because they have not yet benefited from industrialised development.

In the context of impact from ongoing and future climate change, it is increasingly important to understand the broad spectrum of adaptation. Historically, most work on climate adaptation has taken a global, large-scale, or sector-based perspective. There is a gap in research on local adaptation processes, and the factors enabling or constraining them (ISET 2008) and a need for studies based on evidence of local adaptation practices.

The present study was designed to contribute to filling this research gap. The aim was to document and assess the strategies that mountain people use to cope with and adapt to variations in available water resources induced by climate change. The results were based on the findings from five case studies undertaken in four countries in the greater Himalayan region (China, India, Nepal, and Pakistan). The case studies identified and documented local responses to flood hazards and water stress as part of the projects 'Too much water, too little water – adaptation strategies to climate-induced water stress and hazards in the greater Himalayan region' and 'Himalayan climate change impact and adaptation assessment'.

Water served as an entry point to assess local adaptation strategies to (climate) change. These are often responses to a combination of stresses or changes – environmental, physical, economic, social, technological, institutional, and political – and rarely made in response to climate stresses alone. However, the economic and social effects or implications of climate stress are often fundamental in triggering adaptive responses. Therefore addressing the impacts of water stress and hazard alone is not enough. Wherever relevant, non-climatic stresses have been considered in order to understand the responses to stresses and hazards related to water.

This report presents the main findings from the case studies in Part 2 in five separate chapters. The full reports of the field teams are provided on a CD in the back of the book.

Approach and Methodology

Field documentation and assessments were carried out over a period of one year in five case study areas in China, India, Nepal, and Pakistan on how people respond to water stress and hazards in the context of climate variability and change. The five case study sites span the Hindu Kush-Himalayas from west to east, covering a variety of geographical and climatic situations. Two studies in the Koshi basin provided an upstream-downstream context in Nepal and India.

ICIMOD held national consultation meetings and then selected the following partners for the field studies based on criteria such as their previous experience in adaptation research, long-term experience working with communities, and potential as long-term strategic partners:

- the **Aga Khan Rural Support Programme** (AKRSP) worked in Chitral district in the North West Frontier Province in Pakistan;
- the **Institute for Social and Environment Transition in Nepal** (ISET-Nepal) worked in the middle hills of the Koshi basin in Nepal;
- **Winrock International** worked in the Koshi basin and flood plains of Bihar in India;
- the non-government organisation **Aaranyak** worked in the floodplains of the Brahmaputra in the state of Assam in northeast India; and
- **Kunming Institute of Botany** (KIB) collaborated with the **International Agroforestry Centre** (ICRAF) to work in the Salween and Mekong river basins in Yunnan province, China.

The field teams were supported by a resource group which included members from ICIMOD, Stockholm Environment Institute (SEI, Bangkok), IIED (International Institute for Environment and Development, UK), United Nations Environment Programme (UNEP), and the Institute for Social and Environmental Transition (ISET). Two regional workshops were organised for the field teams to discuss and agree on a common research design and to review their progress and outputs. Resource persons provided strategic assistance via critical reviews of draft case studies.

The field teams were asked to focus the discussion on the impacts of past and current water stresses and hazards (versus 'impacts of climate change' per se) when in the field. They investigated the following questions at selected sites.

- How are people affected by water stress and hazards?
- What are the local short- and long-term responses?
- To what extent can these strategies reduce vulnerability to water stress and hazards in the context of climate change?

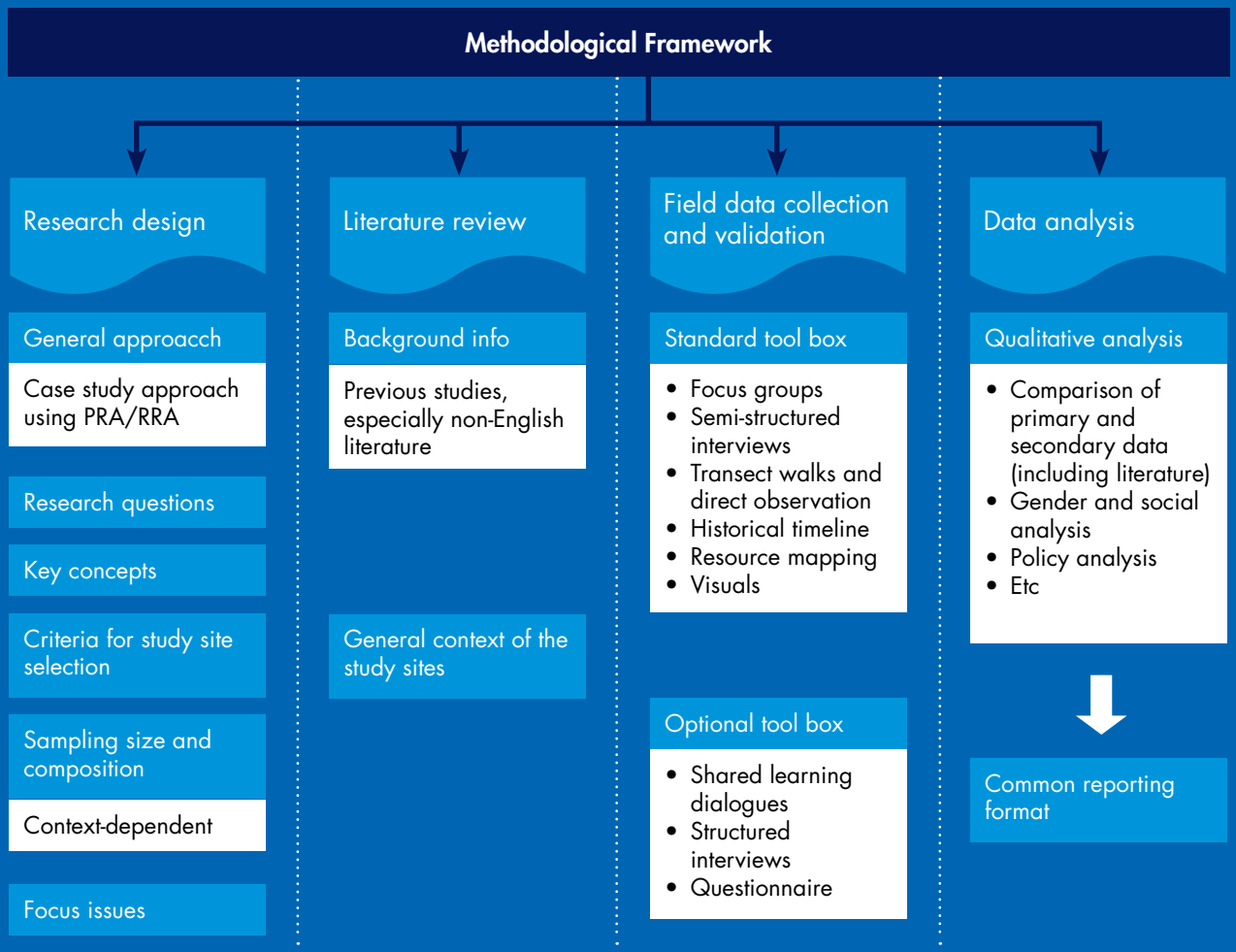
The field-work teams used the same general, common approach for data collection (Figure 1) which included the following key components:

- A literature review on the topic of community adaptation to environmental stress so that teams could build on knowledge already gathered
- Selection of study sites based on selected criteria and covering different types of water stresses and hazards
- Field data collection using participatory and rapid rural appraisal. All teams used semi-structured interviews and focus groups, transect walks, direct observation, historical timelines, resource mapping, and visuals (photos and videos). Other tools for data collection were used depending on the context and needs.
- A common reporting format focusing on impacts, responses, and factors influencing adaptation strategies served as a guideline for data collection.

The nature of the assessment was mainly qualitative (i.e., people's perceptions and narratives). The qualitative information was complemented by quantitative data whenever possible. People and key stakeholders provided information about the effectiveness and success of the adaptation strategies through focus group discussions.

The assessment also focused on identifying the political, cultural, and socioeconomic factors that hinder or promote the adoption of sustainable and equitable adaptation strategies at the selected sites. Thus, the field teams also considered several salient issues in relation

Figure 1: **Methodological framework**



to adaptation to water stresses and hazards in order to compare the case studies, including the role of poverty, indigenous knowledge, risk trade-offs, and social networks.

The teams worked with policy consultants who conducted a parallel inventory of existing policies and their impact (or lack of impact) on adaptation strategies in the selected cases. A guideline developed in consultation with the policy study consultants provided a common framework and methodology for all the studies.

The four objectives of the policy studies were to:

- Identify policies relevant to adaptation to water stresses and hazards in the selected sites and for those selected policies;
- Explore the objectives of policy making relevant to adaptation;
- Analyse the factors and processes that affect policy implementation; and
- Assess the extent to which policy implementation affects the ability of different groups of people to adapt effectively to water-related stress and hazards in the context of climate change.

The key preliminary findings on the linkages between planned adaptation (state) and autonomous adaptation (people) are included in this synthesis report.

A 'writeshop' was organised in 2009 for the country teams, policy teams, and resource group to jointly develop a draft synthesis report which provided the base for the current document.

Conceptual Framework

From coping to adapting: Responding to 'too much' and 'too little' water

In order to suggest possibilities for adapting to changes in water availability and hazards, it is important first to understand how people avoid the negative impacts of 'too much' or 'too little' water in present practice. Therefore, the conceptual thinking of this study considered the relationship between development processes, ways to cope with daily risk, and adaptations to climate change. This section describes this conceptual framework and clarifies the main assumptions of the study.

The study drew on several different conceptual frameworks that have been developed to make rural livelihoods more resilient to change. At its heart, the study assumes that people's livelihood strategies already include intentions and actions to ward off risk wherever possible. These actions, however, are often insufficient to manage the additional difficulties posed by extreme events, major changes, and variability in climate.

People in mountain environments and downstream areas are commonly confronted with too much water (riverine floods, flash floods, waterlogging) or too little water (droughts and water stress). They deal with these hazards through approaches ranging from accepting losses to diversifying their livelihood activities. In other words, for generations people have taken action as part of livelihood strategies to survive in environmentally marginal areas.

People also have a range of coping mechanisms to limit the negative impacts of extremes on their lives and assets, which may have long-term implications for their well-being. The purpose of these mechanisms is to maximise well-being; and this includes dealing with a range of factors besides the risks posed by water stress and hazards.

It is important to remember that not all responses to change, stress, and extremes are a process of adaptation (see Box 1). Some responses are maladaptive as they inadvertently increase sensitivity or exposure to water shortages or floods. Coping mechanisms such as using expensive pumping systems to irrigate agricultural fields or selling off livestock when water is scarce usually provide only short-term relief.

Coping strategies may also hinder options for alternative income sources in times of need, sometimes by damaging vital lifelines found in social networks. When people use these coping mechanisms to respond to new situations, there is no certainty that they will work at all. Indeed, the mechanisms may no longer be sufficient to respond to the changes taking place, and new thinking is required to reduce vulnerability to the new change.

The key to shifting from short-term coping towards adapting lies in reducing people's vulnerability and requires addressing the underlying root causes that make people sensitive and exposed to water-related stress and hazards. Typically, these hazards are not related to the climate alone (Figure 2).

People are affected differently by change due to differential access to and ability to benefit from assets such as natural resources, information, or education. The

Box 1: **Definitions in the field of adaptation**

Responding: Any action in response to stress. Responses do not have to be adaptive or sustainable. They do not have to be part of a strategy but can be spontaneous. Although responding can be a synonym for adaptation, it does not imply that sensitivity or exposure (vulnerability) is reduced.

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

Adaptation: A process of adjusting to changes in variables that influence human well-being and survival. Adaptation takes place with different actors at different levels of consciousness, purpose, and timing. Adaptation goes hand-in-hand with development processes and also needs to reflect other changes, not just climate-induced changes. In general, to be successful, adaptation should be sustainable in the long-term.

Maladaptation: Responses to change can result in 'maladaptation' when the strategy fails to reduce risk and increases vulnerability in the long term.

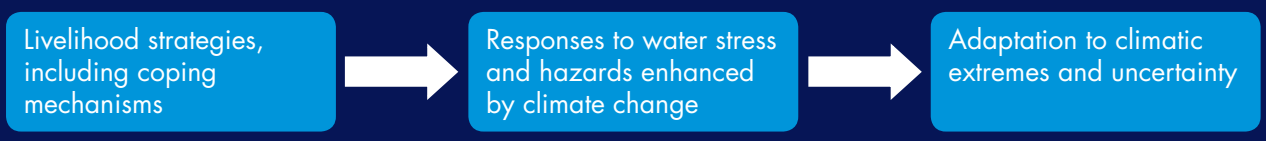
Resilience: The extent to which a system is able to absorb the adverse effects of a hazard, or the recovery time for returning after a disturbance. Highly resilient systems can endure or bounce back quickly, despite high stress.

Vulnerability: How likely an individual or a system is to be harmed by a defined hazard. Vulnerability is a combination of sensitivity, exposure, and capacity to respond to a specific stress. It is relative to the stress and is not the same for everyone.

Impact: The way a human or natural system is affected by environmental change, including extreme events.

Risk: In the context of environmental change, risk refers to the threat posed by a change, i.e. the probability of an adverse impact. Climate change risk is a function of the magnitude of an individual hazard and/or change and the degree of vulnerability of a system to that hazard and /or change. Unless a system is vulnerable to the hazard, there is no risk.

Figure 2: **The shift from coping to adapting**



Livelihoods already have strategies to reduce risk posed by climate variability and coping mechanisms to deal with water-related hazards (floods, drought). This mode of response may not be sufficient when climate change enhances stresses and extremes. The shift to sustainable livelihoods therefore requires improved actions but must be couched in an appropriate policy context that goes beyond the local level.

factors that influence people's access include gender, caste, ethnicity, entitlements, social networks, wealth, and policy contexts. Although people are not passive victims without the impetus to improve their lives, moving from coping to adapting requires the right enabling conditions to allow responses to take root and develop sustainably.

Factors beyond the local level influence people's vulnerability because some actions taken at community or household level to adjust to new situations may not work in existing policy and market contexts. For example, climate factors such as precipitation and temperature determine crop choice, but the market also influences cash crops. The ability to transport crops to the market may be essential to access cash incomes, but may depend on the existence of a road.

Key Findings and Lessons Learned

This discussion draws on the findings from all five case studies. The studies looked at situations where people are responding to too much water (floods, waterlogging) or too little water (drought, water stress) in regions spread across the greater Himalayas: in the dry mountain valleys of Chitral in Pakistan, the middle hills in Nepal and flood plains of Bihar, India in the Koshi basin, the flood plains of Brahmaputra in Assam in India, and the hill areas of Yunnan, China. The main findings from each study site are summarised in separate chapters in the next section.

Many of the areas are chronically water scarce and in others people have lived with recurrent floods and droughts for centuries. However, the nature of the risks is changing, as the dynamics of the hazards are changing along with changes in people's vulnerability to them. With this, people's perspectives on the hazards and their attitudes towards their livelihoods are shifting.

Gentle, expected floods can bring beneficial deposits of fine nutrient-rich silt that increases soil productivity. However, as climate change and variability bring extreme events more frequently, floods increasingly become more intense, frequent and destructive, often depositing large quantities of coarse sediments on inundated areas, which render the land unusable.

The overall impact of floods on the landscape, lives, and livelihoods has brought about significant changes in the socioeconomic conditions and cultural milieu of villages and society. Water stress is also likely to be more severe in the future. With increased demand for water, more competition, and more variability in water availability, people are struggling to manage with former arrangements, even if they have always lived with water scarcity.

Nevertheless, people in these communities have developed their own ways of responding to drought or flood situations, although the strategies may not always have been optimal. Historically, people have always adjusted to changes, whether these are climatic, political, economic, or social. The responses that we documented are mostly focused on reducing exposure and sensitivity to variability in water availability through effective and efficient utilisation of resources. In general, the responses have been oriented more towards short-term actions than towards long-term planning.

The different responses and the experiences with them in this time of change were looked at in terms of common factors and common messages for those who are supporting the development of new adaptation approaches to meet the challenges of climate change.

Message 1 – Livelihood diversification emerges as a central adaptation strategy but support through institutions and policy is needed for long-term sustainability

People in mountain environments who are confronted with too much or too little water already have approaches for dealing with climatic uncertainty, variability, and extremes, ranging from accepting losses to diversifying their livelihoods through both on- and off-farm activities.

People with diverse income sources appear more resilient to water variability than those with fewer income sources. With significant changes in climate, government, or society, these strategies may no longer be sufficient on their own. When strategies no longer work due to the magnitude of change taking place, new thinking is required to reduce vulnerability to this change. Livelihood diversification emerges as a central strategy that can help people overcome periods of insecurity resulting from climate-related water stress, but the availability of many of these activities is conditional on enabling policies and institutions. People are never entirely isolated from larger institutions, policies and market trends, which influence everything from crop choice to entitlements. A good understanding of this broader policy and institutional context will be crucial in order to identify and support adaptation practices with a potential to be sustainable over time.

Message 2 – Social networks and local institutions play a vital role in enhancing adaptive capacity

Social networks and institutions contribute significantly when facing challenges related to uncertainty and scarcity in water resources. Social networks facilitate collective water management, equitable distribution of irrigation water, livestock management, communal grazing, and securing external assistance to supplement traditional adaptation strategies. Traditional institutions like the gram in Chitral district, Pakistan, and the designation of women as water guards in Yunnan Province, China, help to manage water conflicts.

Networks play a vital role in making migration an option, for example by ensuring that migrants go to the same location and support each other once there, for example for migrants in Chitral. In communities where cultural ties are strong, kinship and willingness to cooperate and help their fellow villagers has helped deal with some tenure issues, landlessness, and homelessness created by the continuous loss and gain of land.

Access to new land for settlement and farming in a dynamic riparian environment is assured when land rights are recognised by community and social institutions. However, in the light of increasing population pressures villagers could be facing a changed situation. When different cultural/ethnic groups are found in the same location and must suddenly deal with sharing dwindling or eroding resources, tension or conflicts can arise because relationships have not been established to deal with these issues. Strong networks within different groups can similarly create conflict if they prevent outsiders from aligning themselves with the customs and norms.

Message 3 – Cultural norms affect people's adaptive behaviour; despite being deeply rooted, they can shift over time in response to the needs

Responses to water stress and hazards are often influenced heavily by cultural norms and traditions. Consequently, different groups in the same community respond differently. This includes behaviour and attitudes related to cultural taboos and superstitions that are associated with ethnic identity, as well as gender differences.

In the state of Assam in India, for example, non-Mishing people are unwilling to use the flood-tolerant housing design used by the Mishing communities, even though the construction has proven to help avoid flood impacts, simply because they do not want to be associated with the lower-caste Mishings.

At the same time, many people acknowledge the need to make exceptions. A shift in attitude may be the result of fewer options, as well as generational differences. In order to deal with climate-related changes and stress, people in Assam have had to take on new occupations and livelihood options previously considered socially unacceptable, such as trading, selling fish, and liquor production.

Message 4 – With good governance and planning that takes into account climate risk, infrastructure development can contribute to enhancing water security and flood management

Reducing the risk posed by floods and droughts is often associated with infrastructure construction. In the case studies, infrastructure development has been mainly for irrigation and flood control.

Water-related infrastructure such as dams, pumping stations, water tanks and drainage systems (serving irrigation and flood control needs), mostly managed on a communal basis, have strengthened coping capacities of local communities. The irrigation infrastructure built in past decades in Yunnan has provided the basis for current local water security.

In Assam and Bihar, poor governance of embankments has led to the acknowledgement that embankments are not a panacea for flood protection as they have both contributed to waterlogging and been a causal factor for catastrophic floods resulting from sudden breaching.

In Nepal, people have responded to water stress by digging trenches in riverbeds to access groundwater. These trenches allow for access to limited amounts of water for irrigation, but may give rise to conflicts between those who have resources to hire machinery, labour, and pumps to transfer the groundwater to the fields, and those who do not. As a result, trenches and wells must be guarded from theft. Most of the larger infrastructures in the study areas lack a governance system allowing for the participation of local, affected, or benefiting populations. Facilitating the inclusion of the local level would contribute towards good governance, and a more sustainable maintenance of the structures.

Message 5 – Factors enabling adaptation may also be constraining factors

Enabling factors for adaptation include policies, institutions, relationships, networks, or infrastructures that play a role in reducing the risk posed by water stress and hazards. These are always specific to the local situation and condition. However, what serves as an enabling factor one day can be a constraining factor the next. Further, enabling factors can come at a high cost, and may benefit one person but not another. Enabling factors might simultaneously be constraining, forcing people to make choices leading to tradeoffs that can have consequences for their overall well-being.

While infrastructure development such as embankments have provided protection most of the time in Assam and Bihar, people have also been falsely lured to feeling safe settling near them. This false sense of security has increased vulnerability to floods, because traditional strategies to reduce flood risk have not been implemented. In both Assam and Bihar, infrastructure has also adversely affected people's traditional mobility and natural river flows, further increasing their vulnerability to floods. In Nepal, the development of roads to provide vital access to markets has damaged numerous natural springs, leading to greater water scarcity.

Message 6 – Adaptation requires striking a balance between short-term priorities and long-term gains

The purpose of diversified livelihoods is to maximise well-being, and this includes dealing with a range of factors apart from the risk posed by water stress and hazards. Some of the approaches adopted to support well-being now may compete with approaches aimed at resilience later. Immediate concerns for financial gain, for example, may outweigh long-term financial stability, resulting in actions that pay off now but at a high cost to later benefits.

Adaptation is a process of moving towards resilience, and requires long-term thinking. Poor people in marginal environments plan in a different time frame. To them, there is no practical reason to question whether responses to water stress and hazards will be sustainable in fifteen years time if they do not ensure survival today or tomorrow.

Some choices made to meet immediate short-term goals may have adverse consequences in the long term, such as selling off land and livestock during periods of crop failure due to floods or droughts in order to be able to pay off short-term debts.

Message 7 – National institutions and policies strongly affect people's ability to adapt at the local level, but the national level is rarely informed by adaptation concerns and priorities

Policy landscapes dealing with water resources, disaster risk reduction, agriculture, and other issues related to local adaptation tend to be filled with overlaps and contradictions. In the countries studied, they also largely fail to take climate change and the adaptation needs of local people into account, or even to prioritise the well-being of poor rural people.

For example, investment in irrigation in Yunnan in China has provided the physical basis for strengthening communities' coping capacity. When drought occurs, irrigation system management is adjusted to reflect water supply limits and to minimise losses in agriculture. However, the agenda is driven by the government's economic interests in the cash crops rather than ensuring that people are able to cope with dry periods or inadequate rainfall. This is demonstrated by the fact that upland communities continue to face water constraints because they have not been the focus of infrastructure investments.

The weak links between local adaptation and enabling policy appear to stem from both the generally low priority given to climate change adaptation by most governments (even in China, which is putting considerable resources into greenhouse gas mitigation policies), and poor feedback loops for bringing local priorities to the attention of policy-makers. Where local level officials can sometimes mediate policy measures, as in the case of Yunnan, national policies and institutions can be more supportive.

Conclusions

Local adaptation is an area of growing interest, nationally as well as in the international environment and development policy communities, in part because it is on the local level that the benefits of adaptation will be the most obvious. Furthermore, adaptation at the local level has clear links with development, as many of the actions that are considered necessary for households and individuals to adapt to climate change are also high on the sustainable development agenda.

The case studies presented in this report document many creative responses to water stress and hazards, but show that these need to be aligned with other processes if they are to be successful, even over a short period. The

effectiveness of these responses is often influenced by the development context in which people live. National policies and institutions may have an important impact on local level livelihood choices, depending on how these get translated down to the local level. At the same time, if local needs and concerns are communicated upwards in the policy hierarchy, they can inform higher levels of agenda setting, which can in turn ensure that local priorities are reflected in broader decision-making. If local concerns are ignored, or if no channel is available to enable dissemination to different levels, the higher levels can be inconsistent with local needs, and at times be major drivers of vulnerability to climate variability.

National policies often do not take into account or build on existing capacity to respond. Thus, even if responses are taken at a local level, they may not be able to influence the real cause of vulnerability, consequently leaving people in a vicious cycle of coping without moving them onto the pathway towards resilience.

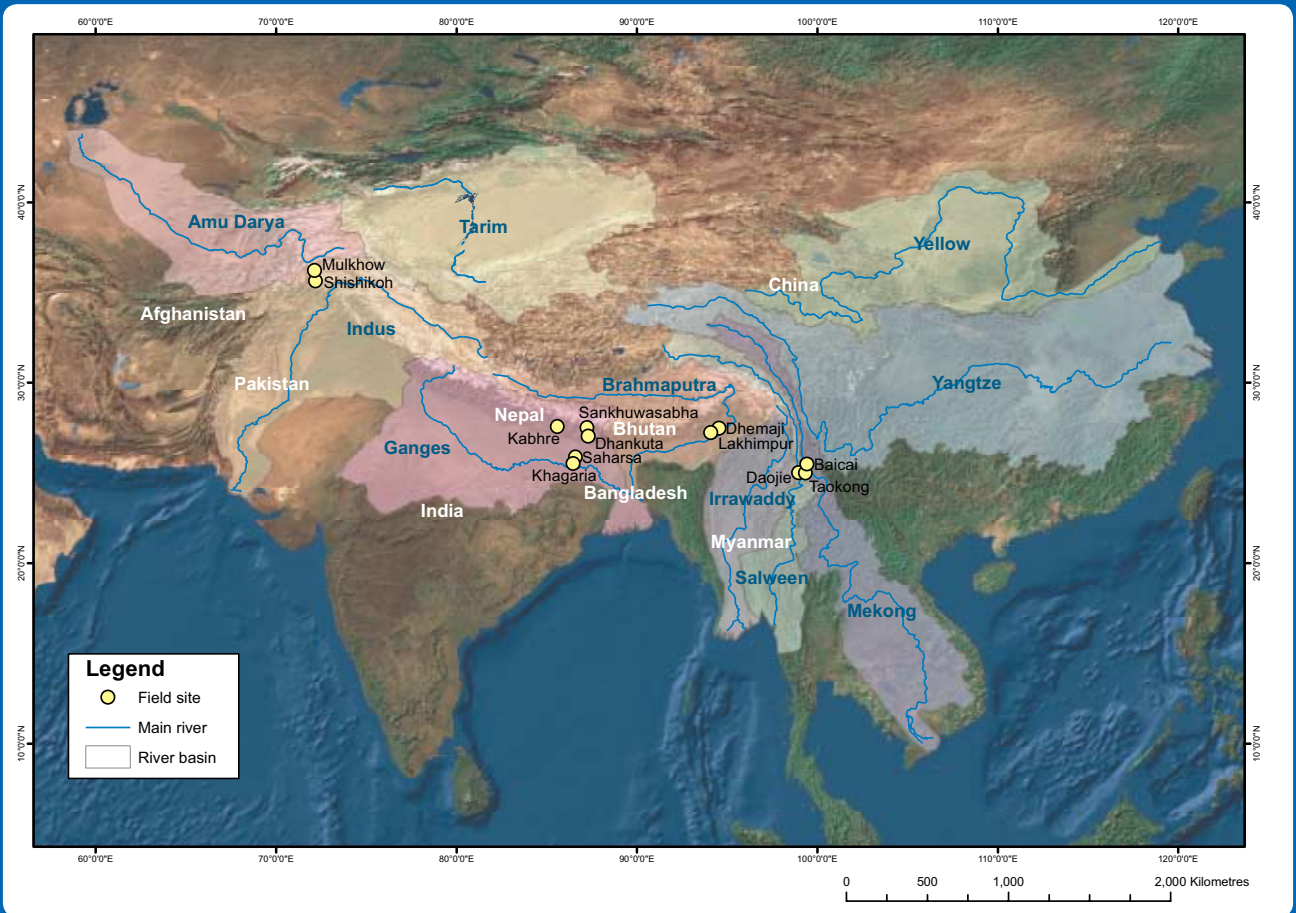
Unfortunately, there are inadequate methodological tools for assessing whether responses are moving towards increased resilience over the long term, have only short-term benefits, or inadvertently move towards increased exposure and/or sensitivity to stress, hazards and change. An analytical framework to help make these distinctions would provide a useful contribution to the field of knowledge on adaptation to climate change.

The results from the case studies show that effective use of existing capabilities and enabling conditions coupled with access to livelihood options and opportunities can enhance the capacity to respond successfully to water stress and hazards; however, this does not guarantee that vulnerability will be reduced. Besides the importance of the larger enabling environment, responses to water stress and hazards can be considered adaptive only if they build resilience to change and variability over the long term.

Enhanced resilience means that people have the ability to increase their well-being even if water stress and hazards worsen. Learning to manage uncertainty means learning to live with change, variability, and extreme events.

The main findings of the case studies are presented in the next section (see map below for location of the sites).

Location of the sites of the case studies



Part 2

Case studies

Main findings

Traditional Knowledge and Local Institutions Support Adaptation to Water-Induced Hazards in Chitral, Pakistan

Aga Khan Rural Support Program, Chitral

Key messages

- Traditional water distribution and management practices have been the most effective strategy for efficient use of limited water resources and reducing vulnerability to climate extremes.
- Social capital has been the most enabling factor for collective action in both traditional management of common resources and acquiring services and development support from NGOs for strengthening adaptive capacity.
- Dependency on climate sensitive resources for livelihoods increases the vulnerability to climate variations unless households have multiple sources of income to help diversify their livelihoods.
- Community responses to climate extremes need to be strengthened through development and implementation of policies that strengthen or supplement adaptation practices.
- Provision of basic services like education, health, and physical infrastructure is instrumental in building resilience among the community.
- Women are the most vulnerable segment of society and policies and programmes aimed at empowering women need to be devised.

Introduction

The study examined adaptations to flash floods or droughts among marginal farmers and herders in a geographically, socially, and economically marginalised and isolated region – Chitral, District in the extreme northwest of the Northwest Frontier Province (NWFP) of Pakistan. The area is an interesting case because it has always had 'too little or too much water' as a dry, water insecure area that suffers flash floods. The local people are vulnerable economically and physically to water stresses and hazards.

Extreme terrain and isolation make its inhabitants more vulnerable. Chitral's 14,850 sq.km (20% of NWFP) border on Afghanistan to the north and west, Gilgit-Baltistan of Pakistan to the east, and the districts of Dir and Swat to the south. The Chitral River and its numerous tributaries have carved deep, convoluted valleys into the mountainous terrain. Chitral's inhabitants have very limited cultivatable land near their traditional settlements on old fluvio-glacial terraces or alluvial fans on the valley bottoms (Figure 3).

Livelihoods and socio-cultural context – Chitral has a population of about 385,000. Its 48,000 households have about 8 persons each on average. The overall literacy rate is 59 – 77% for men, 40% for women (AKRSP 2007). The population has diverse ethnicity, traditions, and customs due to past and present migration from outside. About 90% of the population engage in farming and 75% also get income from off-farm sources. Population increases have led to fragmentation of land holdings, thereby increasing cropping intensity and the vulnerability to water stresses (AKRSP 2007).

Dry rain shadow climate – Chitral is in the rain shadow of the Hindu-Kush and does not receive monsoon rains. The mean annual rainfall is about 650 mm in lower Chitral (Drosh) and 500 mm in the central valley. This precipitation falls mainly in spring and winter. Summer and autumn are dry, with 10-25 mm of rainfall per month. Further north into the rain shadow, in Upper Chitral, the annual precipitation of 200 mm comes mostly as snow at higher elevations. The only two routes into the district are via the Lawari Pass (3,200 masl) in

the south and the Shandur Pass (3720 masl) in the north; both are usually closed by heavy snowfall for at least five (winter) months of the year.

Study sites

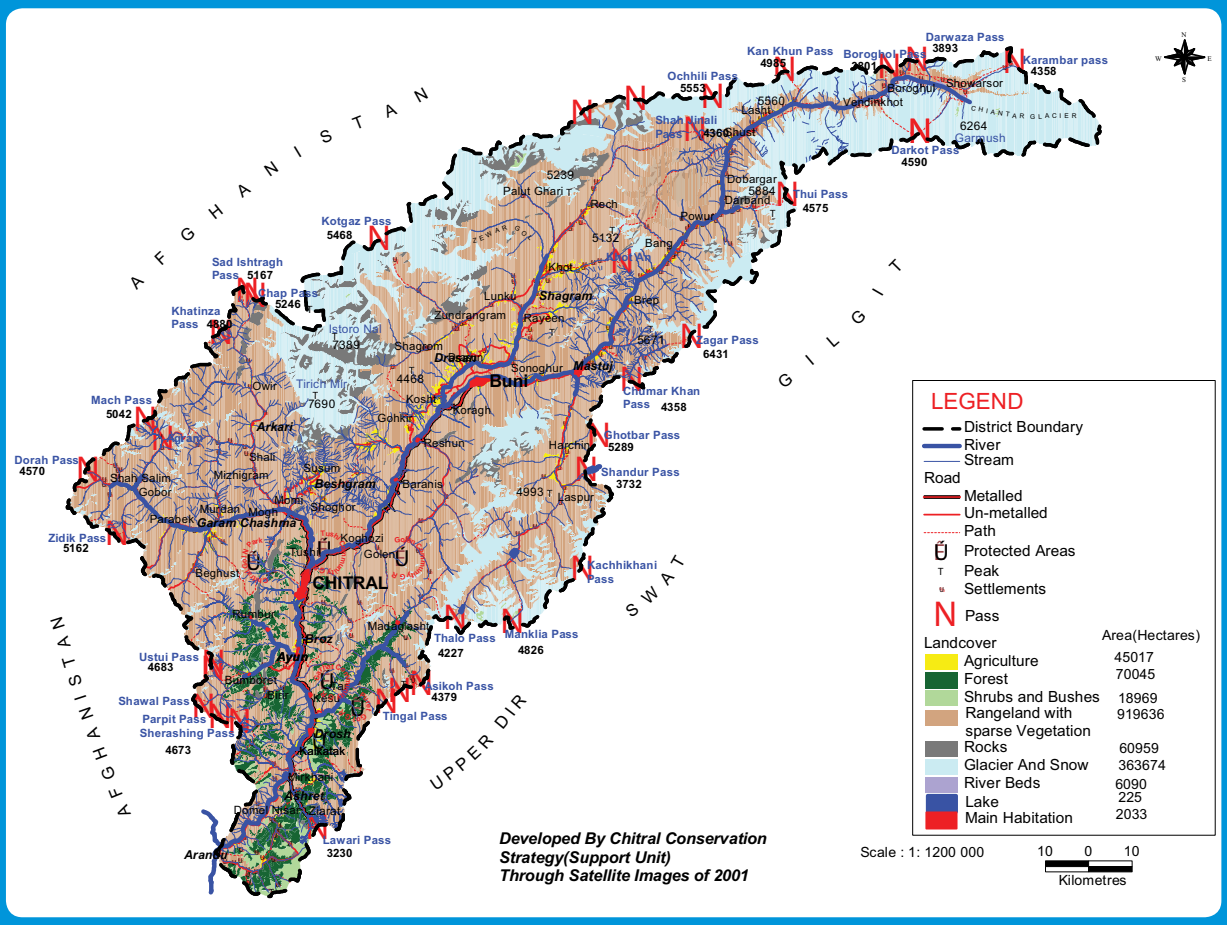
The study was conducted in two (of 24) Union Council areas in Chitral – Shishikoh and Mulkhow. Mulkhow (average elevation 1,600 masl) is in the north of the district about 85 km from the district centre. It is surrounded by mountains, including the permanently snow clad Terichmir peak (7,700 masl). The undulating terrain and steep slopes have lower, double cropping, and higher single cropping, zones. The 14,000 inhabitants belong to about 1,600 households.

Subsistence agriculture is the main source of livelihood. The average landholding of just less than a hectare allows for production of cereals and livestock. The people of Mulkhow are a single, ancient ethnic group, the Khow. Historically, the area has been water deficient. Variations in the frequency and duration of rains are the main reasons for prolonged droughts affecting the socioeconomic conditions of the dwellers.

Shishikoh (1,400 - 4,000 masl) is a side valley in lower Chitral with a population of 12,400 (DCR 1998). It covers 56,586 ha, of which grazing land is 64%, forest is 26%, and cultivated land is 2%. The remaining 8% is glaciers and permanently snow-covered mountains (IUCN 2005a). These physiographic features create varied seasonal temperatures, colder at higher altitudes. The general climate is dry, temperate. Occasional summer rains may cause flash floods, which is exacerbated by rapid and continuous deforestation (IUCN 2005b).

Flash floods have been increasing in frequency, and have led to shrinking and erosion of the inhabited and cultivated land for decades. This has forced many people to migrate or build their houses higher up the slopes. With tenure problems and average land holdings on the sloping land as little as 0.45 ha per household (IUCN 2005b), the farmers are not investing to make it more productive. Consequently, the main sources of livelihood are forestry and livestock raising, complemented by daily, seasonal, and annual migration for labour.

Figure 3: Landcover map of Chitral (Source: Forest grazing lands and watersheds (2004) Chitral: IUCN, CN-CCS Support Unit)



Impacts of Water Stresses and Hazards

The main impacts of water stress and hazard involve drought in the Mulkhow study site and flash floods in Shishikoh. Recurrent droughts and flash floods in the study areas have eroded the assets of the local population, reducing their adaptive capacity and making them further vulnerable to the water induced hazards. In these remote areas with limited development interventions, the opportunities to diversify livelihoods are almost negligible, which further increases vulnerability to the impacts of water stress and hazard. Throughout Chitral, women are particularly vulnerable, regardless of the nature of the hazard.

Mulkhow – the impact of drought

Depletion of water resources – Agriculture has been severely affected by the drying up of water resources, mainly springs. Between 1998 and 2008, 53 natural springs in Mulkhow (about half the total) were depleted.

Poor agricultural production and crop failure – Shortage of water has reduced the area under cultivation and crop yields. Many farmers have faced a serious problem of complete crop failure when the wheat crop did not mature. The crop has to be prematurely harvested and fed to animals, resulting in huge loss in terms of time, labour, and money. Despite being in a double cropping zone, the farmers of Mulkhow now cultivate only a single crop – mostly wheat. Maize and vegetable production is negligable.

Loss of trees – Similarly, loss of trees (fruit and non fruit) due to water shortages has become a serious problem in Mulkhow because household nutrition and fuelwood needs are supplemented by these resources. Walnut trees, which used to be a source of cash income have already disappeared. A key informant said the drought of 1998-2002 was so severe that his village lost almost 70% of the trees.

Shishikoh – the compounded effects of flash floods

Loss of land and infrastructure – The flash floods in Shishikoh have damaged households, destroyed communication and physical infrastructure, and eroded

Typical landscape in Mulkhow, Chitral district, Pakistan, showing settlements and fields

A very intense rainfall event triggered a flash flood in Shishikoh, causing substantial damage to agricultural fields

cultivable lands. Loss of productive land and poor productivity, due to flash floods and debris fall, have led to food insecurity.

Higher prices – The destruction of Chitral's meagre communication infrastructure by frequent flash floods contributes to price increases for consumable items in village shops making the communities more vulnerable to potential hazards. Transporters charge more than usual during the flood season because, after flash floods, they usually repair and maintain the main communication road that passes through Shishikoh.

Loss of livestock – Both flash floods and drought affect livestock. Water stresses and hazards negatively affect the livestock sector due to a shortage of fodder. Animals, especially cattle and goats, are lost in flash floods or droughts and, after the extreme events, may become susceptible to various diseases, start losing weight, and die due to limited availability of fodder.

Less water for domestic use

Vulnerability of women – The depletion of water sources, such as springs and perennial streams in Mulkhow has seriously reduced the availability of water for domestic use, which has resulted in poor health and hygiene, especially among children and women. The shortage of water has also limited the social lives of women as they often cannot wash their clothes, which constrains their participation in social events and confines them to their households.

Responses to Floods and Droughts

The communities have always responded to water stress and have developed traditional responses that include irrigation structures, water harvesting, and community management mechanisms. Responses to water-induced hazards are more specific to drought in Mulkhow and to flash floods in Shishikoh. People at both study sites diversify their livelihoods with migration for employment, and have similar responses to impacts on livestock.

Mulkhow – adaptations to persistent drought

The communities of Mulkhow have ancient systems to deal with the historical shortage of water. Their traditional local institutions contribute to the fair distribution of irrigation water, the collective management of irrigation infrastructure, and the collective harvesting and storage of water. Individual farmers might also pool, borrow, swap, or purchase water for kind or services. As water shortages are intensifying, farmers are modifying their cropping systems to produce more drought tolerant crops.

Local systems for water distribution – Under the traditional distribution system, water is allotted according to the size of land of different groups – a person having more land has access to more water and vice versa. Similarly use of water between villages is also defined, i.e., some villages use water in the daytime, while some use it at night depending on the geographical location and potential evaporation losses.

The distribution of water is managed by a water distribution committee comprised of elders who develop a water distribution schedule for the member households according to their water rights. There are no written rules or bylaws; the system is based on a social code of conduct that each beneficiary household has been following for generations.

Collective management of irrigation infrastructure – Improving the efficiency of the limited irrigation infrastructure is another strategy adopted by the inhabitants throughout Mulkhow region. Maintenance and repair of irrigation networks to avoid water losses is undertaken under the system of 'mirzhoi' under which the community hires one or more persons (paid in cash or grain) for maintenance of water channels.

The system ensures regular maintenance and repair of irrigation infrastructure and creates employment. Larger repairs such as re-excavation are carried out under a collective system called 'mone' (service by turn) where each beneficiary household contributes its share of labour material or cash depending on the resources available to them. Similar kinds of arrangements have also been made among villages when the scale of

Traditional water distribution and control structure (nirwalu) in Mulkhow for dividing water in equal portions for two downstream users

work is beyond the capacity of one village. Equitable distribution of water is also ensured through a traditional water control structure called 'nirwalu' (a round-shaped hole in the middle of pairs of stone or wooden planks with an equal dimension that is installed on the two corners of a small dug pond.

Traditional water harvesting – In Mulkhow, the traditional water harvesting reservoirs have been very useful for tapping meagre water resources from perennial streams and springs and using the water according to a predefined distribution arrangement. Water harvesting is done mainly for irrigation and drinking, however, some microstructures constructed by the women were used to provide water to livestock on a regular basis.

The water reservoirs are innovative; they reduce water losses and lessen the workload of the farmers. For example, people with turns to get water at night, store their share of water in the reservoirs to use during the day. The strategy has been helpful especially for female-headed households because the women cannot go outside at night. In addition, the transformation of these traditional structures into concrete water reservoirs with the support of GOs and NGOs has further institutionalised the use of water in the area.

Pooling of water – When less water is available, the farmers at the tail end of the irrigation system may not receive their allocated amount of water due to evaporation and seepage/leakage in the distribution system. To deal with the situation, two or more farmers pool their water and equally divide the time of irrigation.

Borrowing and swapping water – The system of borrowing and swapping water for farming is a common strategy to supplement irrigation water needs in some villages. Key informants revealed that borrowing and swapping water is an ancient practice to address water shortages. The system works well for all, especially for poor farmers and those located at the tail end of the water distribution system.

However, population increases and changing rainfall patterns have led to acute water shortages since the early 1990s. The system in Mulkhow has evolved into a commercial practice with trading of water for kind (like fodder, fuelwood, and poultry), services (weeding, harvesting, irrigating land, household work, and others), and cash. Earlier people did not buy or sell water – farmers with an immediate need for water would ask their relatives and tribes with major water rights for free-of-cost water support. Now, farmers in Mulkhow use a mixture of these coping strategies.

Modifying crop systems and land tenure – Farmers in Mulkhow are modifying their cropping systems to adapt to water shortages. The crop management practices include use of improved agricultural inputs, planting earlier, and agroforestry. The farmers also plant fruit and non-fruit trees on the borders of cultivable land to reduce the intensity of sun, increase land productivity, and supplement household firewood needs. Drought tolerant and early maturing poplar and rubinia are the most common trees planted in the region. Households with limited or no land rent fields from large landlords on a contract basis such as a 50/50 profit or loss. Farmers with less water prefer to do contract farming with a farmer who has more water rights to provide deficit water for their own lands as well.

Shishikoh – adapting houses, settlements, and land use to cope with flash floods

The design and location of houses and settlements are critical in protecting people from flash floods. In Shishikoh, the majority of people make their houses from stone (instead of mud brick) so that they are more resilient to water damage. The increasing rate of flash floods has compelled them to leave the valley bottoms and construct their houses on slopes. Local people consider the nature of soil, vegetative cover, grazing routes, and previous history of flash floods while constructing houses on slopes. However, this strategy may not be practicable for everyone due to limited land holdings, the high cost of construction, and their emotional attachment to the land.

Adaptations in Livestock Raising

The communities in both Mulkhow and Shishikoh depend heavily on livestock in their livelihoods. Being the custodians of livestock, women have a lead role in responding to climate variations in the livestock sector.

Lending livestock to avoid selling – Lending or borrowing domestic cattle is a major strategy employed to avoid livestock losses due to water shortage. Since the shortage of fodder makes rearing animals impossible for households with limited resources, they lend their animals to well-off households, especially relatives, instead of selling or slaughtering them. Two types of lending systems were documented in Mulkhow and Shishikoh.

In the first, animals, mostly cows, are lent to relatives, neighbours or any other household in the village for a certain period with an agreement to take care of it, the recipient household utilises the products of the lent animal and returns it when the agreed time finishes. The agreement can be extended with mutual consent. The second type of lending is called 'zhawki' – long-term lending of a young animal in an agreement under which the recipient household rears the animal and uses the products, but returns it once the lent animal gives birth to a calf, which the recipient household keeps.

Borrowing fodder – Borrowing fodder and weeding others' crops for fodder is also popular among poor households to meet fodder shortages. In addition, women collect wild shrubs to supplement the livestock fodder needs.

Pooling and shifting herds – To address the shortage of fodder, households in Mulkhow shift their cattle to high pastures to graze freely without any caretaker, but villagers make regular visits to the pasture to check the status of animals. Under the traditional system of sotsiri, households pool their animals for grazing attended by one or two members of each concerned household on a rotational basis for agreed periods, mostly daily. A traditional system called pajal (shepherds) is also intact in Mulkhow in which local men or boys are paid in kind or cash to graze the animals in high pastures and protect them from predators at night.

Modification of livestock breeds – To cope with fodder shortages due to water stress, people in Mulkhow rear local breeds of cattle because they require less feed due to their small size and are also acclimatised to the local climatic conditions. Women might shift from goat to sheep rearing in order to minimise the loss of animals because the local breed of sheep is more resilient to drought and provides quality wool for the production of local carpets and traditional woolen fabric (shu).

Mobility is an adaptation to diversify livelihoods

People at both the Shishikoh and Mulkhow study sites have been coping with water stresses and hazards through mobility – through seasonal migration, for employment, seasonal movement of herds to areas with more water and fodder, or permanent migration to places where they have better opportunities for livelihoods.

Seasonal migration of the labour force – The impact of water induced hazards in Shishikoh and Mulkhow compels a significant proportion of the male workforce (skilled and unskilled) to migrate to other areas for better livelihood opportunities. They migrate out both individually and in groups. Households with limited resources are more willing to migrate.

Social networks play an important role in facilitating the migration process. Migrant communities in Pakistan's major cities assist new arrivals to get accommodation and jobs. The migrants also help and support each other in case of mishap. Internal lending is a common practice among the migrants to purchase rations for home, pay school fees, and arrange travel expenses. Migration takes a heavy toll on women as it leads to an increase in their workload when they have to take over the household chores of the migrant men.

Seasonal movement of families and herds for water and fodder – The dwellers of Mulkhow practise short-term intra-rural migration to overcome water shortages. In summer, almost half of the dwellers shift their families, belongings, and livestock to temporary houses at high altitudes. They return to their permanent settlements in November.

Permanent migration – In addition to seasonal migration, permanent migration is used as a strategy to deal with the persistent drought in Mulkhow. Between 1998 and 2008, approximately 195 (10% of total) households permanently migrated from Mulkhow to different localities in Chitral. Though men make the final decision, women play a key role in mobilising and convincing their male partner to migrate permanently and settle somewhere else.

Factors Influencing Local Adaptation

Several factors in Chitral may either enable or constrain the capacity of the local communities to build their capacity to adapt to water stresses and hazards. These factors combine social, economic, geographic, and political issues.

Strong, inclusive social capital – Social networks and organisations play a key role in shaping adaptation strategies and reducing vulnerability of the local communities in the study areas. Strong social capital promotes active participation of community, a sense of responsibility, and cooperative action among the communities, which is key for sustainability of the adaptation strategies. In addition to this, it allows the community to collectively defend their interests and organise access to the services of development agencies.

Strong social capital among the communites in Mulkhow has kept alive the centuries-old traditional resource management systems. However, in Shishkoh, in some instances, conflict over common resources has divided the communities into rival groups, weakening the social networks and resulting in forest degradation.

Traditional knowledge and systems – Traditional knowledge and systems are inherent in the communities of Chitral, but with the passage of time, these traditional systems have been eroding. The systems are still very strong in Mulkhow and play a vital role in strengthening the adaptive capacities of the communities. The traditional water distribution and management system not only ensures optimum utilisation of meagre water resources but also promotes collective action for the difficult maintenance, which is key for sustainability of adaptation strategies.

Economic situation – The capacity to adapt to the climate variability and extreme weather events depends highly on the economic condition of the communities. Economically well-off households with multiple sources of income are more resilient to the adverse affect of climate variability as they have better access to quality health services, educational institutions, and employment. Households whose livelihoods are based solely on natural resources are affected more by the climate-induced hazards, which may result in maladaptive practices such as selling off livestock, valuable assets, and lands; or further exploitation of forests; that make them more vulnerable.

Role of NGOs – In the relative absence of government investment in the development of the area, NGOs are playing a key role in the socioeconomic development of the communities, which enhances their adaptive capacities. However, in some communities, especially Shishikoh, cultural traditions prohibit the participation of women in public spaces, which prevents them from accessing development interventions undertaken by NGOs that stipulate the participation of women as a requirement for implementation of development activities. In Mulkhow, the educated youth have played a key role in mobilising communities to work with NGOs.

Isolation and poor geographical access – Communities in the study area are hindered in their adaptive capacity by the geographic isolation that limits their access to the information and technical skills necessary to diversify their livelihoods. For example, microfinance is used as an effective coping and adaptation strategy among many communities, but limited physical access, lack of information about products/services, and complex procedures, limit the widespread use of this option. Limited access to markets for labour, business, and other sources of income generation prevents diversification of livelihoods.

Government policies and governance – The lack of proper implementation of policies and poor governance limit the capacity of people to adapt to extreme events. For example in Shishikoh, large-scale forest harvesting by the government through contractors is making the locals more vulnerable to flash floods. Similarly, in the absence of a policy on land settlement and use, the communities are constructing their houses in areas that were hit previously by flash floods. Limited investment by the government in social (health, education) and economic (energy, employment, access to market) sectors is another factor that prevents the communities from building their adaptive capacities.

Conclusions, Recommendations, and Policy Implications

Climate induced hazards in the form of flash floods and water scarcity have negatively affected the livelihoods of the inhabitants of the study areas. Negative impacts of extreme events are evident in the form of depletion of water resources, loss of agricultural land, poor agricultural productivity, loss of livestock, and destruction of the meagre physical infrastructure. Extreme events have also increased the workload, limited the social lives, and created poor health and hygiene conditions for women. The prevailing gender roles further exacerbate these impacts and make the women more vulnerable.

The long history of drought and flash floods in Chitral has equipped local communities with the knowledge and skills to cope with changing, climate-induced situations. Traditional water management, pooling of resources, crop diversification, traditional livestock management, and migration are major responses to these water hazards. These indigenous mechanisms focus mostly on reducing vulnerability to climate hazards through effective and efficient utilisation of resources.

The major factors affecting adaptation were identified as strong social capital, existence of traditional knowledge and systems, economic situation, isolation and poor geographical access, acceptance of or resistance to NGOs, and government policies and governance. Livelihood strategies traditionally used to reduce climate risks can enhance resilience to water stress as long as

the social contacts withstand the social and economic changes. It is uncertain how the traditional strategies will manage to adapt and facilitate adaptation to a drier or wetter climate in the future. The following recommendations are based on the aspirations of the community respondents.

Improving traditional irrigation infrastructure – Strengthening traditional irrigation and water harvesting structures will reduce communities' vulnerability. Lining irrigation channels and up-grading traditional reservoirs into concrete structures will promote efficient utilisation of water resources. With large irrigation projects, the effects of adding large quantities of water into the fragile soil and increasing the cropped area should be investigated to prevent further degradation and loss of the limited soils.

Livelihood diversification – The livelihoods of the people in the study area are based generally on climate sensitive resources and there is an urgent need to provide them with alternative sources of income. Diversification of livelihoods through development interventions in capacity building, facilitating off-farm income generating activities, and creating job opportunities through major development interventions should be promoted by decision makers and development actors (both government and NGOs) to reduce the vulnerability of the communities in these areas.

Fostering social capital – Social networks and institutions help communities adapt to changing environmental conditions through collective management of resources. Proper institutional building measures will further strengthen the social capital within the community that maintains efficiency, effectiveness, and sustainability of adaptation measures.

Enabling environment – Community responses to climate extremes need to be strengthened through the development and implementation of policies that supplement and strengthen the current practices. Policies on forest and land settlement and use need to be reviewed to reduce vulnerability and enable adaptation.

Access to basic services – Basic services, like education, health, electrification, and communication, will be instrumental in building adaptive capacities and catalysing strategies for income diversification. Fulfilling the basic development deficit is a very cost effective measure for increasing resilience. Thus, government policies should target factors that enable adaptation rather than waiting for funding of large-scale infrastructure.

Gender mainstreaming – Women in the study were identified as the most vulnerable segment of the society. Therefore, special measures are needed to develop policies/programmes that target this most vulnerable section of the community through the relative empowerment of women instead of setting absolute minimum standards.

Herding is an important part of livelihoods in Chitral

Living with Water Stress in the Hills of the Koshi Basin, Nepal*

Institute for Social and Environmental Transition-Nepal

Key messages

- Decentralised systems, such as rainwater harvesting, offer incremental solutions to addressing emerging water stress but require larger policy shifts to scale up and acheive a significant impact.
- Access to and flow of information, goods, and services into and out of an area is a necessary condition for being able to respond to stresses.
- Social capital and the presence of multiple institutions help to support adaptation.
- Diversification and access to alternative sources of livelihood emerged as a central strategy for helping people adapt to stress, whether induced by climate change or other ongoing change processes.
- The variety of income sources, not the level of income, seems to be important for adaptation.

Introduction

The study in the Koshi Basin of Nepal examined both wet and dry sites and the mosaic of vulnerability that leaves people coping with the effects of climate-induced stresses and hazards. Although the study examined the impacts of both flood and extended drought – too much or too little water – people generally consider that water availability has declined overall in the last decade.

The people of the hills and Terai of Nepal's Koshi basin are already experiencing climate-related hazards, such as erratic monsoons, floods, and extended periods without rainfall. They recognise that with changes in the climate, they will need to diversify their crops, agricultural practices, and livelihoods to cushion the impacts.

Study area – The Koshi is Nepal's largest river system draining almost a third of the country (Figure 4). It encompasses a great diversity in topography, climate, vegetation, demography, and culture (Table 1). The inhabitants of the Koshi basin face multiple hazards, such as droughts, floods, landslides, and earthquakes. In Nepal, the Koshi basin is home to about five million people living in eighteen districts, four of which are in the Terai. The area is contiguous with the Koshi area of Bihar, India.

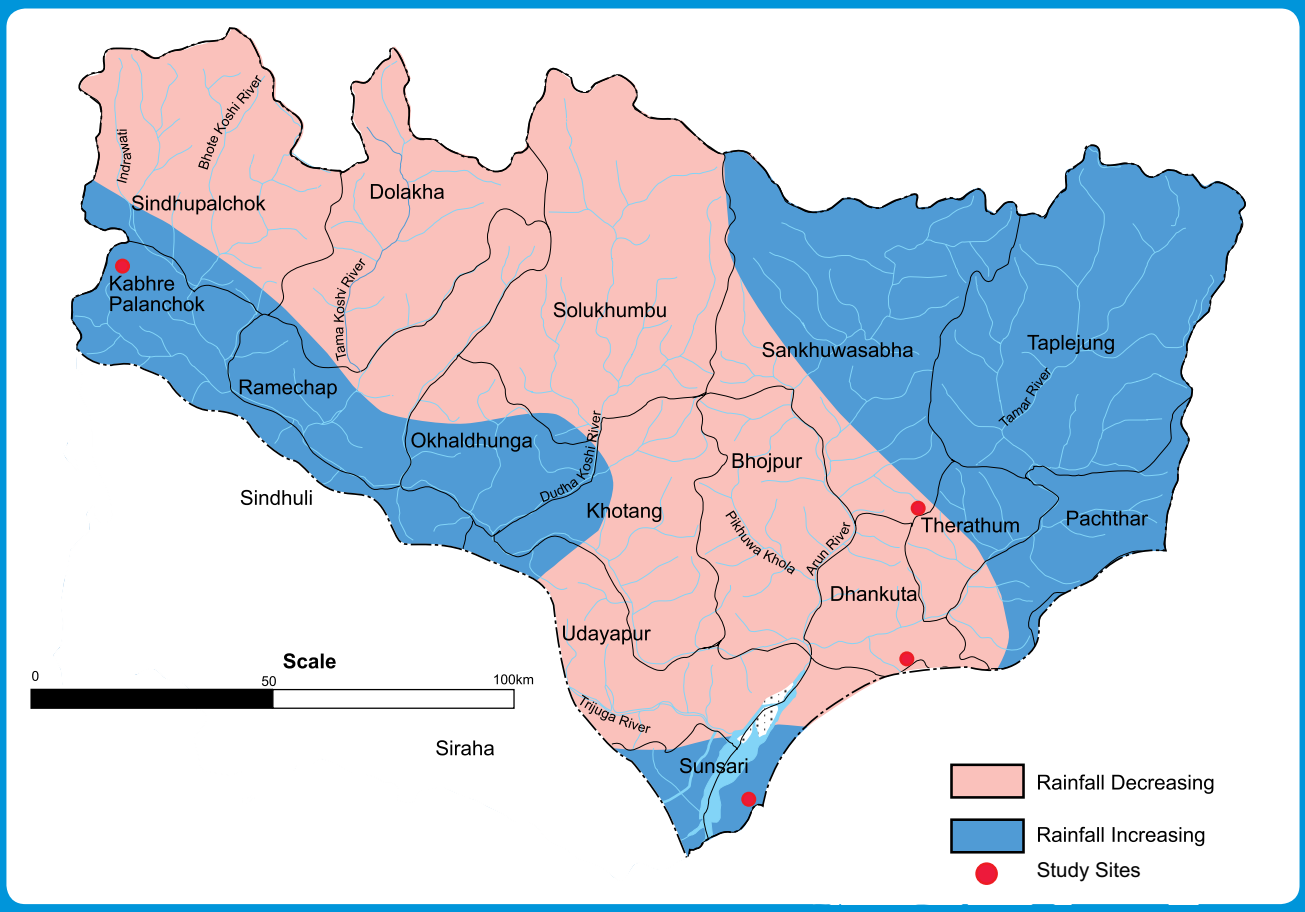
Study Sites – The study was conducted in three districts in the hills of the basin: Sankhuwasabha, Dhankuta, and Kabhre. A fourth district, Sunsari in the Terai, could not be visited during the study period due to severe flooding. The study sites were the four villages of Okharbote in Sankhuwasabha, Maunabudhuk and Danda bazaar in Dhankuta, and the dry valley of Panchkhal in Kabhre. Okharbote in the High Himal physiographic region of Nepal is typical of an area receiving high rainfall (>5,000 mm/year). Maunabudhuk in the High Mountain region receives moderate rainfall (~2,000 mm). Danda bazaar and Panchkhal in the Middle Mountain region receive low (~1,000 mm) rainfall.

The sites had different accessibility. Okharbote village is about a seven-hour walk from the Dhankuta-Basantapur; Maunabudhuk and Danda bazaar are on the Dharan Dhankuta road; and Panchkhal is located about 50 km northeast of Kathmandu.

Precipitation and replenishment of springs – Precipitation patterns in the Koshi basin are directly associated with the South Asian monsoon, with about 80% of the annual precipitation falling between June and September. Due to the great variation in the topography, the spatial and temporal complexity of

* A documentary film '**In the Grip of Drought**' on this case study is available on a separate DVD from ICIMOD.

Figure 4: **The part of the Koshi basin located within Nepal**



Basin area: 60,400 km²
Elevation range: 100 to 8848 masl
Population: 5,081,463

Male female ratio: 1:1.02
Person/km²: 37 (high mountains) – 498 (Terai)
Literacy rate: Male: 65%; Female: 35%

Access to potable water: 46%
Sanitation coverage: 30%
Energy: electricity - 30.9%; kerosene - 67.4%; biogas - 0.2%; other - 1.5%

Table 1: **General features of the Koshi Basin**

Features	Vegetation	Crop	Fruit and vegetables	People	Industry	Transport
Middle Mountain	Pine forest + mixed hardwood and oak	Rice, maize, wheat, millet barley, pulses, sugarcane, radish, potato, ginger, cardamom and tea	Mango, papaya, banana, orange, lime, lemon, peach, plum, potato, cauliflower	Gurung, Magar, Tamang, Newar, Bahun, Chhetri, Damai, Sarki, Sunar, Kumal, Rai, Limbu	Rice, flour and oil mills, cement factory, cottage industry handicraft, curios, hosiery, metallurgy, furniture, plastics, hotels and lodges	Road linkages to major centres, suspension bridge, trails
High Mountain	Fir, pine, birch and rhododendron	Oats, barley, wheat, potatoes, buckwheat, yams, amaranths, medicinal herbs, cardamom, tea	Chestnut, walnut, apple, peach, plum, apricot, potato	Khas Chhetris, Tibetan related groups, Thakalis, Bhotiyas, Sherpas, Tamangs, Ghales	Cottage industry, carpets, blankets, hand woven cloth, trekking	Limited roads, some suspension bridges, trails
High Himal	Open meadows + tundra	Grazing (June-September)	Apple, walnut, vegetable seed, potato	Occasional herders, Sherpas and Bhotiyas	Mountaineering and trekking	Trails, no road linkages

rainfall is large within short distances. The annual arrival of the monsoon rain results in the emergence of springs at various elevations. Stable, perennial springs are often located at the footslopes of the hills; springs at intermediate elevations start to flow a few weeks after the monsoon begins; and springs at higher elevations flow later during the season.

Specific hazards in the study area – The inhabitants of the Koshi basin face multiple hazards. In the hills, landslides, gully erosion, and debris flows are common; while in the valleys, sediment deposition and bank cutting are common. The Terai suffers from floods, riverbank erosion, and sand deposition on fields. Drought conditions are common in both the hills and Terai and affect rainfed agriculture.

Current livelihoods – All the respondents interviewed have multiple sources of income: 83% have agriculture as a source of income (49% say it is the primary source). Farmers produce cereals, vegetables, and fruit. Livestock are an important source of income for 74% of the surveyed households and a secondary or tertiary source of income for the remainder.

There were a significant number of wage earners – about 20% earn their income within the district, 4-5% outside the district, and 21% outside of Nepal. About 14% of respondents have teaching as a major source of income, 11% rely on business or other secondary sources, and 3% are students or engaged in industry. Some rely in part on a pension, about 10% from the British or Indian armies, and 5% from the Government of Nepal. About 47% of the households earn income from small business and trade, including the running of local teashops and general stores. Three families (5%) reported that trade and business is their main source of income. For 20%, service is the major source of income. A few families sell firewood to survive.

Water and irrigation systems – Drinking water systems generally tap spring sources, store the water in a tank, and distribute it via community tap stands. All three villages studied have gravity systems to supply drinking water. Users' committees manage the systems, but institutional, technological, and social issues are resulting in dysfunction of the existing schemes and adding to the emerging water stresses. For irrigation, farmers divert streams using temporary dams as at all four sites, agriculture is mostly rainfed.

Impact of Water Stresses and Hazards

Worsening water availability in the hills and mountains has affected local livelihoods and daily life in the villages in many ways.

Water for domestic and irrigation uses – Both upland and lowland villages suffer from inadequate water for domestic use and irrigation. As discharge in upland sources declines, villagers require more time to fill their water vessels or must travel to sources at lower elevations to meet their needs. It can take 30 minutes to reach the source and about an hour to return, and several trips per day may be required. Consequently, they use more time and labour getting water, and pay with their health because the water quality of some lower sources is worse. Children have to miss school

Woman and girl in the dry Jikhu Khola riverbed, Panchkal, Nepal. Securing water for agriculture and household use is an increasing challenge, especially for women

and studying to spend 3-4 hours per day collecting water. The hindrances to education will affect future capacity to adapt. Smaller or affluent families and those living near the bazaar areas hire porters to fetch water.

Health and sanitation – The lack of adequate water has worsened sanitation. Many toilets, built with support from external agencies, have become redundant due to the lack of water. Occasionally people flush the toilets using grey water left over from washing clothes. Personal hygiene is affected visibly as people cannot wash their clothes, hands, and feet frequently or take regular showers. The lack of water makes it hard for women to wash dishes. At all three sites, villagers worry that the condition is ripe for occurrence of epidemics.

Agriculture – Continuing drought conditions have caused rainfed agriculture to fail in some villages, while in others the effect is moderate. In Dhankuta, the maize yield has decreased and the topography limits expansion of the area under maize cultivation. Discharges from sources have declined, so even farms with irrigation facilities are producing lower yields. Disputes about sharing water have increased, affecting the social relations already under stress in the aftermath of the decade-long insurgency and political turmoil. Since agriculture is the main source of income for about half the population, the loss of crops is gradually weakening the economy.

Livestock raising – Although livestock is the major source of income of a quarter of the population, families are increasingly unable to maintain the same number of animals as before. The local dairy enterprise, developed over the past two to three decades, has suffered as a result.

House construction – The shortage of water has also affected the construction sector. A few families engaged in building construction for contractors, but the work has ceased to function in winter when there is no water available to make concrete mixes. Construction work usually takes place in market areas where increasing demands for water have already put stress on the existing supplies.

In Danda bazaar in Nepal's mid hills, households may only collect two pots of water per day.

Response to Water Stresses and Hazards

Himalayan herders and farmers have a long history of responding to environmental uncertainties, whether through seasonal migration, shifting land use patterns, or livelihood diversification. They have lived with and survived hazards, such as flash floods, and droughts for centuries. Today, farming is still a main livelihood, so people must find alternatives when floods, droughts, or pests destroy the crops.

Generally, people who were not dependent on ecosystem services, such as wage earners or service providers, were affected less by the immediate impacts of droughts, hailstorms, and heavy downpours.

Temporary migration – Following each crop-destroying disaster, people would historically borrow from local moneylenders so they could travel to seek temporary work as migrant wage labourers in other places. Being able to borrow money from local moneylenders provided a safety net during hard times, but the interest was very high.

Today, during the agricultural slack season (November to February), people continue to take loans to travel to work as wage labourers in cities, India, or abroad and return after earning some money.

People now migrate to wage-labour sites, such as urban centres and construction areas. They might stay for a year or two or just a season. If the migrants succeed in landing a relatively permanent job, they normally visit their families and villages once every two to three years. If they do not secure such a job, they may return to the village in a few months. Unlike permanent migration, it is both internal (within the country) and external (outside the country).

Permanent resettlement – Relocation and permanent resettlement began in the late 19th century, and has mostly occurred within Nepal from the highlands to the Terai. Uncertainty and difficulties associated with hill farming motivated a majority of hill dwellers to move to the foothills and the Terai. In the 1960s, the Nepali state

also promoted resettlement in the Terai forests.

Domestic water use – People try to obtain water for domestic use through both structural and non-structural means. In water deficit areas, about half the population travels to sources at lower elevations when the supply from regular water sources declines. Communities may devise local rules for collecting water. For example, in Danda Bazaar, the local rule stipulates that one person can collect water in two containers for one family for one day. The community enforces the rule and those violating the rule face social boycott. Some families take advantage of the rule by using containers that are almost twice the size of regular ones. Men go to carry the heavier containers of water for the two-hour round trip. Some families have installed electric pumps to lift water from streams.

Rain water harvesting – Ponds were once a common method of harvesting rainwater in the hills, but many have been lost to other land uses in recent decades. Villagers in Maunabudhuk have continued this traditional method of harvesting rain by building multi-purpose ponds close to their homes to collect rain. Water remains in the ponds for 4 to 5 months to be used for livestock and irrigating fruit trees. In Danda bazaar, collecting rainwater is popular and the village has been the site to pilot a fog water collecting system. Although its performance is not very satisfactory, this system still provides water for a small section of the population that cannot get water from the main system of the village.

Efficient irrigation systems – Since large irrigation channels are expensive and necessitate external inputs like technology, resources, and skills, some families use sprinklers and drip irrigation systems. Others have started using pumps to lift water for irrigation from streams. Introducing non-structural changes to make irrigation more efficient also requires investments in new skills and community support because, rather than individualistic family responses, collective community decisions will be necessary. However, the study sites have not yet employed such changes.

Change in crops – According to the respondents, water shortages have caused about half the population in the study areas to shift their production from cereals to cardamom or from rice to maize. Some have adopted cultivation of tea or cardamom because it fetches a higher price than rice. Cardamom requires less water and less labour input for a limited period. Tea requires a regular supply of large numbers of labourers during the picking season.

Both tea and cardamom require less water than cereals or vegetable crops. Other families have shifted their crops to rice varieties that require less water or that can be sown at a later date if the rains are delayed. Those unable to make such shifts abandon farming altogether, move to a different location, change occupations, or rely on different sources of income.

Changes in the livestock system – Due to water shortages, farmers have problems keeping the same number and size of animals as before. About two-thirds of the population use less water to make khole (boiled liquid feed) for livestock. The decline in water availability is forcing about a third of the population in the study sites to reduce the number of their animals by two-thirds – an economically and culturally difficult decision. An even harder choice for farmers is to reduce the variety of animals. About a fifth of the farmers who had both cows and buffaloes have sold either all the cows or all the buffaloes to keep only one species of cows, buffaloes, goats, or pigs. Some farmers sell milk and buy water to maintain their dairy business with the hope that the next year will be better.

Changes in sanitation practices – The majority of the respondents in the study area reported that due to reduced water availability, they have changed their sanitation behaviour by cleaning, showering, and washing less frequently.

Shift in periods for construction – In the past, people constructed their homes during the winter, the dry agricultural off-season. Since construction requires water, most locals now build houses during the rainy season when water and labour are available.

Occupational changes – When water shortages are acute, people tend to make the hard choice to change

In the dry Jikhu Khola riverbed, wealthy farmers use heavy machinery to dig trenches to get groundwater for irrigation.

or abandon their occupation, or move from a water scarce area to a place where water is available. They also gradually shift their livelihoods from farming to the service sector or trades. Continued water problems force many people without these alternatives to leave the village.

Factors Influencing Local Responses

Various factors influence the choices people make to cope with water stresses. They include mobility and access to information, markets, services of institutions, technical support, technology, and tools and equipment.

Support systems – Electricity and communication facilities are available in the study areas. Access to both has helped local trade, including the use of cold storage facilities and the operation of small businesses. Farmers use cooperatives and other agricultural and livestock services to improve production and sell milk and vegetables in local markets. All three sites in Sankhuwasabha and Dhankuta districts have educational establishments and health centres. These facilities and cash income, from the sale of farm products, has helped people obtain their immediate needs.

Mobility, transportation, and communication – The ability to move in and out of an area allows people to respond to stress successfully. For example, the shift to tea and cardamom would not have been possible without access to roads that allowed local producers to secure inputs and reach the markets. Making a decision to move requires family support, initial investments, access to information, and the liberty to leave home for long periods and to take risks. Such strategies help a family shift from farming to a non-agricultural source of income outside the area, and to diversify the household's income basket.

Services – Various services; such as transportation, markets, communications, and technical backup for agriculture and livestock are important for enhancing local resilience, so the absence of these services and their unreliability can make local adaptive responses very difficult. For example, the chemical fertilisers and pulse and vegetable seeds that are available in local markets are often of inferior quality because there are no institutions to regulate and ensure quality. They are also often not available when farmers need them during the cropping season.

Infrastructure development – Road building on mountain sides can damage springs. Bus stations, public buildings, or sports fields often encroach on the flattest ground available – the traditional ponds near villages. The lasting impact of roads on water springs is only evident when erosion of the roadside slope causes the water channels to crumble. Villagers find it difficult to demand that road construction not destroy springs because the immediate benefits of a road seem to outweigh the loss of a spring. In the long term, the loss of the spring adds to local water stress while the road improves mobility, helping villagers to avail of alternative livelihoods.

External factors – The study site communities are affected by the larger global and national context; they face the negative impacts of rising oil prices, which increases the transportation costs of trading goods. Frequent strikes and road closures prevent farmers from transporting their products to market, which is making many farmers wary of investing in agriculture.

Political instability – Political stability is often a prerequisite for individual or community responses to succeed. During the decade long insurgency, many people left their villages because the remittance money and even salaries had to be shared with rebels. Other people left because they did not want to be pulled directly into the conflict. The educated and those with some economic base and influence in the village were asked to leave. In such circumstances, people had few incentives to grow more food.

Changing demography – As a consequence of migration, the absence of able-bodied men in the villages has changed peoples' perception of life and farming. So many men must seek alternatives that the local economic systems have weakened. The opportunities provided by improved mobility and access to information then become irrelevant as strategies to adapt to the emerging water stresses.

Notion of 'development' – In Nepal, development has always been equated with the availability of electricity, roads, and telephone services. Yet, even when these services are available and reliable, people are still moving from their homes and traditional livelihoods because these services do not help them to adapt to water stresses. This question requires much deeper inquiry.

Gender perceptions on water – Men and women expressed different perceptions regarding the impact of water shortages. When the definition of the problem is different, a solution will be different too. These nuances need consideration in the design of adaptive strategies.

Conclusions and Way Forward

The people of the hills and the Terai of Nepal's Koshi basin are already experiencing the stress of climate related hazards, such as erratic monsoon behaviour, floods, and extended periods without rainfall. They are coping with the effects, but need to develop effective adaptive strategies. The information collected clarifies people's perceptions about adaptation. Clearly, they recognise that the diversification of crops, agricultural practices, and livelihoods can cushion the impacts of changes in frequency, intensity, and duration of rainfall (flood or extended drought).

Although the team selected study sites to represent dry and wet areas based on rainfall data, the respondents at all four sites reported water shortages. There is almost a consensus that water availability has declined in the last decade. Danda Bazaar is on a ridge and has always had physical limitations on water availability but the periods without water are becoming longer.

Although respondents say that rainfall has become erratic in the last five years, precipitation records do not show distinct trends. This could indicate increased local variability. Increases in variability affect the recharge of local springs, reducing the amount of water available in existing drinking water systems. This is particularly so if water sources are situated at higher elevations.

Responses to the emerging conditions of too little water often need to adhere to principles like catching the rain where it falls. Decentralised systems using rainwater harvesting for household water needs or storing water in ponds to promote recharge, offer incremental solutions. Scaling up these activities to make a significant impact would require large policy and behavioural shifts. However, behavioural change is not automatic and depends on factors such as access to information and knowledge. It also depends on the appropriate husbanding of water stored in the reservoirs, ponds, soil moisture, and watersheds. Adaptations, such as the use of drought tolerant seeds, can help farmers to adapt but must be suited to local specificities within the economic, social, and political landscape.

Diversification and access to alternative sources of livelihood emerged as a central strategy to help people adapt to stress, whether induced by climate change or other ongoing change processes. People with diverse income sources adapt more easily than people with few income sources. The variety of income sources, not the level of income seems important for adaptation.

People suggest that the state and government agencies must focus on providing an enabling framework for them to pursue their strategies rather than micromanaging all their activities. Under a facilitative structure, many of the locals argued that they could respond to disruptions at local level. Many villagers suggested that the stress posed by the Maoist insurgency and current insecurity was more serious than drought, though the long-term effects may add further to the mosaic of vulnerability.

A flow of information, goods, and services into and out of an area is a necessary condition to respond to stresses. Likewise, social capital and institutional checks and balances are helpful in supporting adaptation. The limits to adaptation depend upon the nature of the physical infrastructure and access to secure sources of water. When physical infrastructure and water sources are absent or limited, people will find it hard to adapt.

Life in the Shadow of Embankments – Turning Lost Lands into Assets in the Koshi Basin of Bihar, India

Winrock International India

Key messages

- Past flood control measures have changed the agro-ecology of the Koshi basin and increased the intensity and frequency of floods, droughts, and other water-related stresses and hazards.
- The communities have mainly responded by adjusting the cropping cycle; introducing new and improved varieties of crops, such as sunflower, wheat, and maize; using water-logged land for makhana (foxnut or water lily) cultivation and sand-covered land for vegetable cultivation; using cheap, local technologies, such as bamboo tube-wells and movable pumping sets for irrigation; and applying better cultivation methods.
- Off-farm seasonal migration has become an important adaptation strategy. Temporary migration in search of jobs has increased with the increasing scale of water hazards and has helped offset losses incurred from floods, droughts and water-related hazards, facilitated by improvements in transport and communication and better access to credit and banking facilities.
- The state machinery's limited reach, corruption, and an inefficient bureaucracy have led to poor delivery of government programmes, which otherwise hold potentials to improve communities' capacity to adapt to water-related hazards and stress.
- Non-state actors such as markets and NGOs, to some extent bridge the 'knowledge gap' created by poor government extension and information delivery services. Bridging this gap could enhance the adaptive capacity of the people to respond to floods, droughts, and other water-related hazards.
- Autonomous 'adaptive' strategies in the region have at best helped community groups cope. These strategies provide a blueprint of what needs to be done.

Introduction

This study in the Koshi River basin in India examines the relatively long history and ramifications of human intervention to manage and control the river in this region. The extensive flooding on the flat terrain of northern Bihar results from huge variations in water volume and the deposition of large amounts of sediment during the monsoon.

As the Koshi River loses momentum on the plains, it deposits sediment and shifts course, causing devastation along its path. In the past, the government constructed structural measures, particularly embankments, to deal with floods. These measures have had significant impacts, both positive and negative. Although they limited the area of flooding, those areas inside the structures get longer and more intense flooding and sediment deposition while areas beyond the structures are waterlogged as water cannot drain. The areas prone to flooding or waterlogging have increased 2.5 times over the years (GoB 2009).

The impact of climate change now frequently affects large areas of the basin with droughts as well, creating an urgent need to identify and encourage measures to address it. Communities living in or along the basin have developed their own strategies to deal with both floods and droughts. The Koshi basin supports a huge population that both benefits from its waters and suffers from its hazards.

Geographical context

As the third largest state, Bihar in north India borders Uttar Pradesh and Maharashtra to the west, West Bengal to the east, and Jharkhand to the south. To the north is the international boundary with Nepal. Most of the population of Bihar (83 million) live in rural areas with only 10% living in urban areas.

North Bihar receives about 1,300-1,700 mm of rainfall each year (GoB 2009), mostly during the four monsoon months. The rainfall can be uncertain in terms of both quantity and timing. Most farmers have only rainfed crops, so they face drought and crop failure on a regular basis. Especially for autumn crops, a lack of rains during critical phases in the crop cycle can mean the loss of three-quarters of the expected harvest.

A comparison of the records of 1966-67 and 1986-87 reveals that the flood-prone districts of north Bihar are as or more susceptible to droughts than the districts of south Bihar and Jharkhand. Even Khagaria district, known as 'the submerged district', suffered drought conditions in seven of the 20 years.

Past flood responses and management

Prior to the construction of the embankments, people in the floodplains had adapted and adjusted to the agro-ecological setting, by planning to avoid river flooding during the monsoon from July to September. The annual monsoon overflow of the rivers did not allow the villagers to grow crops harvested in the autumn close to the rivers.

Each village had its own system of floodplain zoning and flexible land-use with different categories of land depending on the soil and altitude (lowland or highland). Specific lands were put to use for different purposes and crops (Singh 2003). For example, people living close to the river mostly grew crops sown in May and harvested in June or sown in November and harvested in March. Those living further from the rivers mostly grew crops sown in June-July and harvested in October.

Many of these traditional land-use systems have disappeared with population growth, extension of cultivation, flood protection measures, and other infrastructure developments in the region.

After considerable deliberations on how to lessen the impacts of the shifting Koshi River, the Koshi project was launched in 1955. It involved the construction of embankments, which were completed by 1959. The construction of a barrage across the river in 1963 was to facilitate irrigation. Massive construction activity followed in other river basins in Bihar.

Despite additions to the total length of embankments, Bihar has the highest number of flood-affected people per capita in India. The area threatened by floods has grown continuously from 2.5 million ha in 1952 to 6.9 million hectares (ha) in 1993 (GoB 1994). Within Bihar, 74% of North Bihar plains are flood-prone. Since 87% of the population depends on agriculture for livelihoods, survival in such a large area flooded for much of the year has become difficult. The state that used to enjoy food surplus now suffers chronic food deficits.

Study sites

As the impact of the Koshi project varies in different villages, the team selected the study sites with reference to their location on the embankment and canal in order to observe differences. Table 2 briefly describes the study site villages.

Socioeconomic context and livelihood patterns

In all the villages in the study, only 20-30% of the people own land, the rest are landless, working as labourers. The upper caste and, to some extent, the middle caste people own most of the land.

Governance – The local people have little or no role in the governance of day-to-day issues despite decentralisation through the Panchayati Raj Act. Elections of local level bodies were held only recently after decades. Even these bodies have caste politics and are a battleground for state and national level political parties. Bihar has a poor record implementing poverty alleviation programmes and government services.

Health and education – The region and study villages are characterised by poor indicators of human development. Although registering an increase of 10% in the last decade, the literacy rate in the Koshi districts is still significantly lower than national standards and state averages. Health services are poor, especially in inaccessible villages. This creates serious hardships for the people with a prevalence of water-borne diseases like malaria, kalaazar, and Japanese encephalitis brought by the floods and waterlogging.

Table 2: **Basic characteristics of the study sites**

Village, district	Location relative to the embankment and river	Accessibility before and during the rains	Water-related Stresses
Chandrain, Saharsa district	0-2 km outside the left embankment	Accessible by all-weather roads; road condition bad	Waterlogging; not completely recovered from sand deposition due to 1984 embankment breach; fields within embankments suffer from massive and widespread sand deposits; villagers live in fear of embankment breach
Dhamara, Saharsa	Between embankment and river on island between two channels of Koshi	Accessible only by boat; boat service bad	River floods and erosion; village lives in constant fear of embankment breach
Tilathi, Saharsa	0-2 km outside the western embankment	Accessible by all-weather roads; road conditions bad	Severe waterlogging
Sarsauwa, Khagaria district	Not protected by any embankment, riverine site between the Koshi and Bagmati rivers	Accessible only by boat and rail; problems transporting agricultural produce	Erosion and river floods; lack of transportation
Rahuamani, Saharsa	8-10 km from embankment and in the command area of the Koshi canal	Accessible by all-weather roads	Canal not working for last few years

Agriculture – Despite sluggish growth in agriculture, most of the workforce is employed in this sector. There are four cropping seasons in the study area. Maize, millet, and paddy rice are the main crops grown during the hot months (May-June) paddy rice is the only crop grown during the early monsoon (June-July). The main crops grown during the winter (November-March) are wheat, legumes, lentils, mustard, potato, and vegetables. Extensive areas in all villages are cultivated with maize, pulses, and vegetables in the hot pre-monsoon season – sown in February-March and harvested in May and June.

Migration for employment – Migration has become a way of life and an important livelihood option for many people, except in Rahuamani. Migration in most cases is temporary; people migrate during the lean agricultural months. Most migrate to the agriculturally dynamic regions of north-west India and to urban and industrial sites for jobs. The majority work as labourers; those with some education or skills land in better jobs. Depending on duration of migration, remittances constitute about one-third to two-thirds of household income.

Animal husbandry – The dairy business is not an important source of livelihood in the study villages, except in Rahuamani, which is close to a town, and Sarsauwa, which has a long tradition of cattle rearing. Poor women in all the villages raise small ruminants, mostly goats, to supplement household income. Fisheries are not an important livelihood option in this region; even the fishing community, the Mallahs, have moved to other occupations for their livelihood.

Impacts of Water Stress and Hazards

The impacts of floods and droughts on the changing landscape, and the increasing intensity and prolonged nature of the floods on the general well-being of the people have been immense. Increased waterlogging, sand deposition, and soil erosion have affected people's livelihoods, especially related to agriculture.

The impacts have been different in the four different zones that emerged after the construction of the embankments – zones trapped between the

In some areas in Bihar high iron content causes damage to teeth.

embankments, protected by the embankments, unprotected, or a distance from the embankments.

In areas trapped between the Koshi embankments, erosion and sand deposition on fields is intense. Nearly a million people live in the 380 villages in this zone, including Dhamara, one of the study sites. Villagers of the area still hope that the floodwaters will bring silt, rather than sand, to fertilise their land. Agriculture within the embankments did improve considerably and Dhamara has experienced agricultural growth.

In protected countryside close to the embankment, a significant portion of agricultural land remains waterlogged most of the year making agriculture virtually impossible in villages such as Chandrain and Tilathi. The villagers live in constant fear of embankment breach, as the Koshi embankments have breached eight times (Mishra 2008). They keep vigil at night during the rainy season as they would have very little time to move to higher ground in case of a breach. This problem is particularly acute in a strip of land about five km wide along the embankment.

Areas that have been in the direct path of the Koshi flood after an embankment breach take years to recover and return to normalcy. For example, Chandrain was in the direct path of the waters during the 1984 breach and has yet to recover fully 25 years later.

Large populations living along unprotected stretches of the river experience the adverse impacts of upstream embankments. Beyond Ghonghepur, the Koshi is free to wander on its western side where rivers, like the Kamala and the Bagmati, join it. However, the combined waters make life difficult for unprotected villages like Sarsauwa.

Communities further away from the embankment and the river have benefited from the Koshi project and have not had to deal with the river's swelling or changing course. Many came under the command of the Koshi irrigation canals. Despite government promises, the canals created irrigation potential that has been massively underutilised (GoI 1973) in villages such as Rahuamani. The experience of the floods of 2008 also shows that even this zone is not safe from the devastation caused by embankment failures.

In the first three zones – between the embankments, protected by the embankments, and in unprotected areas – agriculture is impossible from June to October or December, depending on village location and the duration of waterlogging.

The perennial flooding has affected the availability of clean drinking water, and other aspects of human well-being including livelihoods, education, and health. Prior to the embankment construction, animal husbandry and pisciculture (fish farming and aquaculture) supported large sections of the population. The construction of embankments, barrages, and other infrastructure has diminished vast open grassland areas causing a significant reduction in the cattle population. The livelihoods of the Mallah fishing community declined as the obstruction of the river's flow and neglect of ponds and reservoirs reduced the fish stock and variety.

Adapting to Water Stress and Hazard

People have adapted to changes brought by floods and droughts in different ways. Many parts of North Bihar have witnessed the development of alternate land-use and cropping systems to adjust to water-related stresses. Most adaptations in agriculture aimed to cultivate land intensively during the short period land can be cultivated. Some of these strategies are analysed in the next section.

Non-structural responses

Communities have adapted to water-related stress and hazards by making small changes and adjustments in livelihood practices, institutional arrangements, and social relations. Most non-structural measures and strategies adopted by the communities require little or no investment except adjustments in cropping season and practices.

Adjustments in the cropping cycle – In the villages of Dhamara and Sarsauwa, which suffer river floods almost every year, farmers still take the risk of planting monsoon season (June-July) paddy, even though the fields get flooded during these months. Farmers living between the embankment and the river or in unprotected areas broadcast paddy in the field hoping that the crop might survive if the floods are low. This risk-taking becomes worth their while once every three years, when the fields actually produce a bumper harvest.

The same categories of land support a good crop harvest in the dry, winter season (November-March) depending on where the river is flowing. If the river deposits thick layers of sand, there will be low crop yields or no crops at all; but if the floods deposit a good layer of silt, as has happened in Dhamara village in 1990, the fields will produce good harvests of wheat, maize, and pulse.

Cultivation of crops in the hot pre-monsoon season (sown February-March and harvested May-June) is a new response to acute waterlogging in lands close to or outside the embankment. Farmers in Tilathi and Chandrain do more cultivation in this pre-monsoon season as both villages suffer from long periods of acute waterlogging. In Tilathi, where waterlogging is more acute, only a small portion of land is cultivated in June-July. Farmers cultivate areas with winter (November-March) and spring (February-March) crops in Chandrain village where most of the village is within the embankment.

Farmers irrigate crops from November to March, when two to three watering times are required for wheat, maize, and rice. In all the villages, farmers irrigate fields through privately owned bore-pumps. Although farmers in Rahuamani are in the command area of the Koshi canals, they have not received water from the canals for the last five years.

New and better crop varieties – The area planted with a new rice variety has increased in recent years especially in Tilathi and Chandrain villages. This coarse rice is grown mostly for household consumption to address food security for poor households as it does not command a good price in the market compared to other rice varieties.

Farmers have started to use other new varieties of wheat, maize, and vegetables that are better flood or drought adapted and higher yielding. Since the late 1990s, they have also cultivated an early variety of maize that is harvested by May before the first floods occur. Private seed marketing companies introduced the new crop varieties and tried them first with big, entrepreneurial farmers.

Other new crops, such as sunflower, have been introduced in the flood-prone villages of Dhamara and Sarsauwa. In the latter village, farmers plant sunflower on lands completely under water for four months of the year. Sunflower is a profitable commercial crop, which destroys weeds, improves soil productivity, and costs little to cultivate.

Water lily (*Euryale ferox* Salisb), called makhana locally, is now a major aquatic crop cultivated in waterlogged

In some areas of Bihar, water lily (makhana) cultivation is providing an alternative use for waterlogged land next to embankments.

fields. It is a nutritious non-cereal food commonly used in the preparation of sweets and other recipes. Its cultivation requires standing water (maximum one metre deep), the right soil type, and favourable climatic conditions. Large areas of waterlogged land and other water bodies in the Koshi basin are now under this crop. With the decline in fish stock, the Mallah fishing community depends on this crop for its livelihood. The crop is demanding to cultivate but commands a good price in the market. The growing demand for makhana is evident from the increased number of private companies cultivating it commercially.

On land within the embankments, sand deposition poses a serious problem. Here, several Muslim vegetable farmers lease these lands for vegetable farming. Some sand-covered land is good for vegetable farming, especially for the cucurbit family of plants. Vegetable farming is widespread in Rahuamani due to its proximity to markets in Saharsa. New, high-yielding vegetable varieties have increased the profitability of vegetable farming and helped landless Muslims improve their lives.

Better cultivation methods and techniques – Farmers have developed practices to reduce the degradation of land or soil fertility even though the land available for intensive cultivation is already declining and the time period available for cultivation is short. They use mixed cropping and rotational cropping to maximise crop yield yet keep the soil fertile. Common practices are to mix the cropping of maize with summer rice and maize with lentils and/or millet. In many places, farmers use the field bunds to grow teak trees or manajera[1] plants. They also use the same water body for water lily cultivation and fish farming. Manajera and lentils, apart from their other uses, are nitrogen-fixing plants sown especially to reclaim soil fertility.

Animal husbandry – In most areas of Bihar, farmers have decreased cattle rearing or changed the cattle breed because the spread of waterlogging has reduced common grazing land. Meanwhile, the rearing of small ruminants, mostly goats, has increased especially among poorer castes and classes, such as the Musahars and Muslims. Goats are easier to manage and feed even during floods. A practice similar to sharecropping, share rearing of goats is widespread in the region. Goats command a good price in the market – an adult year-old male goat can be sold locally for Rs1500.

Migration and remittances – Off-farm seasonal migration has always been a livelihood option for people living in the floodplains, especially those who are resource-poor. It has increased since the construction of the embankment has increased stresses caused by floods and droughts and changed the agro-ecology. The disruptions to agriculture have forced both landed and landless labourers to seek employment outside their villages.

For example, in Chandrain, Tilathi, and Dhamara villages, about 80% of adult males migrate during the non-agricultural season. Most leave their villages at the end of May or beginning of June after they complete the hot season farm activities. They return when the land is ready for cultivation, either in the beginning of the cool, dry season (early November) or the hot season (February). While the men are away, women, children, and old men do not have much farm work except for labour on some government-sponsored rural schemes. With improvements in transport and communication, finding work in far-off places has become easier. Each household has its own social network which refers them to outside work opportunities.

Access to loans – Although the traditional money-lending castes do not operate in this region, people in the village who are relatively better-off provide small loans without collateral, but at high interest rates. Work migrants often need this small cash to cover the cost of their travel and the upkeep of the family they leave behind. Small farmers also need petty cash to buy seeds and fertilisers before the planting season. Local shopkeepers sometimes provide goods on credit and charge interest for deferred payment. With improvements in rural banking, workers can more easily send remittances to families.

Overall, migration has been a very important adaptation strategy to adapt to the changing nature of hazard and stress in the basin. It is expected that migration will increase further with growing population pressure on land resources and more employment opportunities in economic growth centres in other parts of India. However, the introduction of employment guarantee schemes in rural India could lessen dependence of temporary migratory work.

[1] Manajera is a kind of shrub that helps in nitrogen fixing and reclaiming soil fertility. It generally grows along the boundary of the agricultural fields and is often used as fuel during floods and prolonged waterlogging.

Structural responses

Without much external support, communities in north Bihar have developed several autonomous responses to deal with water stresses.

Bamboo bore wells – In the early 1970s, bamboo bore wells were introduced in north Bihar. Their cost is low using locally available bamboo materials and expertise. It costs a farmer about IRs 7,000-8,000 to bore a bamboo tubewell about 25 metres deep – the cost of a regular tube boring is at least 5-6 times more. Bamboo bore wells last for about 10 years and can easily be used to irrigate about one acre of land. The increased use of bamboo tube wells has increased the intensity of land use by small and marginal farmers and contributed to addressing the wide income disparity in the villages.

Movable pump sets for hire – Movable pumping sets can easily be rented at Rs 60/hr (of pumping) in order to obtain sufficient water. The sets are mounted on small bamboo carts that are moved from field to field to service bore wells and fields. The pump owner provides diesel or kerosene for the pump and plastic pipes to transport water. Those who do not own bore wells pay another Rs 5-10 for pumping water from a private bore well.

Food and fuel storage systems – Households make cylinder-shaped silos (storage towers) of mud, cow dung, and bamboo strips that are elevated several inches above ground to store food (mainly maize and rice) and fuelwood (cow dung cakes, maize stubs, dried manajera plants, bamboo roots, and so on). They make the cow dung cakes round and bigger for easier storage and transport in times of emergency. They also make long cow-dung cakes of dung and mustard stalk as a wood replacement.

Flood-adapted housing – Most households in the project areas used local materials to construct their houses. Bamboo frames hold bamboo screens plastered with mud and cow-dung. The roof is thatched with locally available dried grass or crop residues. Households in all the villages build houses on a plinth. Villagers in Dhamara and Sarsauwa build houses on even higher plinths over the debris of old homes to be above the maximum flood level. Dhamara residents are confident that the river will have to flow over the embankments before flooding their homes.

Most households, especially those that can afford it, construct a tube well as part of the raised homestead. In villages suffering from perpetual waterlogging, the plinth level is not so high, but new houses made of bricks and cement, are constructed at higher plinth levels. In these villages, remittances are used mainly to build brick and cement houses with flat roofs that can serve as points of refuge during big floods.

Factors Influencing Local Adaptation

Absence of a rehabilitation and resettlement policy

The study sites experience a loss of access to their productive assets, especially agricultural land, when floods breach an embankment or a river changes course and during prolonged periods of waterlogging. Floodwaters breaching an embankment also deposit sand on fertile agricultural land.

The government does not have a policy to encourage reclamation of land damaged by sand deposits and waterlogging. It considers all land outside the embankments to be protected. In reality, these lands have lost their productive capacity temporarily or even permanently, due to the poor drainage caused by these conventional flood control structures. Various drainage schemes have failed to improve the situation. The state has not compensated Bihar residents for this loss in land productive assets.

Increase in green revolution technology and packages

Nevertheless, two factors have revived agricultural growth – access to agricultural credit and penetration of the market by private seed and fertiliser marketing companies. Through aggressive marketing, new and improved hybrid seeds have been made available in nearby towns. The assistance of some NGOs has popularised new methods of cultivation, such as rice intensification or SRI. The increases in remittances have promoted investments in agriculture.

Portable water pump used for irrigation in some areas of Bihar, India.

Most innovations happen at the local level without outside help because state extension services are effectively absent, extension officers are overworked, government seed distribution centres hardly function and even if they do, do not provide seeds on time. The quality of seeds distributed by private traders is not monitored.

Access to markets and food storage facilities

Inadequate roadways and improper transportation facilities have a direct impact on access to markets. In most cases, producers are forced to sell their products within the village or in nearby villages. Thus, they have little opportunity to negotiate for better prices. Although the community has its own household food storage system, there are no cold storage facilities at the study sites for long-term storage. Therefore, poor access to markets and lack of adequate long-term food storage facilities constrain market potentials, and adaptation.

Improvement of road and railways facilitate migration

The rural infrastructure has improved during the last three decades. The improved transportation system has facilitated labour mobility to areas with potential labour demand and has increased access to markets and other facilities. However, despite increased investment in infrastructure, large areas of the region remain inaccessible.

Rural banking and easy transmission of remittances

Banking in the rural areas has improved greatly. Households have used remittances to develop their assets in certain sectors, which has improved their capacity to adapt to floods and droughts. However, some problems remain. Those individuals who are poor and illiterate have difficulty opening bank accounts. They have no option but to depend on sending remittances through people holding bank accounts. Sometimes, this leads to pilferage of their hard-earned income. Despite the growing reach of nationalised banks in rural areas, they have often failed to benefit poor and marginalised communities. Most poor people have had to depend on informal village moneylenders to obtain of credit.

Rural telecommunication system

In the study areas, improvements in telecommunication have brought access to a mobile telephone network that enables the population to keep in touch with potential employers. Access to telecommunications has helped in early warning about floods.

NREGS and other poverty alleviation programmes and schemes

Various poverty alleviation and environmental management policies and programmes could increase the resilience of people in disaster-prone areas. The National Rural Employment Guarantee Scheme (NREGS) is one of the largest social security programmes in the world. It provides 100 days of employment locally to households in all the districts of India. Besides alleviating poverty, this scheme creates community and household assets that can be used in dealing with floods. However, in practice in the study villages, inefficiency and corruption in the bureaucracy has prevented the scheme from being implemented fully and from achieving its ultimate objective. Some structures being built through this scheme lack the quality that could enable adaptation.

The implementation of other programmes, such as the distribution of subsidised food grains for families below the poverty line through the public distribution system and a housing scheme, happens in ways at the ground level that defeat their purpose. A possible cause is corruption and inefficiency in the bureaucracy.

Lack of adequate infrastructure for education

People with education and skills get better jobs when they migrate, while others only get opportunities for manual labour and are more prone to exploitation. Illiteracy is the main cause of low adaptive capacity of the people in the area.

Large sections of the population in the study sites do not have access to education despite increased budgets and spending on education and the introduction of literacy programmes. The situation is worst in the flood-prone areas of north Bihar. In a large number of inaccessible villages, absenteeism among teachers is common.

Conclusion and Way Forward

Conventional flood control structures changed the agro-ecology of the Koshi basin, increased the frequency and intensity of water related stress and hazards, and increased the area that is flood-prone or waterlogged. Erosion and sand deposition have put huge areas out of cultivation temporarily or permanently. The embankment

structures are not failure-proof as evidenced by eight failures in the past. Considering the projections for future climate change, these conventional structures could cause further distress and destruction.

Communities have been experimenting and innovating strategies to deal with water stress and hazards in their own ways. These innovations include

- making adjustments in the cropping cycle and better cultivation methods;
- introducing new and improved crop varieties and use of waterlogged land for water lily cultivation and sand-covered land for vegetable cultivation; and
- using cheap, locally available, and appropriate technologies for irrigation, such as bamboo tube-wells and movable pumping sets.

These 'softer approaches' devised by the people themselves compensate many of the losses incurred from floods, droughts, and other hazards. They are based on the approach 'get away from the flood rather than prevent it', which is an ecologically sound way of dealing with rivers in flood plains.

There is a need to rethink the way we deal with rivers and other natural resources in floodplains as reflected in policy instruments and in a structural change in governance at the local and national levels. The delivery of government programmes and schemes will improve with the involvement of communities and civil society in environmental governance and in the development process.

To the state's credit, it has helped communities respond to water-stresses through improvements in transport and communication networks in the region, huge investments in rural development, present (albeit weak) law enforcement, and working democratic political systems. These enabling measures need to be further strengthened and streamlined.

Communities have their own autonomous responses to cope with excessive floods or droughts. The promotion of these autonomous measures and other measures could improve the communities' general well-being. This study could not determine the extent of these practices and their effect on the overall well-being of the people. Further studies and detailed analysis are needed to understand the benefits of these measures.

Finally, community-initiated responses provide a blueprint for scaling up and strengthening an adaptation strategy for the region. There can be no permanent or fixed adaptation strategies as a resilient system or community requires flexiblity to change strategies according to the demands of the situation. Better governance must provide the enabling structure for this flexibility. Increased investments should focus on improving the capacity of communities to adapt.

Adjusting to Floods on the Brahmaputra Plains, Assam, India*

Aaranyak, Guwahati, Assam

Key messages

- Indigenous communities living in flood-prone areas in eastern Assam have been responding to floods and other water-related stresses in unique ways, based on their traditional knowledge systems.
- With the intensity and frequency of the hazards increasing in recent times, their ways of coping and adapting have also changed and have sometimes become less effective.
- Cultural norms play a significant role in determining how these communities cope and adapt.
- In recent years, prolonged and extreme floods, intensified riverbank erosion, and siltation have severely challenged the capacity to respond and rendered agriculture (the prime source of livelihood) no longer viable in Matmora, and less productive in Majgaon.
- The communities need help to strengthen their adaptation capacities through intervention programmes aided by good governance.

Introduction

This study in the Brahmaputra Valley of Assam examines one of the most flood-prone valleys in India. Every year, floods, flash floods, riverbank erosion, and sand deposition on fields overwhelm the landscape. However, flash floods have become more devastating since the mid 1990s, especially on the northern bank of the Brahmaputra Valley.

Indigenous communities living on the riverbanks have developed traditional livelihood mechanisms seen in their dwellings, agriculture, livestock-rearing practices, and food storage. They have ways of foretelling floods and the weather, which have enabled them to cope and adapt.

Until two decades ago, farmers perceived short-duration floods as beneficial because the flood waters brought nutrient-bearing silt that helped enhance soil fertility along the riverbanks. Since then, the floods have become more intense and frequent. They submerge more areas for longer periods, causing damage to crops, and eventually rendering the soil unsuitable for any form of cultivation (Goswami and Das 2003). The communities are having to cope and adapt in new ways.

The Brahmaputra river and its tributaries drain the state of Assam in northeast India (population 26 million). The river originates from glaciers in southern Tibet (elevation 5,300 masl) and enters the Bay of Bengal after traversing 2,880 km through China, India, and Bangladesh. About one-third of the Indian part of the Brahmaputra Basin is in Assam. The Brahmaputra Valley within Assam consists mainly of vast alluvial floodplains covering an area of about 56,480 sq.km (altitude 34-130 masl).

Study sites

The team looked at two villages, Majgaon and Matmora, located in Dhemaji and Lakhimpur districts in the eastern part of Assam on the northern bank of the Brahmaputra River bordering Arunachal Pradesh (see Table 3). The five villages at these sites are home to three important indigenous communities: the Mishings in Matmora village and the Ahoms and Chutiyas in Majgaon. In Matmora, there are also several Assamese caste groups, including Brahmins and Koibarttas and a small population of Bihari people, who came to Assam from Uttar Pradesh 30 years ago.

* A documentary film '**Living with Floods**' on this case study is available on a separate DVD from ICIMOD.

Table 3: **The study sites in Assam**

	Village	Households	Community/caste group	Population (% covered)	Block/ District
Majgaon	Majgaon	68	Ahom, Chutiya, Baishya	283 (80%)	Bordoloni (Dhemaji)
Matmora	Bahpora	128	Koibartta, Brahmin Bihari	557 (50%)	Dhokuakhona (Lakhimpur)
	Opar Khamon	33	Mishing	147 (60%)	
	Khamon Birina	70	Mishing	336 (60%)	
	Tinigharia	22	Mishing	150 (40%)	

All the villages have experienced floods, especially since 1950 when a displacement in the bedrock occurred which made this area more flood prone and triggered an earthquake, and have made common attempts to cope and live with these stresses. However, there are also marked differences among these communities in the degrees of exposure and vulnerability to water hazards and in the way they adapt depending on each ethnic or caste group's culture, traditions, indigenous knowledge, and access to outside interventions.

People at both research sites reported changes in the local climate. In Majgaon, the summers have become warmer and longer. Increased rainfall intensity and frequency of heavy rain spells have led to more flash floods. Floods have become more furious and rivers now carry more sediment.

The microclimate has assumed the properties of an arid desert area, with groundwater going down and soil layers underneath losing moisture. According to the locals in Matmora, the climate has become hotter and more sultry, monsoon rains have become irregular and unpredictable, and heavy rains and storms more frequent. The village and nearby areas were devastated in 2007 when a major flood in the Jiyadhal River breached embankments.

Impacts of Water Stress and Hazards

Matmora

The annual cycles of water hazards combined with increasing impoverishment have reduced the communities of Matmora to disparate groups of the poor, displaced from their ancestral places and challenged with having to begin life anew each year.

The hazards have led to homelessness, landlessness, breakdown in agriculture, and loss of traditional livelihoods.

In the last two decades, the Brahmaputra River has engulfed parts of several embankments and more than ten villages – compelling people to shift to new areas or adopt semi-nomadic lifestyles. Increased spells of heavy rainfall have prolonged flood inundation, and the two recent big floods in 2007 and 2008 left 1-2 m deep layers of sand in more than 25 villages.

Matmora was an agriculturally prosperous area with self-sufficient farmers; the floods have reduced it to a sandy and barren landscape where agriculture has ceased to be the main source of livelihood. People have sought to become daily wage earners; fisher folk; carpenters; or small traders selling country liquor, milk, and other local produce. Many migrate to other places for menial labour in factories, industries, and service jobs. Some collect driftwood from the bed of the Brahmaputra River, risking their lives at times to sell the timber. Some have become skilled boat makers catering to the high demand for boats and using the timber from the rivers or trees in and around the village. Weaving has become an important income generating activity for the women, who also work as labourers in the construction of roads and the embankments.

The local scale migration, both temporary and permanent, has caused psychological trauma and social dislocation for many. Many young people who migrated in search of jobs have had to discontinue their education. This has drastically decreased the educated population in the area, once known for its contribution to social and literary fields.

Two types of chang-ghar (house on stilts of the Mishing community) in Matmora: left, the original design of bamboo and wood; centre, wealthier households invest in concrete to make higher stilts.

Majgaon

A chronically flood-prone area, Majgaon remains inundated for half the year. It has lost most of its vegetation and fruit trees from prolonged waterlogging, which has degraded the soil. The deposits of silt and debris brought by the 2007 floods have made areas in Majgaon a wasteland and seriously affected agriculture.

The deposits filled many wetlands, affecting fish production and fishing as a livelihood in these areas. Then again, continued silt deposition for decades has gradually converted some low-lying marshlands into plains, which are new farmland for the villagers.

Rice agriculture is still the primary source of livelihood, with people cultivating ahu (summer) and bao (deep water) paddies. However, about half the village population have found livelihoods outside the village as daily wage earners. Another 23% of households have taken up fishing and 14% liquor making. Other sources of income are livestock rearing, especially ducks and pigs. The community used to raise chickens until this became increasingly difficult in a flooded environment. During the monsoon, fish have become abundant in rivers, wetlands, and rice fields, making fishing an important seasonal livelihood source.

Responses to Water Stress and Hazards

The communities have responded to floods and associated hazards in diverse ways based mainly on their local knowledge and the skills acquired living in riparian environments. These responses have been aided to some extent by external interventions.

Housing and settlements

Mobile settlements – The Mishings of Matmora have traditionally been riverbank dwellers, making them better adapted in dealing with floods. They have always been flexible, moving to new places to cope with the river's changing course. The original villages have moved to new locations more than six times since establishment of the first embankment on the Brahmaputra in 1954. The villages moved as a community, retaining the village name and transplanting village institutions like the village school and the murang ghar (community hall) to the new setting each time.

Traditional Assamese houses are built on an elevated platform (left) with a separate granary built on stilts (right).

However since 1998, when the river waters engulfed four-fifths of the villages, this adaptation strategy is no longer working. Households have started moving on their own, independently of the village, breaking down age-old village institutions. Many ended up in nearby villages or on sections of the embankment that remained intact after the floods.

Chang-ghar housing – The Mishing live in traditional stilt houses called chang-ghar made of thatch. They build the houses on wood and bamboo stilts at an average height of 2-2.5 m (6-8 ft) above ground – in line with the highest flood level experienced in the area in recent times. The design of a chang-ghar provides ideal protection from floodwaters and allows for a variety of activities, such as livestock rearing and food storage. The more recent use of concrete materials for stilts or staircase has made the dwellings stronger against flood currents, but has reduced the dwellings' flexibility and made repair more costly.

Raised homesteads – Other communities, such as in Majgaon and Bahpora, live in houses with foundations elevated 0.5-1.2 m (2-4 ft) above the ground as a response to the floods. They are reluctant to live in stilt houses due to cultural biases associating this type of dwelling with ethnic groups such as the Mishings.

The height of the earthen or brick-and-concrete foundation of raised homesteads varies depending on the economic situation of the households and their decision on how much to invest in raising the homestead – higher platforms mean greater investment costs because more materials are used. The platforms are also used to shelter livestock. During floods, the households will take shelter temporarily by a roadside or in the nearest available concrete public building, such as a school.

Responses in agriculture

Mixed rice cultivation in Majgaon – Due to damage by floodwaters, the Majgaons no longer cultivate sali (wet season rice); instead, they plant bao (deep-water rice), which is adapted to water and resistant to floods. Farmers now mix indigenous varieties of summer rice (ahu) and deep-water rice to provide options in case the crop of one variety fails and to optimise the use of land. In a 'normal' year, when the floods are not so prolonged and virulent, both rice varieties survive. However, early flooding in April or May might damage the summer rice while the better-adapted bao will survive and ensure food security for these communities. Indigenous varieties of bao show considerable tolerance to flood waters.

Experiments in boro paddy – Boro (winter season rice) is a viable alternative variety suitable for perennially flooded areas. A group of farmers in Bahpora village (Matmora) are cultivating boro paddy in waterlogged areas with technical guidance from the district agriculture department. In the absence of irrigation facilities, investment in a pump set is necessary for off-season rice cultivation.

Agriculture on a river levee – In an effort to identify new land for cultivation in safer, higher elevation areas, villagers are starting to occupy land with grassy forests located on the river levee in the western part of the village. These areas used to be marshlands but bedrock displacement, triggering the 1950 earthquake, elevated them on both sides of the Na-Nadi River. Villagers flattened some of these areas to make fields for winter crops, such as mustard, black gram, lentil, cereal, cabbage, and even wet season rice.

Diversification from farm to non-farm livelihoods

To cope with the breakdown in traditional agriculture, farmers are diversifying to new sources of livelihood. However, they do not always successfully reduce their vulnerability.

Fishing – The subsistence activity of fishing is developing into a viable alternative livelihood despite the cultural norms of certain communities that discourage it. The villagers themselves, or fish traders, process and sell dried fish in the dry fish market of neighbouring Morigaon district. This profitable small enterprise has the involvement of cooperatives and well-established production and marketing channels. The proven benefits are motivating more and more people to engage in this enterprise.

Processing and sale of homemade traditional liquor – Traditional winemaking for domestic or home consumption is an age-old practice, but now some communities process and sell both traditional wine and the cheaper country liquors for income.

Employment in service and other jobs – The source of income most immediately available for people is menial labour in construction or agriculture in nearby areas and towns. The ongoing construction of the new embankment and installation of erosion protection structures in Matmora are providing temporary employment.

Young men migrate to other districts for service jobs and employment in the informal transport sector. Others get jobs in neighbouring states like Kerala and Nagaland. Most migrant youth do not settle permanently in these places of employment. The remittances they send help keep their families from poverty during the floods.

Indigenous crafts – Many women in these communities have traditional weaving skills to make mats for household use. The women are now earning a steady income from their woven products. They are improving their weaving quality and design by paying more attention to the requirements of the market for quality, good design, and quantity. The Mishing women are doing well in this activity.

Resale of agro and dairy products – Another livelihood activity with less risk is buying and reselling for a profit agricultural and dairy products, like rice, milk, curd, and gud (condensed sugar). This is giving rise to a new class of middlemen traders who were once primarily producers or farmers.

Factors Affecting Adaptation

A wide range of factors – social, governance, infrastructure, and environmental – enable or disable adaptation to the growing variability of water-induced hazards in Assam.

Social factors

Traditional knowledge base, skills, and capacities – The communities have a long history of living along the river and cultural linkages with water. This has equipped them with survival skills and the mental conditioning to be ready to start over after every disaster. Skills, such as swimming, and boat and raft making, have helped these communities to survive every flood or other water-related hazard that has come their way.

Experience has endowed the communities with the indigenous wisdom to observe changes in the weather that foretell the coming of rains and floods. There are are also folk beliefs regarding traditional medicine and healing, local skills and raw materials for housing construction, pig farming, wine-making, and food storage. Modern acquired knowledge has enriched some traditional practices.

Cultural norms, taboos – However, cultural perceptions can also hinder adaptation by these communities. Non-Mishing communities are reluctant to adopt the stilt house for dwellings and the traditional societies have reservations about income generating activities like fishing. For many years, these perceptions have hindered their capacity to adapt. These norms are not rigid, but it takes time to change people's behaviours and mindsets.

Support role of local institutions and social networks – Local institutions are serving as a stabilising factor in this turbulent environment and helping the communities to adjust to the stresses of floods and other water hazards. The Namghar, community prayer house fulfils the religious and spiritual needs of the Assamese caste groups of Majgaon and Bahpora. It guides people's behaviour through a set of norms for social harmony.

Amongst the Mishing community, the kebang (union of villagers) and the murang ghar (community hall) are local institutions that provide platforms to keep community social networks alive and strengthen personal relationships among community members. They are a forum for open discussion, collective decision-making, and settling problems and conflicts.

Social cohesion, amicable relationships, and, with the Mishing community, strong bonds of clanship motivate people to help each other during floods and distress. Those who have boats lend them to others in need; people provide shelter to those displaced. They accommodate and help each other while sharing shelters by the roadside or on an embankment, and lend money to those in need with nominal interest. This sense of community amidst disaster helps people survive better in times of need.

Women's self-help groups – Several self-help groups were functioning prior to 2007. They started early in the decade and flourished with diverse income generating activities until the major floods of 2008 and 2009 affected their enterprise activities. Many of the SHGs continue to offer micro and small lending activities that have provided cash for households and communities during floods and hard times.

Governance factors

Government policy and programmes – The construction of roads under the National Rural Employment Guarantee Act programme and the ongoing construction of a new embankment to plug the breaches in the old Matmora embankment have benefited people in times of flood. However, these programmes are not available to everyone and government policies and programmes leave much to be desired, especially in terms of empowering the communities in a sustainable way and building their capacities to cope with disaster through training.

The lack of proper policies and programmes has hindered adaptation in these areas. The programmes could provide for the construction and maintenance of embankments, flood insurance, flood plain zoning,

Traditionally, Assamese women weave their own clothes. Some are now selling their products as a result of the impacts of floods.

Young women using local boats during the floods in Assam.

restoration of degraded lands, innovative agriculture on degraded land, alternative livelihoods for people affected by floods, and routine relief and rehabilitation work. People stay in vulnerable places like embankments or close to riverbanks due to the lack of environmentally and culturally suitable rehabilitation and resettlement packages. The lack of reliable early warning systems has also hampered people's preparedness for floods.

Local politics and governance of embankments – Three consecutive major floods in Matmora from 2007-2009 were mainly the result of a failure to repair and maintain the embankment in a timely and technically sound manner. These events and the apparent assumption that floods will breach the embankments every rainy season could suggest that bad governance, corruption, and an unholy alliance between the contractors, politicians, and government departments are hindering proper maintenance.

External assistance and intervention – Relief and rehabilitation development agencies, local NGOs, and welfare organisations have helped the communities cope with the immediate effects of floods and return to normal life. Their assistance has provided food and water supply, plastic sheets, medicine, hygiene kits, and facilities for rehabilitation such as boats, raised seed bank, and high-rise platforms. NGOs have also helped to sensitise and train local communities to prepare for floods, which has been useful.

Infrastructure factors

Embankments and flood management structures – Embankments and structural measures serve as both enabling and disabling factors to adaptation. They protect people from floods and erosion over the immediate term and allow people to attend to their lives and livelihoods while finding ways to cope better with the changing nature of the floods. However, people can become too dependent on these structures, which limits their motivation to cope and adapt in other ways.

Communities become used to the protection of the embankment, which gives them a false sense of security and confidence to expand their settlement right up to the river bank. When the embankment collapses, the communities' sense of security collapses as well.

Lack of irrigation – The lack of public irrigation facilities in these areas is a major impediment to increasing agricultural productivity by limiting the communities' options for winter crops, especially the cultivation of boro rice. Thus, the capacity of the communities to cope with post-flood shortages of food is limited.

Environmental factors

Changed nature of disasters – Although people are used to riverine floods, the increased intensity and frequency of floods have made them more vulnerable. Erratic and irregular patterns in rainfall have created uncertainty for rainfed agriculture. Floods due to regular breaches in embankments and the increased sediment load in floodwaters have caused widespread sand deposition, the scale and intensity of which are now beyond the known coping mechanisms of these communities.

Conclusions

The changing nature of water hazards in recent years has made people more vulnerable and rendered traditional adaptation practices less effective. Cultural traditions and perceptions can affect people's vulnerability and adaptation practices both positively and negatively. Both the poor and the rich are vulnerable in different ways.

Women suffer more during floods, which may confine them to their households on raised platforms with a heavy load of responsibility and work to manage drinking water, cooking, and tending their children and livestock. When women are in a boat to transport them somewhere, they must hold back nature's call due to the lack of toilet and bathroom facilities, and put their sanitation and hygiene on hold.

Self-help groups mostly women groups, need to be supported with financial subsidies to enable them to

resume the income generating activities which came to a halt after the floods of 2007. Micro-credit transactions also became irregular because members cannot afford to pay the deposits. Easier lending and repayment schemes could help them cope and adapt.

Promulgation of proper policies and implementation of existing relief and rehabilitation programmes can empower people and enhance their adaptive capacity.

Of the communities of Assam, the Mishings have been the best adapted to floods. However, they have also become the most vulnerable community due to the increasing intensity and frequency of the hazards, the proximity of the river, and their deepening poverty.

The community cohesion that used to be strong is being eroded now as the communities are being scattered to different places and forced to adapt on their own. Researchers and planners need to review indigenous adaptation practices and the changes. It would be relevant to examine whether the traditional coping capacity and adaptation strategies are still useful, and if they can continue to deal with the changing nature of the multiple water-induced disasters, and the social, economic, cultural, and political factors affecting society as a whole.

Traditional coping and adaptation mechanisms that have worked, such as the indigenous house design and early warning indicators, could be promoted through government policies and programmes, perhaps with incentives from the government and other institutions.

Recommendations

- Build the awareness, sensitivity, and capacity of communities to adapt to their changing environment and to develop alternative livelihoods.
- Support the communities to sustain and perpetuate selected local adaptation strategies, such as those mentioned in this report, that have been proven effective in enabling them to live better in hazard-prone areas.
- Train farmers in innovative agricultural techniques suitable for degraded lands.
- Promulgate suitable policies pertaining to embankments, flood insurance, and resettlement and rehabilitation, and implement these programmes in a timely fashion to be effective.

In Assam, some people have become permanent squatters on the embankments due to lack of other options.

Diversified Livelihoods in Changing Socio-ecological Systems of Yunnan Province, China

Centre for Mountain Ecosystem Studies of Kunming Institute of Botany, and World Agroforestry Centre, China

Key messages

- Government policies play a key role in shaping the extent to which rural households are able to adapt to climate change and climate hazards.
- Economic reform and shifts in property regime have weakened rural institutions and collective action in water resource management.
- Local people's exposure to risks induced by climate change has decreased due to the rural transformation brought about by the open market period and off-farm income opportunities.
- The various biophysical and socioeconomic conditions in the study sites generate differing degrees of exposure to natural hazards and climate-induced risks and diverse options for adaptation.
- Agricultural intensification depends on large quantities of chemical fertiliser inputs, and this might cause maladaptation as well as greenhouse gas (GHG) emissions.

Introduction

The study examined adaptations and responses in three locations in Yunnan, China. It also studied how state policies and local institutions have shaped the capacity of the rural population to respond and adapt to climate change and climate-induced risks. This paper highlights how external interventions can help strengthen the functioning of rural institutions and innovations relevant to adaptation.

In many parts of Yunnan Province, China, mountain farmers have responded to threats from climate variability for decades now and centuries in the past. Climate change may increase the expected magnitude, frequency, and intensity of such threats. The success of adaptation practices developed by rural farmers depends on the nature of prevailing state policies, formal and informal institutions, and financial investment in risk-reducing infrastructure.

Over the past half century, rural farmers in China have faced uncertainties in the transformation from a centrally planned and collectively managed agrarian economy to a market-driven one. At the same time, they have faced climatic uncertainties and change. These two processes, climatic and economic, both affect the short-term responses of farmers to climate risks and change, which in some cases leads to maladaptation or unsuitable responses.

Study sites

This case study was conducted in three villages that represent different topographic, altitudinal, and agro-ecological zones in western Yunnan, China. Yunnan Province covers 394,000 sq.km, and includes the headwaters of Asia's six largest rivers that sustain over 600 million people within the basin boundaries. It is home to 46 million people, most of whom dwell in the mountain regions.

The mountain geography creates a mosaic of settlement patterns, land use, and livelihood practices. Local people, including 25 distinct ethnic minority groups, have adapted in ways that demonstrate their local ecological knowledge and intimate relationship with the environment and climate.

The three villages are located in Longyang District, Baoshan Municipality, which is famous for its high production of grain (almost 1 million tonnes in 2007) and intensive cultivation of cash crops, including coffee, sugarcane, off-season vegetables, tobacco, and walnuts. The three sites have distinct wet and dry seasons with precipitation mainly concentrated in May-October due to the influence of the Indian monsoon. Daojie and Taokong are in the Salween River watershed; Baicai is in the Mekong River watershed (see Figure 5).

- Daojie village is in a low, dry-hot valley with little precipitation (~ 740 mm) and very high evaporation. Its climate is suitable for tropical cash crops like off-season vegetables, sugarcane, and coffee.
- Taokong village is at a mid-elevation, which has moderate precipitation (1,000 mm). It sits in a wide valley suitable for intensive agriculture and tobacco and it has good access to Baoshan City, with markets for farm produce.
- Baicai village is in the highlands with high precipitation (almost 2,000mm). Its inhabitants depend on forest products, NTFPs, and livestock production.

Political change – from People's Commune to Household Responsibility

Rural institutions in Yunnan differed greatly in two historical phases: the People's Commune phase before 1978 and the Household Responsibility System since 1979. This transformation brought a significant change in land use decisions, property rights, tenure arrangements, and the role of markets in production planning. The shift in governance affected the capacity of communities and households to adapt to climate change.

The People's Commune phase – In the 1950s, the central government collectivised all assets (lands, machinery, and livestock). For almost 30 years, it planned land use and allocated a quota for grain production to each People's Commune. Labour was organised collectively for farming and infrastructure development. The government could mobilise massive numbers of people to construct large reservoirs, irrigation channels, drainage systems, and terraces. It responded to population growth in rural China by constructing large-scale water infrastructure to support food self-sufficiency and disaster prevention. Government technicians or the communes maintained water facilities including dikes, gates, and pumping systems. In this rural mountain region, the central government heavily subsidised large infrastructure construction.

Household Responsibility System (HRS) – Since 1979, the communes have been dissolved gradually to introduce the HRS. The government allocated farmland to individual households according to the size of the family and availability of land. Individual households now make their own decisions on agricultural production and selling their products in the market. Although some large infrastructure facilities have been privatised, most are still owned by local government or collectively, but are managed through contracts with private agents.

Climate – change and uncertainty

Regional climate change studies show that the change of surface temperature in Yunnan province (0.015°C per year) from 1901~2005 has been slightly higher than the global average and a little less than the averages for the Northern Hemisphere and China (Cheng and Xie 2008). However, temperature changes at the three sites present a complex picture.

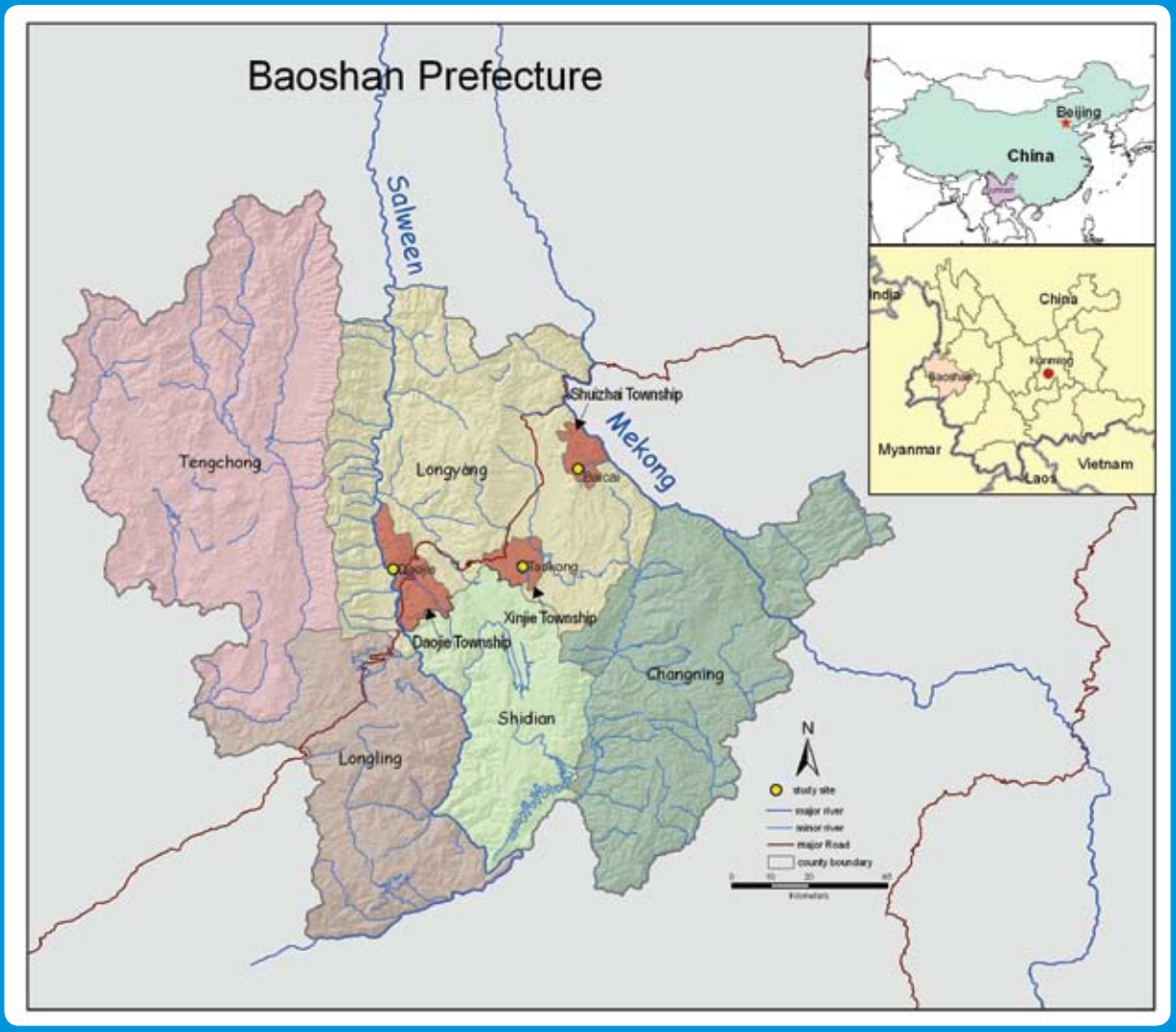
Since the 1980s, temperatures in Daojie (the arid valley site) have gradually decreased by 0.5°C. In the other two sites at higher elevations, temperatures have increased by almost 1°C over the same period. Throughout the past few decades, inter-seasonal, inter-annual, and spatial variability in rainfall trends has been dramatic at all meteorological stations in Baoshan, with both increasing and decreasing trends (see Figure 6).

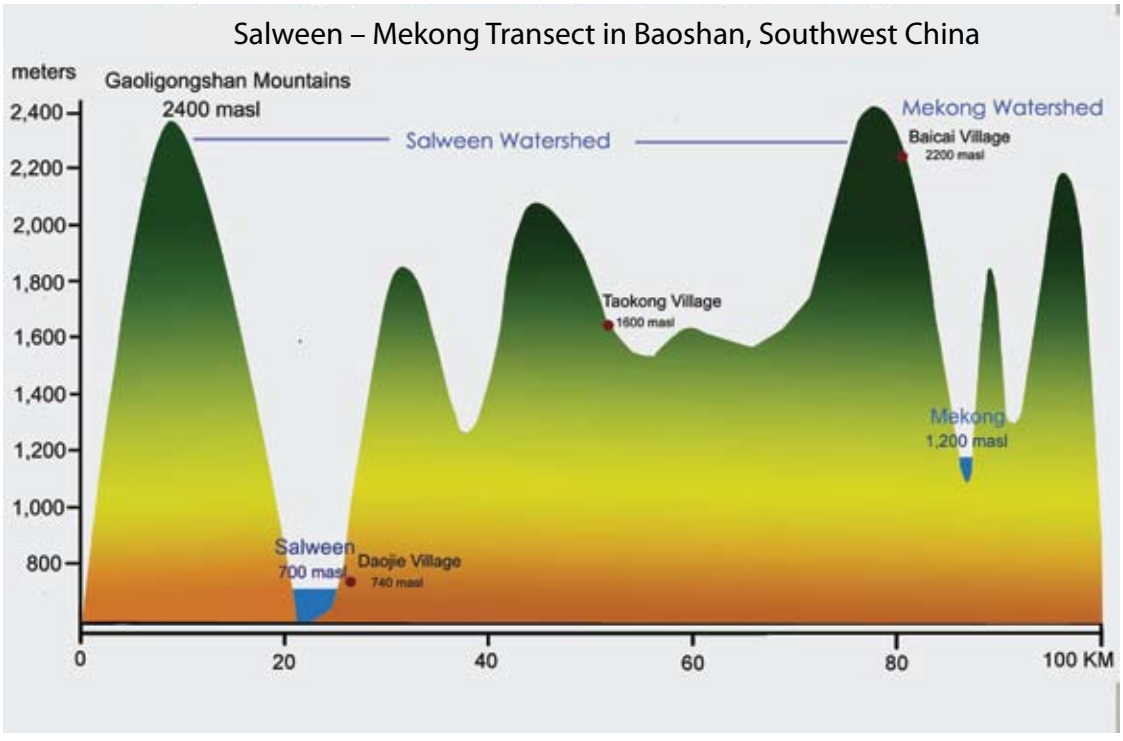
Ma et al. (2008) found that the monthly rainfall in Longyang District increased during the past 50 years by 43.1% and 54.9% in May and September and decreased by 27.6% and 14.4% in June and July, respectively. The increase in May rainfall suggests an earlier onset of the monsoon. The change in monthly rainfall from May to September indicates monsoonal variability and less water availability during the main summer crop-growing season.

Impacts of Water Stresses and Hazards

The impacts of changes in water supply and climate in the studied locations vary greatly depending on elevation, environmental conditions, and on the socioeconomic situation of rural inhabitants.

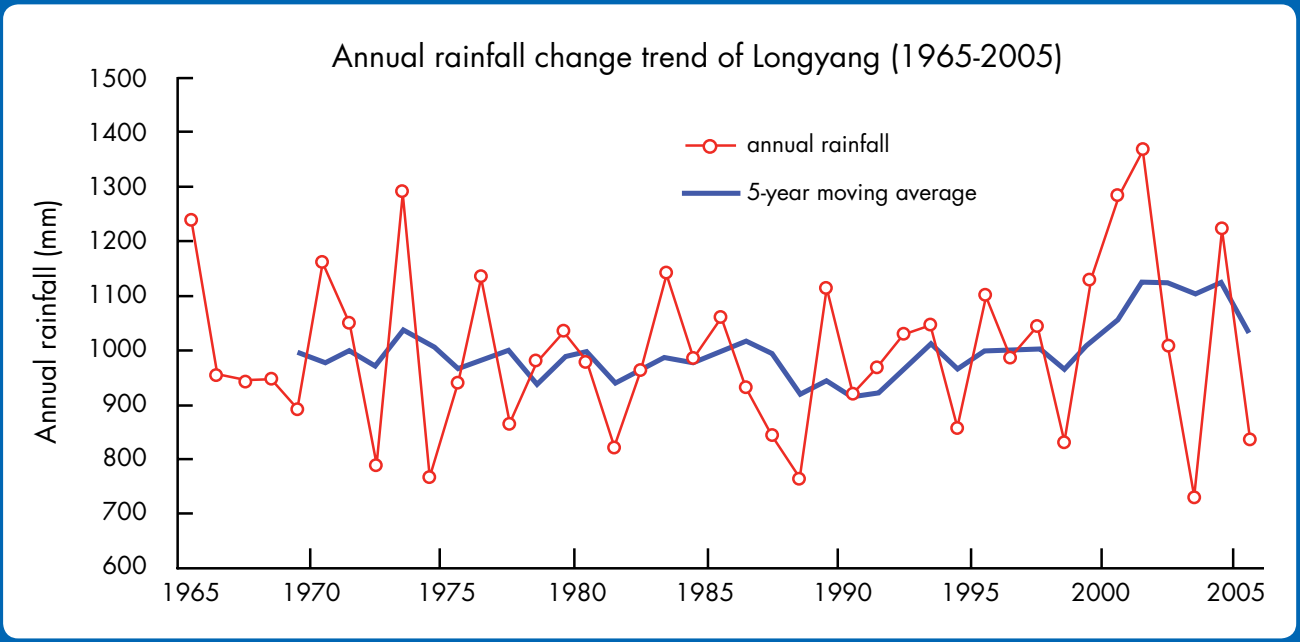
Figure 5: **Location of study sites in Yunnan Province**





Source: Centre for Mountain Ecosystem Studies, Kunming Institute of Botany

Figure 6: **Inter-annual variability of rainfall trends in Longyang District, Baoshan**



Daojie – floods and droughts at low elevation

In Daojie, several serious floods and droughts were recorded in the 1970s, 1980s, and 1990s. Floods destroyed some farming land in the past. Market forces have caused cropping patterns in paddy fields to change from rice and cotton to sugarcane and off-season vegetables. This shift requires more water for irrigation particularly during the dry season.

Since most arable land is rain-fed, variability in precipitation and shifts in the monsoon pattern have triggered severe water shortages. Farmers reported decreasing water supplies in both irrigated and rainfed fields. They estimated that since the 1980s there has been a 30% decline in water flows in irrigation channels during the spring season, though the reasons for this are not clear.

Although Daojie is located on the Salween river, the river water is not accessible for either agriculture or drinking due to the steep, deep gorge. Thus, water brought from a distance in irrigation channels is crucial for the Daojie villagers' domestic use and agricultural production.

Increased winter vegetable production has worsened water resources by increasing demand. Overuse of chemical pesticides and fertilisers is common so water pollution also limits access to safe water.

During the rainy season, floods have often washed away farmlands near the riverbank. However, especially from January to April, almost all farmers experience water shortages due to reduced rainfall and increased competing demands for water resources from upstream villagers. Their drinking water is also poor quality due to the high alkali concentration in water sources – caused by limited quantities and poor quality of construction and maintenance of irrigation canals.

Taokong – competing demand for limited water at mid-elevations

In Taokong, villagers do not get enough water due to insufficient precipitation. Even though they have an irrigation system, the reservoir now has reduced water storage capacity because of sediment build up since its construction during the 1950s collective period.

Film used for reducing evaporation from the soil in Daojie village, Yunnan Province, China

There is increasing demand for water for agricultural intensification in the valley and urbanisation in Baoshan City. The largest reservoir used to provide water mainly for irrigation but now provides more for drinking water. The quality of the drinking water is deteriorating from being mixed with irrigation water and from the heavy use of chemicals in agriculture. Another impact of climate variability is that strong monsoon circulation has increased hail events, which destroy tobacco and other crops.

Baicai – Living with flash floods and landslide risk at a high elevation

Baicai is located on steep upland slopes and in the past villagers were exposed to flash floods and landslide risks. They were often concerned about rainfall intensity and duration, which could trigger landslides. The village leader initiated afforestation that limits exposure to landslide risks and improves livelihoods. Unlike in the lower study sites, the warming of the climate has been beneficial as it may increase the yield of food crops if there is good access to water. According to a village leader, 'A drier and hotter year is good for us, but it is not good for our downstream neighbours.'

Responses to Water Stresses and Hazards

During different periods, people at these three study sites have used both short- and long-term responses to cope with recurrent water stresses and hazards due to climate variability and change. The responses in these three villages have depended on the shifting socioeconomic and political contexts during the communal and HRS periods and thus differed at the individual and community levels. The main responses by individual households and community organisations have involved afforestation, irrigation, crop selection, and changing cropping patterns.

Individual responses since initiation of HRS in 1983

During the communal period, individual households could not respond because land use and labour decisions were

Small field-based water tanks store water for irrigation during the winter in Daojie village, Yunnan, China.

planned collectively. Since the start of HRS, individual households could respond to water stresses by adjusting farming and livestock management decisions and doing off-farm work. However, these common responses may vary depending on the impacts felt, the consequent responses, and the individual household's socioeconomic situation. The following strategies have evolved over time to address water availability.

Changing crop variety and cropping patterns – In Taokong, villagers plant maize, yam, or bean instead of paddy rice in the summer cropping season when water availability was low – even though this caused some reduction in income. Villagers also replant, postpone planting, or replace crops if the rains come late (after early June).

In Daojie, responses to water shortage and market forces changed after the communal system was disbanded in 1983. The changes to cropping patterns are shown in Table 4.

Water-saving farming technologies – Farmers have adopted dry seeding of paddy rice and begun using plastic sheeting on vegetables to retain moisture and maintain consistent temperatures. They are also using techniques for improving water retention of upland maize.

Improved irrigation methods – In Daojie, the high clay soil content of some fields can hold water longer, so the villagers make small water tanks and channels along their fields to store extra water during the winter irrigation season. The channels enable them to direct water to the roots of the crops for water saving. Some better-off households with fields near the Salween River have purchased water pumps to draw water from the river. Poorer households will sometimes have to rent the pump if there is a severe water shortage.

Single earth dam built by an individual household for irrigation of paddy in Taokong, Yunnan, China

Coping mechanisms by poor households – Poorer households are more vulnerable to climate impacts on livelihoods because they often lack alternative income sources. During serious droughts in both Daojie and

Table 4: **Village interviews, 2009**

Time	Cropping Patterns		
	Paddy field (irrigated land)	**Irrigable land**	**Rain-fed dry land**
Before 1983 (communal system)	Early rice + late rice	Maize	Cotton
1983-2005 (change to HRS)	Midseason rice (MR) + sweet potato MR + tobacco MR + vegetable (small area)	Maize + tobacco Maize + sweet potato Maize + vegetable Sugarcane Longan	Sugarcane Maize (1 season/year)
After 2005 (expanded market)	Irrigated: MR+ vegetable Lack of water: maize (quit rice) + vegetable (80%)		Maize + beans (less)

Taokong, poorer villagers borrow grain or cash and raise fewer pigs because they have less maize to feed them.

Leaving for off-farm work – As the incidence of droughts has increased, respondents said that more villagers are leaving for longer periods of seasonal migration for off-farm work. For example, in Taokong, most families have at least one member involved in off-farm work. If there is a drought, two or more family members might go out for off-farm work for a longer period and may travel to further destinations in search of work.

Collective action

When water shortages occur, individual households might adopt immediate coping mechanisms that prove to be insufficient, competitive, or contrary to the needs of other households. Greater organisation and cooperation in the wider community is required to make long-term adjustments to change. At the village level, communities respond in the following ways.

Distribution rules for irrigation – In Daojie, when there is not enough irrigation water, the village committee (VC) implements a system of irrigation water distribution and rotation among village groups. Villagers from each group also watch over the main irrigation channels to ensure the water distribution is fair. The water fee is three times higher when water supply is low, due to increased costs of guarding the water facilities. As a result, villagers' costs for agriculture are increased.

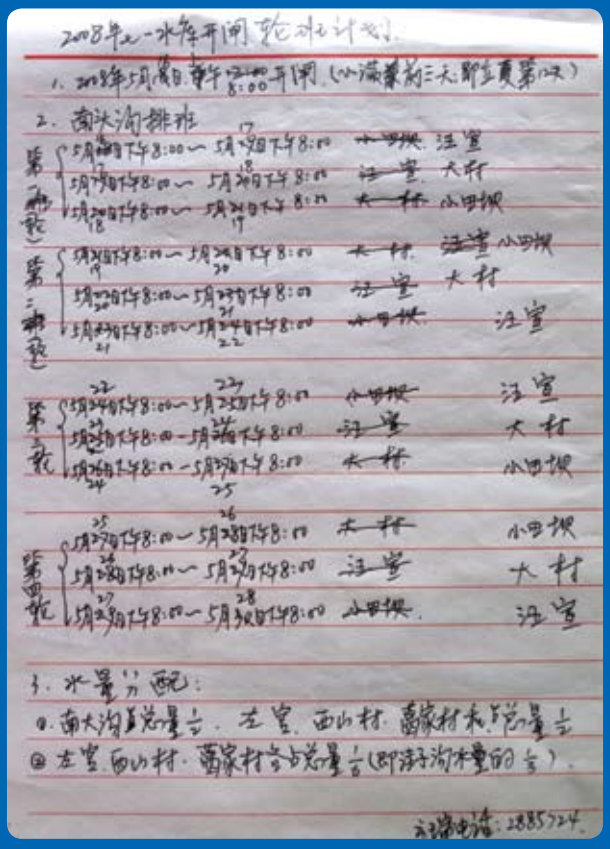
Hiring contract managers is a common practice to manage irrigation water in villages with water shortages. In Taokong, village leaders hire the contractors to be in charge of water pumping and guarding the pump stations. In Daojie, the contractors are selected by an open bidding process to manage the distribution of both irrigation and drinking water. However, the VC or village groups still manage the irrigation system maintenance. The capacity of these community organisations determines the ability of communities to maintain and improve the irrigation systems.

Drinking water management – In Daojie, each household has drinking water piped to their house since 1994; however, the water quality remains poor. Originally, the water was provided free, but in 2003, the VC established drinking water regulations to limit the use of drinking water for farming purposes and to improve water use efficiency. It has also implemented water fees and, in 2006, a water quota of 2 tonnes/person/month. If a household uses more water than the quota, the VC imposes a fine six times higher than the water fee. Most households have built small water tanks to store water for use during the dry season, which is very convenient for women's household chores.

Increasing role of women in water distribution – Recently, women have become more involved in guarding water. In Taokong, only men were involved in guarding water until a few years ago. With more men away for off-farm work, women are now involved, which has reduced physical fights among the men. Both men and women are supporting the further involvement of women.

Afforestation – In Baicai, afforestation programmes initiated by village leaders have significantly increased forest cover. The gradual process of afforestation over a long period has dramatically reduced land degradation, landslides, and soil erosion. Villagers are getting more income directly from timber, fuelwood, NTFPs, and fruit, which is improving their livelihoods dramatically.

Rotation schedule for Daba reservoir in Taokong village, agreed at the annual meeting called by the township government to discuss the distribution of irrigation water from the main reservoir.



Maladaptive responses

Despite existing water shortages, villagers are planting cash crops with low drought resistance. Technical improvements, overuse of pesticides and fertilisers, and the application of frost resistant chemicals on vegetables have impacts on water and human health, and increase dependency on the market. The local government has implemented hail prevention measures that protect against loss of tobacco, but reduce rainfall, which has an adverse effect on other food crops.

Factors Influencing Local Adaptation

The study documented specific factors that enable adaptation and factors that constrain it. However, some factors, such as the community organisation during the communal period, can in some instances enable adaptation and in others constrain appropriate and sustainable responses.

Enabling factors

Communal period infrastructure and institutions – During the communal period, local institutions and collective actions governed the community to help ensure that all villagers had equal access to resources, irrigation, and infrastructure. Although resources were not always used efficiently, both large and small irrigation facilities constructed during the communal period still benefit people by providing physical infrastructure for their adaptation responses.

In both Daojie and Taokong, past investments in irrigation infrastructure enable villagers to cope relatively well during droughts. During droughts, the management of irrigation systems adjusts to reflect the limited water supply and to attempt to minimise agricultural losses. The communal system was an enabling factor that allowed villagers to make adaptive responses at the village level. However, the ability of individual households to respond to climate risks and impacts was constrained in this system.

Local leadership can be an enabling factor – For example, in Baicai, a village leader initiated afforestation activities to cope with serious landslides and soil erosion. Later, these activities evolved into a long-term adaptation strategy. In Taokong, some village groups have better irrigation infrastructure than others as a result of strong leadership.

Governance systems – The transformation to the HRS has enhanced the ability of people to choose their own autonomous individual responses to risks and stresses. In all study sites, individuals have more incentive to innovate or respond since the introduction of the HRS.

Government policies allowing markets, rural reforms, poverty reduction, and environmental protection have provided opportunities for local adaptation. The villages and households have good access to technology, markets, information, and government programmes, such as techniques for agricultural water saving, employment opportunities outside agriculture, and measures for environmental improvement (e.g. Sloping Land Conversion Program). These policies are a key to strengthening community and individual households' adaptive capacities.

Government environmental protection programmes such as Natural Forest Protection Program, Sloping Land Conversion Program, and Grain for Green Program; have contributed to reducing landslide events in Baicai. With compensation payments from the central government for converting sloping farmland into forest, villagers are able to do more off-farm work and to invest in cash crops, animal husbandry, and fruit trees.

Improved management of irrigation water at the local government level – Since the HRS was introduced in Taokong in the early 1980s, new water management rules were established. These included a schedule for distribution of irrigation water and a rotation system to respond to increasing water demand. However, these rules only help with the equal distribution of irrigation water to a certain extent, because the township government is not directly involved in the enforcement of the rules to avoid conflicts.

Government aid and technological responses are being used to mitigate disasters – Historically, hail, landslides, and crop diseases had impacts on livelihoods; but various technological measures are now used to reduce the damage. For example, agricultural technology stations at the village level provide support to ensure that crop diseases or insect pests are reported and prevented in a timely way. There is government compensation for extreme disasters, such as providing water pumps when there is a drought. In Taokong, the government established a hail prevention station to protect against hail, especially for tobacco, but the technique reduces rainfall, affecting the farmers' other crops.

These factors enabled people in these three villages to change cropping patterns, improve farming technology, intensify agricultural practices, change irrigation methods, and diversify livelihoods. In Daojie and Taokong, once a drought occurs, the extent to which households are able to cope depends on the extent to which they are engaged in diversified agricultural practices and off-farm income generation.

Constraining factors

During the communal period, individual households did not have discretionary power for decisions on land use. This affected their ability to adapt to changing biophysical and socioeconomic conditions. For example, people in a dry, hot valley were forced to plant cash crops without consideration of climate there, so often agricultural production efforts failed.

Inappropriate technology might cause maladaptation – All three villages have access to technology, which allows villagers choose varieties of crops needing more chemical fertilisers and pesticides. These have negative impacts on water quality and human health, which many villagers do not yet realise, but which are likely to increase in the future.

Lack of governance for maintenance – Old water infrastructure is still the basis for irrigation and drinking water supplies in the communities, but the lack of maintenance of these systems is currently causing water shortages. For example, in Taokong, an irrigation channel from the reservoir built in 1956 is now filling with sediment. The dam has also developed physical weaknesses. In part, these problems reflect the relative lack of governance for the management of these infrastructures.

Bias in government extension agendas may not benefit the majority of farmers – Local level governments depend on fiscal revenue from taxes on certain cash crops, such as tobacco and sugar cane. Consequently, the delivery of extension services is biased towards tobacco and sugar cane producing areas. For example, in Taokong, the government responds immediately to hail disasters because it receives revenue from tobacco crops. The local officials are responsible to higher ones for ensuring tax income from tobacco.

Limited financial support for functioning institutions – The management of existing water infrastructure is problematic in many areas of Baoshan. Currently, the government promotes the establishment of water user associations in areas that have recently received infrastructure investments. However, it does not support improved management of existing water infrastructure. Although Flood and Drought Management Coordination Committees exist, they appear to be providing only limited support to rural areas, mostly of which is post-disaster relief.

Conclusions

- Chinese government policies play a key role in shaping the extent to which rural households and villages have the capacity to adapt to climate change-induced risks. Adaptation may not occur without enabling policies and institutional arrangements. However, the Chinese government has often implemented differing, and sometimes contradictory, policies that affect local adaptive capacities.
- Economic reform and shifts in property regimes have weakened rural institutions and collective management of water resources. Large-scale water infrastructure developed during the collective period has been poorly maintained due to ambiguity in property rights and financial support since the introduction of the HRS. Farmers face challenges to adapt to both climate change and China's changing socioeconomic conditions.
- Rural transformation and off-farm opportunities reduce exposure to risks induced by climate change. The thirty-year process of economic reform has helped a large population to come out of poverty. Urbanisation is creating more opportunities for off-farm jobs and niche products for rural farmers. The remittance economy enables villagers to invest in protected farming, such as greenhouses for vegetables, and diversified livelihoods, like livestock.
- The diverse biophysical and socioeconomic conditions at the three sites present varying degrees of exposure to natural hazards and climate-induced risks and offer diverse options for adaptation. Villagers at the three sites encounter different climate change-induced risks at varied elevations and socioeconomic conditions. A shift in monsoon patterns has triggered both more frequent landslides in high elevation areas and water stresses in low elevation areas. Women and elders in rural areas are exposed more directly to climate risks. Water poverty occurs mainly in the highlands and the dry-hot valley due to inadequate water-harvesting

infrastructures. It can be less severe in the mid-elevation plain valleys due to the construction of reservoirs.

- Agricultural intensification (off-season vegetables in dry-hot valley, tobacco in the middle, and high-yield corn in highlands) depends on inputs of large quantities of chemical fertiliser, which might cause maladaptation and GHG emissions. Smallholder farmers are using more fertiliser, which is causing nitrogen to leak into underground water, watersheds, reservoirs, and lakes. Nitrate water pollution and eutrophication are becoming major threats to water resources and human health. According to our first estimates, improving fertiliser application practices and lowering current rates of fertiliser use by 50% can reduce fertiliser emissions by 0.8 tonnes CO_2/ha.

Recommendations

Based on the three study sites, the field team suggests the following recommendations to manage climate change induced risks in mountain regions of Southwest China.

- Utilise regional climate science to facilitate stakeholder dialogue on local adaption. Utilise the availability of historical hydro-meteorological trend data to interpret local climate patterns. This information can illuminate dialogues among different stakeholders including local farmers, resource managers, government officials, and planners, who often have their own knowledge systems and understanding of climate change. Integrating local and scientific knowledge can achieve better adaptation planning.
- Incorporate state afforestation efforts (Grain for Green Program) into local watershed/disaster-risk management. Due to its location at the headwaters of major rivers, Yunnan Province has received large-scale state funding for afforestation and ecosystem restoration. If these tree-planting efforts involve local participation in species selection and site planning, they can benefit local villages by controlling landslides and soil erosion in the uplands.
- Improve small-scale infrastructure. Some mountain hazards, such as flash floods, happen due to precipitation, but their impact may depend upon the banking of rivers, drainage, proper retaining walls, and terracing of fields. Water stresses, such as droughts, can be mitigated by water storage, particularly during the planting season in the early monsoon. Investing in appropriate small-scale water infrastructure (with or without links to large water infrastructure) is a good option for addressing the accessibility of water in mountain regions.
- Revive village institutions. Village institutions and local leadership are necessary for households and social groups to deploy specific adaptation practices. There is an urgent need to develop the capacity of community-based organisations, such as water resource associations and vegetable cooperatives. This can be done through legal, financial, and technical support from government agencies, such as civil affairs, line agencies, and the Communist Party. Village institutions should adopt more market-oriented approaches, such as organic farming and payments for environmental services.
- Provide support to improve farming systems. There is an urgent need to develop climate-resilient crop varieties, early warning for weather forecasting, cropping pattern adjustments, and conservation agriculture with high water use efficiency and low-carbon emissions. Two options for securing food production are extension services for rural livelihood diversification and social insurance for climate risk reduction.
- Promote participation by local people in developing adaptation plans. China is a growing economic power that is able to develop efficient top-down National Adaptation Plans for climate change. However, this approach can only be implemented effectively with the active participation of local people in planning, monitoring, and evaluation.
- Integration of climate change policy. Climate change and climate change adaptation are emerging as new explicit policy domains in China, where the government is superimposing them onto existing sectoral and regional development policies. A great opportunity exists to integrate climate science into sectoral policies at a higher level and for it to inform plans for local level actions. There is also a need to undertake further studies to evaluate the extent to which policies promote or hinder adaptation to climate change in a wider variety of contexts. Both political reform and climate science call for synergy among all government sectors to develop an integrated climate change policy.

Part 3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Acronyms and Abbreviations

Aaranyak	A scientific and industrial research organisation, NGO/India
AKRSP	Aga Khan Rural Support Programme
CICERO	Centre for International Climate and Environmental Research, Oslo
GHG	greenhouse gas
GoB	Government of Bihar
GoI	Government of India
HICIA	Himalayan Climate Change Impact and Adaptation Assessment
HRS	Household Responsibility System
ICRAF	International Agroforestry Centre
IIED	International Institute for Environment and Development, UK
ISET	Institute for Social and Environmental Transition, USA
ISET-N	Institute for Social and Environmental Transition – Nepal
KIB	Kunming Institute of Botany, China
NIDM	National Institute for Disaster Management, India.
NREGS	National Rural Employment Guarantee Scheme, India
NTFP	non-timber forest product
NWFP	Northwest Frontier Province (Pakistan)
SEI	Stockholm Environment Institute
Sida	Swedish International Development Cooperation Agency
SRI	System of Rice Intensification
UNEP	United Nations Environment Programme
VC	village committee (China)
WII	Winrock International, India

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ISBN 978 92 9115 128 8
LCCN 2009-341525

This publication is available in electronic form at
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