

# Role of Policy and Institutions in Local Adaptation to Climate Change

Case studies on responses to too much and  
too little water in the Hindu Kush Himalayas



# 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.



# Role of Policy and Institutions in Local Adaptation to Climate Change

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too little water in the Hindu Kush Himalayas

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# Foreword

For more than two decades, ICIMOD has been making significant efforts to understand, document, communicate, and strengthen local adaptation to climate change in the Hindu Kush Himalayan (HKH) region. Climate change heralds both opportunities and threats to the livelihoods of 1.3 billion people in the nine large river basins of the HKH and downstream.

Climate change impacts in the HKH region are particularly severe owing to the large amount of the population depending on climate-sensitive livelihoods such as agriculture. The fast retreat of glaciers, snow, and permafrost; the increasing magnitude and frequency of hazards such as flash floods, glacier lake outburst floods (GLOFs), and landslides; and decreased water availability and drought during the dry season – all are major threats in the HKH region.

In 2009, ICIMOD published *Local Responses to Too Much and Too Little Water in the Greater Himalayan Region*, which documented local responses to climate-related water stress and floods. The present study focuses on the role of policies and institutions in strengthening or weakening such community adaptation strategies. It examines four key themes that emerged from the findings of the earlier study: local water governance, flood mitigation measures, agricultural diversification, and alternative livelihood options.

The findings of this study will provide key pointers for future policy discourse. Through such studies, ICIMOD aims to contribute to improved understanding of the consequences of climate change for the livelihoods of mountain people and downstream communities, and to strengthen their resilience to withstand, and adapt to, climate change-induced constraints and hazards related to water.



**David Molden**  
Director General, ICIMOD

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## Acronyms and Abbreviations

AKRSP	Aga Khan Rural Support Programme
HKH	Hindu Kush Himalayas/n
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
NAPA	National Adaptation Plan of Action
NGO	non-governmental organisation
PRA	participatory rural appraisal
RRA	rapid rural appraisal
SLCP	Sloping Land Conversion Programme
UNFCCC	United Nations Framework Convention on Climate Change

# Executive Summary

With increased climate variability increasing the risk of floods and droughts, problems of too much or too little water are affecting the lives and livelihoods of the people in the Hindu Kush Himalayan region. Climate change is expected to exacerbate some of the conditions causing these problems. Although climate change has been discussed endlessly in international fora, very little ground research has been undertaken on its impacts. Hence, ICIMOD has been working with national partners in China, India, Nepal, and Pakistan since 2008 to document, assess, and – over the long term – strengthen local adaptation strategies to flood and drought in and downstream from mountain catchments. Case studies have been conducted in specific sites in each country across the greater Himalayan region – in the dry mountain valleys of Chitral in Pakistan, the middle hills and Koshi basin of Nepal, the flood plains of Bihar in India, the Brahmaputra flood plains in Assam, India, and the hill areas of Yunnan, China – to identify and document local responses to flood hazards and water stresses.

Some of these areas are chronically scarce in water; in others, people have lived with recurrent floods and droughts for centuries. Local economies are largely agriculture-based and highly dependent on natural resources such as water, soil, and forests. Although many of the communities in the region are geographically isolated, the ways in which they address water stress and hazards are influenced by changing political, cultural, social, and economic, as well as climatic, conditions. Community perspectives on hazards and attitudes towards livelihoods are shifting.

Households and communities in the region have evolved strategies, on their own, to cope with, and adapt to, periods of flooding or drought. However, some are finding that these responses are becoming less effective, and many need external support to deal with the changing conditions. Water stress is more likely to be severe in the future. With increased demand and competition for water, and more variability in its availability, people are struggling to manage traditional arrangements for dealing with the water scarcity with which they have always lived. The communities studied have developed their own ways of responding to droughts and floods, although their strategies are not always optimal. Historically, people in the Hindu Kush Himalayas have always adjusted to change, whether climatic, political, economic, or social. Governments need to play a major role in providing support for adaptation to change, including through policies that help reduce people's vulnerability and build their resilience. Countries in the region are beginning to develop strategies and policies to support adaptation to change. These need to take account of responses already taking place on the ground so that they support and strengthen measures that have been tested and that work, while also addressing challenges that cannot be dealt with by purely local action.

The findings of the first round of field research are summarised in the publication *Local Responses to Too Much and Too Little Water in the Greater Himalayan Region* (ICIMOD 2009). They reveal evolving responses to complex and dynamic situations along with long-standing 'traditional' practices to deal with increasing climate variability. The responses demonstrate that state policy will always play a role in people's ability to respond to too much or too little water, even when policy signals have been unclear, or implementation weak or non-existent.

Building upon the findings published in 2009, a second round of field research in 2010 focused on key recurring themes of adaptation, comparing experiences in sites in at least two countries to give a regional perspective. This round focused on four thematic issues: small-scale water management and the role of local institutions, agro-forestry diversification and intensification, mitigation infrastructure measures including embankments to adapt to floods, and livelihood diversification, including through migration. This research looked at responses and ground experiences in terms of common factors and key messages useful to those supporting the development of new adaptation approaches, including policy and institutional support.

The findings, published in the present report, echo much of the 2009 research and learning from other studies, with regional comparisons providing a bigger picture and indicating some areas where regional programmes of support can be developed. This research resulted in seven key findings:

- Climate change and variability increase uncertainty and risks, as well as promoting opportunities in livelihood systems, particularly for people dependent on agriculture for their livelihood.
- Markets and government policy have a greater impact on enhancing the adaptive capacity of communities than climate change awareness.
- Policy environments and institutions need to consider short-term responses and long-term strategies to match the pace of climate change and changes caused by other drivers, and to meet new needs for highly adaptive and resilient systems.
- A proper strategy to translate sectoral policies into local-level planning will facilitate development initiatives to address local adaptation needs.
- Structural disaster mitigation measures supported by non-structural measures, with the support and participation of local communities, enhance quick response and improve people's adaptive capacity.
- Local-level institutions and indigenous systems, with the support of non-governmental organisations, can enhance local adaptive capacity.
- Diversifying agricultural production and livelihood systems, including labour migration, is one of the ways that communities can build resilience and adapt to economic and climatic shocks and shifts.

The study also recommends some strategies for adaptation policies and the strengthening of the role of institutions in support of local responses. The specific findings and recommendations for each case study theme in each specific area are contained in Part 2 of this report.

Part 1

# Synthesis



# Introduction

The Hindu Kush Himalayan (HKH) region, extending over an area of 4.3 million square kilometres and covering eight countries from Afghanistan in the west to Myanmar in the east, is predicted to be one of the regions most severely challenged by and socially vulnerable to climate change (IPCC 2007). The region has four of the world's most populous countries, China, India, Pakistan, and Bangladesh, and some of the world's poorest countries where most people live in rural and mountain areas. Poverty has been pinpointed as a major hindrance to developing the capacity to cope with, and adapt to, the uncertain impacts of climate change.

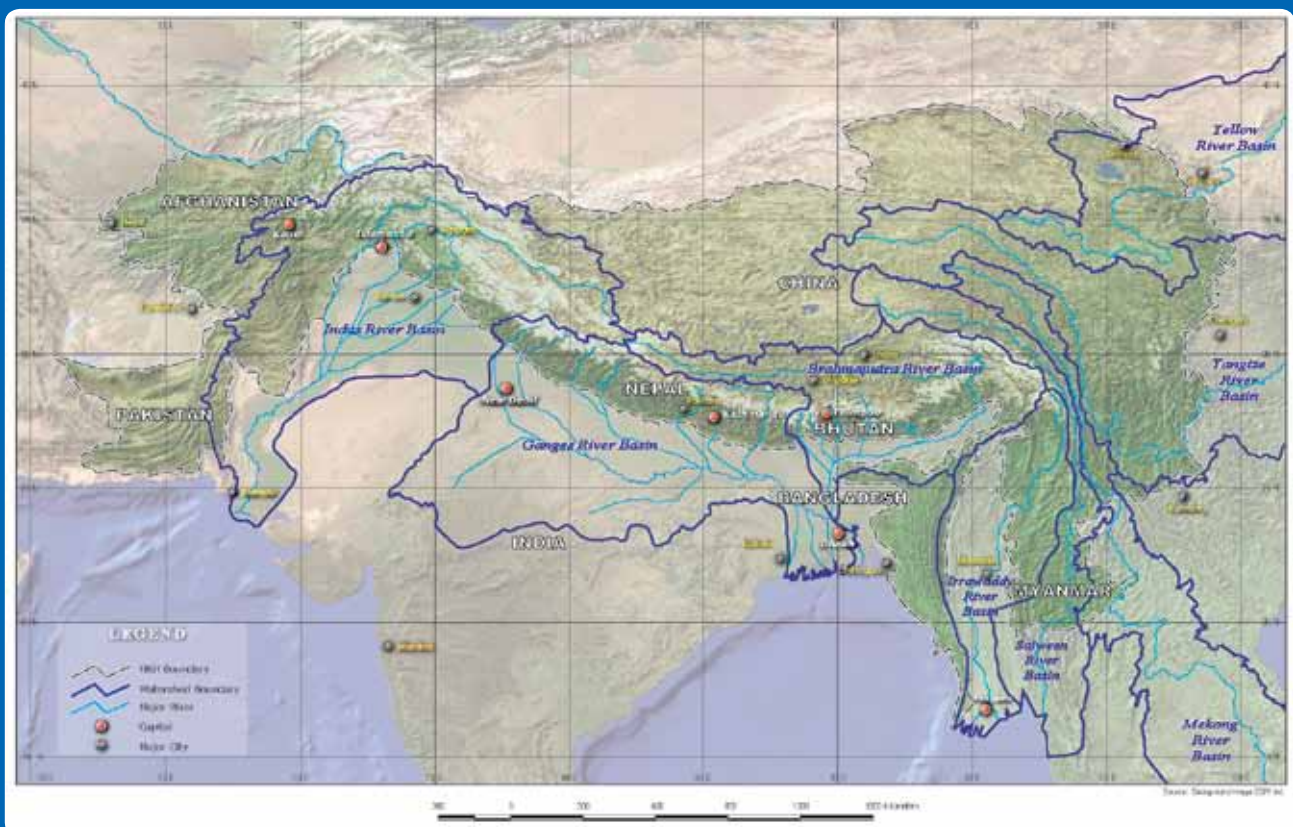
The most visible and widely publicised early manifestation of changing climate is the melting of glaciers in the high mountains. In the Himalayas, this has brought about a decline in precipitation and an increase in droughts in most delta regions of Pakistan,

Bangladesh, India, and China (IPCC 2007) leading to the drying up of wetlands and the loss of their important ecosystem services.

Glaciers are the water source for the 10 major river systems in the region (Figure 1) – the Amu Darya, Indus, Ganges, Brahmaputra (Yarlungtsanpo), Irrawaddy, Salween (Nu), Mekong (Lancang), Yangtse (Jinsha), Yellow River (Huanghe), and Tarim (Dayan) – providing water and ecosystem services, and forming the basis of the livelihoods for 1.3 billion people, a fifth of the world's population. The melting of the Himalayan glaciers seriously affects half a billion people in the HKH region and a quarter of a billion people in China who depend directly on these frozen waters for their water supply (Stern 2006).

The consequences for downstream agriculture, which relies on these waters for irrigation, are potentially

Figure 1: Hindu Kush Himalayan river systems



staggering. Already there has been a noted decline in the yields of cereal crops such as rice, maize, wheat, and millet in the region, on which the world depends for 25 per cent of its supply of cereal food. This decline could further drop by as much as 30 per cent by 2050 (IPCC 2007).

Glaciers also play an important role in determining slope stability, ecology, erosion processes, and surface water. The rapid thawing of permafrost and decrease in the depth of frozen soil has threatened many human settlements downstream, causing frequent landslides and the degeneration of some forest ecosystems (IPCC 2007). In fact, the region is noted for its vulnerability to hazards and disasters, which is likely to be exacerbated by climate change.

Phenomena such as changing temperature regimes, extreme natural events (floods, landslides, and earthquakes), periods of extreme water scarcity, and floods and flash floods are not new to the Himalayan people, who have adapted every aspect of their lives to these conditions for centuries. From temporary migration and transhumance among herder communities in the Northern Areas of Pakistan, to the development of indigenous knowledge to rehabilitate and recover hill slopes eroded by landslides in the mid-hills of Nepal, the people of the region have coped and adapted in various ways. Local adaptation has also come in the form of crop rotation and shifting cultivation among the hill communities of Meghalaya, India; the development of methods for harvesting rainwater in Nepal and snow in Afghanistan during periods of extreme water scarcity; and other flexible livelihood strategies supported by traditional community ways and informal institutions.

However, challenges arising from the rate at which these changes are occurring, in combination with pressure on land, water, and other resources from the constantly growing population and rapid urbanisation of cities, make it more urgent to adapt to change at a more rapid pace and in more innovative ways than before. The HKH region is marked as a 'white spot', with not enough scientific data to be able to make forecasts with any degree of certainty. This makes the design of intervention programmes and adaptation plans difficult.

The mechanisms by which governments allocate resources will need to respond to anticipated and

unexpected changes brought about by variable climate. This is vital to usher in a common desirable future where communities, through supportive programmes, incentives, and enabling legislation, are able to anticipate and quickly respond to the immediate challenges posed by climate change, as the region and the world prepare to address the longer-term challenges yet to emerge. This includes, in the immediate term, policies that support workable local adaptation strategies and that address those challenges that require collective action.

## About this study

To help governments of the region develop recommendations for climate change adaptation policy, ICIMOD commissioned partners in each country to conduct national policy studies that support (or do not support) and address the findings from the field research carried out under the first round of the project 'Local Adaptation to Too Much, Too Little Water' (ICIMOD 2009). The partners that contributed were the World Agroforestry Centre (ICRAF)–China (China); the National Institute for Disaster Management (India); the Institute for Social and Environmental Transition–Nepal (Nepal); and the Institute of Social and Environmental Transition (Pakistan). The International Institute for Environment and Development (IIED) provided overall coordination and inputs. These case studies assess the policy environment in which the field study communities are responding to climate variability, and the impacts of policy on their responses. The research question that the study addresses is: How do political processes hinder or promote the adoption of sustainable and equitable adaptation strategies to water-related stress and hazards in the context of climate change in India, Pakistan, Nepal, and China? By assessing the ways that policy impacts on local people's ability to adapt, the studies aim to provide lessons for policy makers in the four countries studied.

The study focuses on four thematic issues: small-scale water management and the role of local institutions; agro-forestry diversification and intensification; mitigation infrastructure measures, including embankments to adapt to floods; and livelihood diversification, including through migration. It looks at responses and ground experiences in terms of common factors and key messages useful to those supporting the development of new adaptation

## Box 1: The four thematic case studies

### Local water governance

Documented adaptation strategies for water governance in Chitral district (government and community based); explored governance issues and their impacts on water resources; discussed factors promoting or limiting sustainable local management of water systems; recommended measures to address the issues

Partner organisation: Aga Khan Rural Support Programme (AKRSP), Pakistan

Study site: Mulkhow and Shishikoh valleys, Chitral district, Pakistan

### Flood mitigation measures

Documented the advantages and disadvantages of formal government flood mitigation measures focused on embankments; looked into the evolution of flood mitigation, and the government mechanisms and instruments that led to their development

Partner organisation: Aaranyak, a society for biodiversity conservation in northeast India

Study site: Lakhimpur and Dhemaji districts, Assam, India with comparative material from Koshi basin, Nepal and Bihar, India

### Agricultural diversification

Documented cases from the region and improved understanding of the policy context in which the contribution of tree crops supported agricultural diversification and built the resilience of farming communities to adapt with natural and climatic stresses; looked into the policies and local institutions that encourage or provide incentives for tree plantation

Partner organisation: Kunming Institute of Botany (KIB), China

Study site: Baoshan Municipality, Yunnan, China; Mustang district, Nepal; North West Frontier Province (now Khyber Pakhtoonkhwa Province) and Azad Jammu and Kashmir, Pakistan

### Alternative livelihood options

Documented the differentiated impacts of labour migration as a result of water hazards on households and on adaptation; studied the links between remittances and water stress – remittances as a potential way of supporting adaptation for informed decision-making

Organisation: ICIMOD

Study site: Chitral district, Pakistan; Assam, India; Dhankuta, Sunsari and Saptari, districts Nepal; Yunnan, China

approaches, including policy and institutional support, to meet the challenges (Box 1).

Much of the current research and planning assumes that adaptation will occur largely through government-led or -directed technical interventions. However, the findings of the field research demonstrate the extent to which local households and communities are adapting, and will continue to adapt, through actions that are independent of structured programmes and policy. These actions are sometimes referred to as

'autonomous', as opposed to planned, responses to climate change. The policy component of ICIMOD's research is addressing how national policies and strategies can most effectively strengthen and build upon autonomous responses in order to increase local resilience to the water-related impacts of climate change.

# Methodology

The first round of research demonstrated that local institutions play a critical role in enhancing people's capacity to respond to too much and too little water at household and community levels. It also pointed to the influence of national policies and institutions on the development of adaptive capacity, and to the frequent disconnect between national and local plans and institutional options for strengthening adaptive capacity (ICIMOD 2009). Round two (in 2010, on which the current study is based) explored the role played by policy and institutions in local adaptation to climate change to better understand how effective interactions between local and national institutional contexts can be fostered to build adaptive capacity.

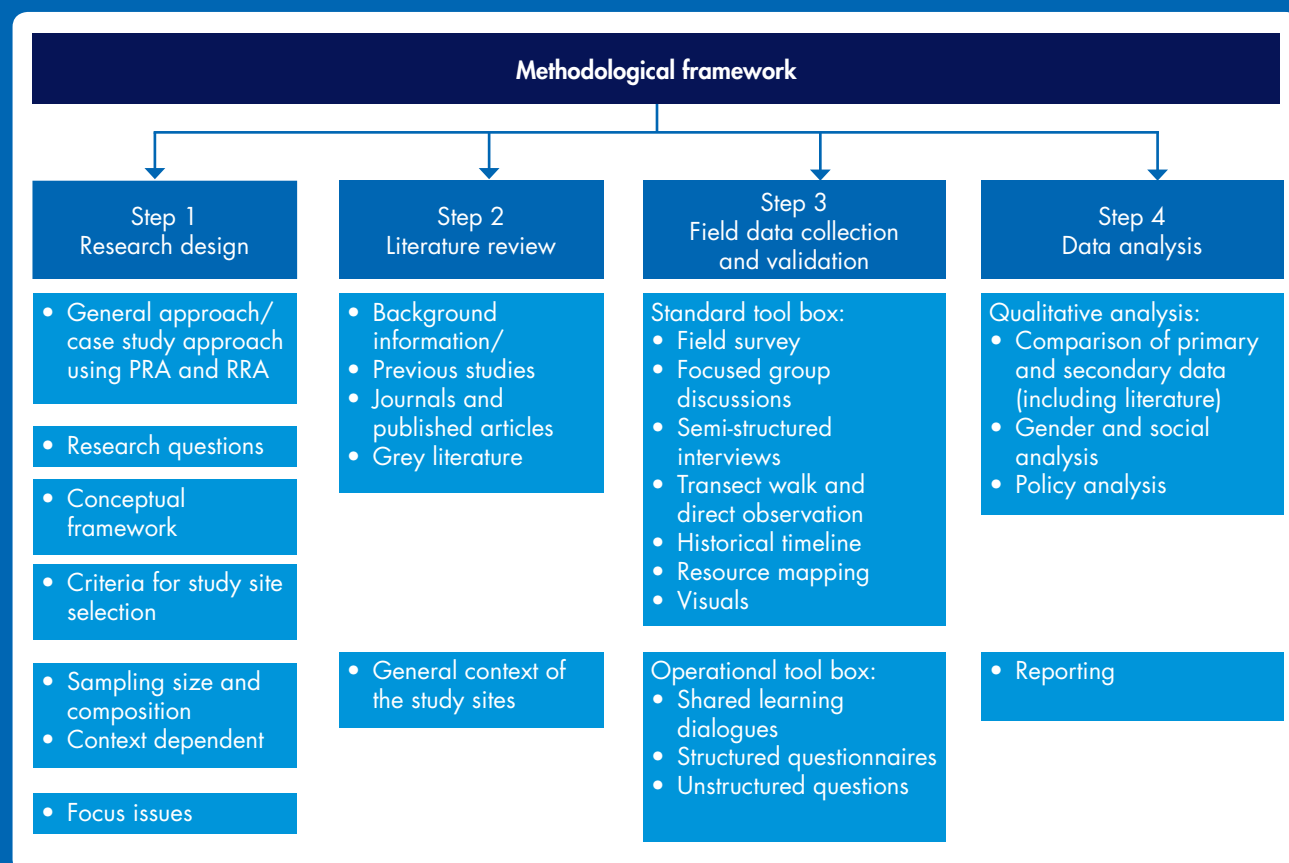
The methodological framework developed in the first round of research (Figure 2) provided flexibility to the teams to customise it according to their research requirements within the broad conceptual/analytical framework developed.

The second round of research sought to reach a shared understanding of the concept of adaptive capacity, the role of local and national institutions in contributing to adaptive capacity, and the ways in which national policies and governance arrangements can support or undermine adaptive capacity at the household and community levels.

The research used a simple way of understanding adaptive capacity as the extent to which individuals or households are:

- healthy (secure and able to be active);
- wealthy (having assets, a viable livelihood, and access to resources);
- wise (having access to information, knowledge, and skills and the ability to use them); and
- well governed (having equitable access to resources, being able to participate in decision-making and governance systems, and being part of supportive social networks).

Figure 2: **Methodological Framework**



The extent to which people are healthy, wealthy, wise, and well governed depends on their access to primary, or 'core' resources for human development, including water, food, energy, and ecosystem services, and to services that provide a 'gateway' to the development of adaptive capacity, such as health care, financial services, education, and political representation (Dixit 2009). Access to these core and gateway resources and services is usually determined by policies and institutions governing their management and delivery. This is the link between adaptation and the institutions that the four thematic areas sought to explore.

Although adaptation receives much attention in policy debate, many fundamental knowledge gaps to understanding the process remain. This study contributes a new way of studying adaptation on the ground by detaching from the debated around concepts and narrowing in on specific mechanisms for managing too much and too little water in the current context. Although the study was carried out in the HKH region, it provides useful insights and valuable lessons for other mountain areas around the world. The unique methodological approach, based on the conceptual framework integrating institutions

and adaptive capacity, is another useful contribution of this study. The study also brought together partner organisations across the HKH region, and allowed them to move across borders to examine their theme in neighbouring countries.

The short timeframe available for the research was a constraint. Teams employed participatory rural appraisal (PRA) and rapid rural appraisal (RRA) techniques and one-off household surveys, which can only provide a snapshot of the situation and are not ideal when studying the impacts of ongoing change. This constraint was overcome to some extent by the use of secondary data and information obtained during the first round of research. It was also not possible for most teams, given the time and resources available, to carry out full comparative studies across countries. One team undertook research in only one country, while one other team relied largely on desk research for its comparative studies. Two teams, however, were able to undertake field research in multiple countries. Despite these constraints, the teams were able to delve deeply into the four thematic areas and pull out important policy findings, as well as directions for future research.

# Conceptual Framework for Adaptation Planning

At scales ranging from regional to local, diverse sets of actors in the countries of the HKH region are beginning to develop plans for dealing with the effects of climate change on the economy and on livelihoods. Such plans need to be informed by an empirical understanding of how effective adaptation can take place.

‘Adaptive capacity’ is the ability to adjust to climate change, including climate variability and extremes, to moderate potential damages, take advantage of opportunities, and cope with the consequences (IPCC 2007).

The role of institutions, as a specific component of adaptive capacity and in mediating adaptive capacity, is recognised in round one of this research and in the broader literature (Agrawal 2010; Dovers and Hezri 2010; Christoplos et al. 2010). However, there is a lack of consistency in the way institutions have been defined in the context of adaptation. There is also a lack of clarity around their role in facilitating adaptive capacity, and a lack of focus on how to move from a discussion of what should happen (adaptation outcomes) to a discussion on how this should happen, or what institutional design is required for delivering effective adaptation outcomes (Dovers and Hezri 2010).

‘Institutions’ are defined here as “commonly understood rules and norms that stipulate what actions are required, permitted, or forbidden in a particular situation” (Poteete and Ostrom 2004). They may be informal (for example, social norms and taboos) or formal (for example, constitutions and property rights regimes) and exist at multiple scales of human organisation. In climate change literature, discussions of adaptation planning normally pertain to organisations (the organisational manifestation of institutions, e.g., departments, associations, agencies), whereas discussions of adaptive capacity pertain to both organisations and institutions.

The ability to adjust to climate change largely depends upon three variables:

- **The existence of a number of key ‘natural systems’ and manmade ‘institutional systems’ that support human development and resilience:** These include the natural systems fundamental to human development, such as water, food, energy, and ecosystems, which help people to withstand climate stresses and shocks. Ability to make use of the assets and services provided by these natural systems is generally dependent on human-built institutional systems such as health systems, education systems, infrastructure, and governance and planning systems. Human-built institutional systems bring together both manifestations of institutions, i.e., institutions as a set of rules and norms that guide action, and institutions in their organisational manifestation. The term ‘institutional system’ recognises that “institutions are embedded in complex, interactive systems of multiple institutions, organisations and actors” (Dovers and Hezri 2010).
- **The quality of these systems, which in this context refers to the extent to which the systems are climate-resilient:** For instance, gender sensitive hurricane shelters in Bangladesh have enhanced the adaptive capacity of vulnerable women. Similarly, the flexibility of local water resource management institutions in Pakistan has enabled an effective institutional response to changing conditions.
- **The accessibility of these systems to people:** This is a particular concern for adaptation planning that aims to address the differentiated and inequitable impacts of climate change on poor, socially marginalised, or physically isolated people.

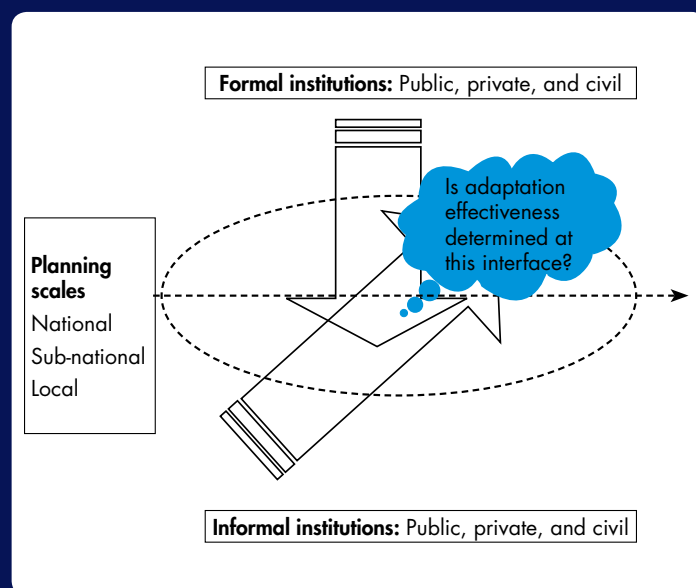
In light of these three variables, institutions play a key role in adaptive capacity. Institutional systems, such as information and planning systems, provide assets and services that vulnerable communities can use when

adjusting to the impacts of climate change. Thus, they mediate the extent to which climate change affects local communities. Similarly, institutions in the sense of rules, norms, and organisations, also play a key role in mediating the 'quality' of natural and manmade systems and 'access' to the same.

Figure 3 identifies some of the systems critical to the development of adaptive capacity, based on the research case studies. The figure takes the form of an inverted pyramid, with each level built upon and interfacing with the previous ones. Adaptive capacity potentially increases with access to each successive level and there is a better interface between each level. The arrows on each side of the pyramid indicate the institutions that mediate the quality of these systems and access to them.

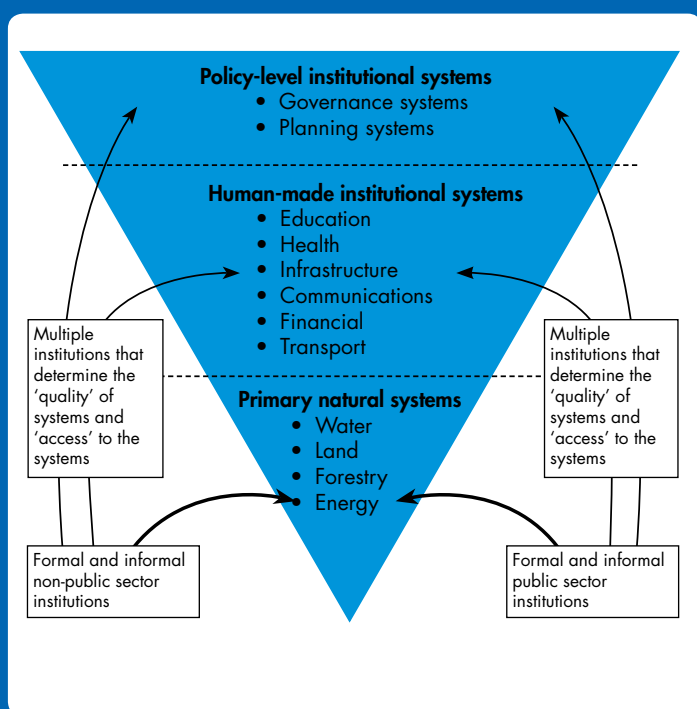
Adaptation planning aims to enhance the effectiveness of institutional systems in building adaptive capacity. This requires clarity around the specific roles of different institutions and the ways in which they interact with one another to enable or disable the development of adaptive capacity. The

Figure 4: Conceptual and analytical framework for adaptation planning



Source: Adapted from concepts developed by Anderson (personal communication 2010)

Figure 3: Institutions and adaptive capacity



Source: Adapted from concepts developed by Moench, Dixit and Anderson (personal communication 2010)

conceptual framework aims at addressing this gap in understanding, particularly in terms of the interfaces between formal and informal institutions, and local and national scales.

Adaptation effectiveness is determined by the interface between the formal and informal, public, private, and civic institutions that operate at different scales of adaptation planning (see Figure 4).

# Enhancing Institutional Interfaces

Institutions play a key role in mediating adaptive capacity. A better interface between different institutions functioning at multiple planning scales is likely to result in better adaptation outcomes.

The conceptual framework outlined in the previous section allows us to:

- understand the factors that determine the horizontal and vertical interface between formal and informal institutions functioning at different planning scales, including the comparative advantages of different institutions and their aims and objectives; and
- identify ways to enhance the interaction between formal and informal institutions functioning at different planning scales.

## Factors that determine the horizontal and vertical interface between institutions

A range of formal and informal, public, private, and civic institutions are involved in mediating adaptive capacity. The study findings indicate that a number of factors determine horizontal and vertical interfaces between these institutions, including a better match between the comparative advantages and aims of different institutions functioning at different planning scales.

## Comparative advantages of different institutions

Different types of institutions have specific comparative advantages in terms of the delivery of aspects of adaptive capacity. Agrawal's (2010) analysis of the United Nations Framework Convention on Climate Change (UNFCCC) database on adaptation sets out the comparative advantages of some public, private, and civic institutions in the delivery of adaptive capacity (Table 1).

Agrawal's analysis also suggests that civic and public institutions are the ones most commonly involved in facilitating adaptation to climate change, while private sector and market institutions play a relatively small role in facilitating or reinforcing adaptation. Furthermore, at the local level, civic institutions when functioning on their own tend to be informal institutions. However, when public institutions are involved in adaptation they tend to collaborate with formal civic institutions rather than strengthening informal civic institutions.

The case studies in this project generally supported these findings, with observations including the following.

- **Water governance:** Traditional community institutions, civil society-organised 'modern' community institutions, and state institutions

Table 1: Comparative advantages of institutions in building adaptive capacity

Institutional realm	Comparative advantage in relation to adaptive capacity
<b>Public</b> Example: Bureaucratic agencies and elected bodies	Public sector institutions are more likely to facilitate adaptation strategies related to communal pooling, diversification, and storage owing to their command over authoritative action, and ability to channel technical and financial inputs into rural areas.
<b>Private</b> Example: Service organisations and private businesses	Private sector organisations, because of their access to financial resources, are more likely to have greater expertise in promoting market exchange and diversification, but may also be able to advance communal pooling if one takes into account not-for-profit service organisations.
<b>Civic</b> Example: NGOs, cooperatives, and membership organisations	Civic sector institutions can strengthen different adaptation responses as a result of their greater flexibility in redefining goals and adopting new procedures.

Source: Agrawal (2010)

operate in distinct geographic communities; the main features that distinguish them, from the perspective of adaptation effectiveness, are their varying levels of equity in allocation and participation in decision-making, accountability to beneficiaries, and flexibility in the face of changing conditions.

- **Tree crop diversification:** Incentives to adopt tree crops are delivered by state and market institutions. Both are oriented towards the economic value of the crops rather than their role in agricultural diversification strategies for adaptation. State and market institutions work in tandem, but markets respond more quickly to crop successes and failures from shifts in climate.
- **Flood mitigation:** Flood mitigation infrastructure and other major flood management measures are implemented and governed by formal public sector institutions; household level responses are facilitated by civil society and formal and informal community institutions. The two exist in completely separate domains within the same geographic space, with no mechanism for communication between the two.
- **Migration:** Labour migration is largely an autonomous livelihood strategy for mountain households in the HKH region. However, migration-related decision-making is influenced

by social networks and market demand (such as lack of alternative livelihood opportunities in the community of origin and/or demand for workers in destination communities). In most of the sub-basins studied, the state has marginal impact on migration-related decision-making.

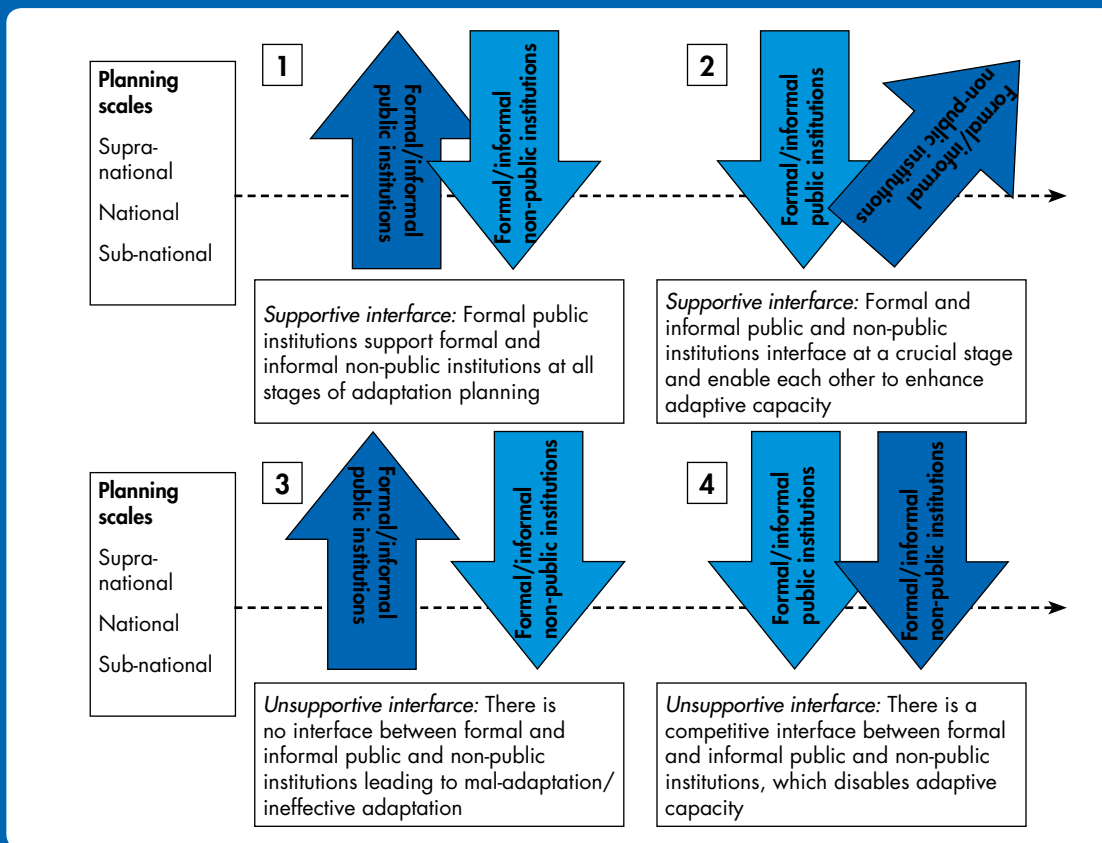
### Aims and objectives of different institutions

Institutions, in their organisational manifestation, function at local to international administrative scales and vary widely in their aims and objectives in relation to adaptation outcomes. For instance, institutions at the national level are more responsive to supra-national and national issues. These include trends in globalisation and national development objectives, which often take the form of economic growth strategies for various economic and social sectors. These drivers explain why the vast majority of National Adaptation Plans of Action (NAPAs) have taken a sectoral approach to vulnerability reduction. On the other hand, institutions important at the local scale are often more responsive to household and small enterprise (including farm) issues and drivers of change, and tend to emphasise livelihood and wellbeing outcomes related to adaptive capacity. Thus, while national and local-level institutions both

Stakeholders' meeting for modern water governance, Chitral, Pakistan



Figure 5: Examples of adaptation planning interfaces



Source: Concepts developed by Kaur and Goeghegan (2010)

aim at enhancing adaptive capacity, there is often a mismatch in their aims and objectives. This results in a lack of synergy between institutions, which in turn leads to ineffective adaptation outcomes. Such a scenario is apparent in water resource management in Pakistan and flood management in India (see Kandlikar and Risbey 2000; Eakin 2000 for similar findings).

## How to enhance the interface between institutions

Institutions interface in different ways (Figure 5). A number of institutions have a role to play in adaptation planning. Depending on the extent to which there is a match between the aims and comparative advantages of different institutions, the interface between institutions can be supportive, non-supportive, or non-existent.

An aim of adaptation planning should be to enable and facilitate supportive interfaces where possible. This includes enhancing institutional interaction where it does exist; creating incentives for interfaces where

they do not exist; and creating synergies in cases where interfaces are competitive.

A clearer focus on institutional change in the context of adaptation planning is essential in designing and incentivising effective interfacing between institutions (Dovers and Hezri 2010). The conceptual framework can help in aspects of planning including the design of collaborative institutional arrangements aimed at enhancing horizontal interactions between multiple institutions (Agrawal 2010). However, the framework highlights the difficulty of enhancing the vertical interface between multiple institutions functioning at different scales. It also highlights that institutional change needs to recognise the role of different institutions in mediating adaptive capacity, and to focus on a better interface between these institutions. It proposes new approaches for creating a more supportive interface between formal and informal institutions functioning at different planning scales. Along with this focus on institutional change, the underlying drivers of unsupportive institutional interactions, including power dynamics, need to be addressed.

# Key Findings

## **Increased uncertainty and risks, but also livelihood opportunities**

Climate change and variability increase uncertainty and risks, as well as promoting opportunities in livelihood systems, particularly for people dependent on agriculture for their livelihood. This was found to be true in Yunnan in China, and in parts of Bihar and Assam in India where large tracts of flooded areas have been rendered unsuitable for agriculture. In areas in Assam and Bihar where flooding has not been so severe farmers have been able to resort to more flood-resistant rice and other crop varieties, and some have shifted to other means of livelihood including migration for work. In China, agricultural and agro-forestry diversification have been a means to adapt.

## **Markets and policy more decisive than climate change awareness**

Markets and government policy have a greater impact on enhancing the adaptive capacity of communities than climate change awareness.

This is an important finding and highlights the need to support adaptation with market-based incentives and adaptation support in the form of crop and livestock insurance, among other emergency support programmes. The findings show that government policy and programmes in China and Nepal and market forces in Pakistan have been effective in enhancing the adaptive capacity of communities.

## **Short-term responses and long-term strategies**

Policy environments and institutions need to take into consideration short-term responses and long-term strategies to match the pace of climate and other changes, and to meet new needs for highly adaptive and resilient systems.

Specific cases in each country show how the policy environment has not been able to respond immediately to problems in flood and drought prone areas. Institutional and policy reforms are urgently

needed to make the governance system more accountable, flexible, and responsive to the needs of the most vulnerable communities. The studies on flood governance in India and tree crops in China, Nepal, and Pakistan highlight the urgency of institutional and policy reforms in providing a short-term response, as well as strategies to deal with long-term solutions.

## **Translating sectoral policies into local planning**

A proper strategy to translate sectoral policies into local-level planning will facilitate development initiatives to address local adaptation needs.

In most countries sectoral planning and programming are limited, and most governments have not been able to link related sectors in coping and adapting to change. Adaptation planning will have to go beyond the usual compartmentalised sectoral planning towards greater decentralisation so that communities can respond quickly, with budget support, to disasters and risks, which are likely to occur with greater frequency with the changing climate. The case study in Pakistan shows how the absence of a proper strategy to translate sectoral policies to local-level planning led to the failure of several projects to produce any viable impacts, despite heavy investment.

## **Adaptive capacity improved through community supported disaster mitigation measures**

Structural disaster mitigation measures supported by non-structural measures, with the support and participation of local communities, enhance quick response and improve people's adaptive capacity.

In the case of India, the study found that properly maintained and timely repaired structures provide people with immediate protection; however, this is not a permanent solution to floods. Floods cannot be managed by structural measures, such as embankments, alone. Structural measures should be complemented and supported by non-structural measures, such as flood forecasting, disaster

preparedness, watershed management, and flood plain regulation.

### **Contribution of local institutions and indigenous systems**

Local-level institutions and indigenous systems, with the support of non-governmental organisations (NGOs), can enhance local adaptive capacity.

In Pakistan, improving the indigenous system of water governance with the support of NGOs has proved that the replication of these systems by government organisations increases the sustainability of interventions and the local adaptive capacity of the people. In China and Nepal, community institutions are largely responsible for maintaining water infrastructure and establishing rules and priorities

for water allocation at the local level. However, to be effective, these institutions require support from government and NGOs in the form of investment.

### **Diversified livelihood systems for resilience and adaptation**

Diversifying agricultural production and livelihood systems including labour migration is one of the ways that communities can build resilience and adapt to economic and climatic shocks and shifts.

In India, Nepal, and Pakistan, and to a lesser extent in China, people in flood and drought affected areas have resorted to temporary labour migration in difficult periods. People and communities with less employment options are the most vulnerable.

# Institutional and Policy Environment for Adaptation

## Exploiting comparative advantages

Adaption planning draws on the comparative advantages of various institutions, overcoming the tendency of public and private realms to operate independently of one another. Formal and informal institutions engaged in the development of adaptive capacity sometimes pursue separate strategies, which may or may not complement one another. This is the case in relation to flood mitigation in Assam, where the formal institutions provide flood infrastructure and the communities employ strategies to mitigate impacts where embankments are ineffective. At other times, different institutions pursue competitive strategies, as in the separate and distinct public, civic, and traditional systems of water governance in Chitral in Pakistan. In both cases, lack of engagement by public institutions with other institutions undermines their effectiveness in increasing adaptive capacity, as they cannot benefit from the knowledge and perspectives of institutions closer to the ground. Public institutions are often rigid in their structure and approaches, and thus not able to respond to changes in conditions and need, as can be seen in the case of agricultural policies in China that incentivise practices that reduce resilience. Public institutions at the apex level are entrusted with multiple functions, but are usually only engaged in policy formulation; often the prepared policy is yet to be disseminated effectively among stakeholders including NGOs and community level organisations. Public institutions generally lack effective coordination, not only within related government agencies, but also with private agencies including NGOs and community level organisations. The mutual distrust and power relations that underlie the failure of the public and non-public realms to interact are extremely difficult to overcome, but outcomes can be improved through better communication and synergy. Linkages with private institutions can also increase the accountability of public institutions, thereby decreasing the potential for corruption.

## NGOs and community-based organisations

NGOs and community-based organisations play an important role in the development of institutions supporting adaptive capacity, but are not engaged with state institutions, nor are their efforts recognised by these institutions. NGOs in Pakistan have introduced an effective system of community-based water governance, which has been taken up in many communities in Chitral. However, neither these arrangements nor the traditional arrangements in other communities have been recognised or incorporated into the government's water sector plans and interventions. This is because of a lack of information sharing among the government, NGOs, and community-based organisations. A better interface could be developed through measures that address the root causes of this disconnect, which often pertain to power dimensions and political considerations.

## Informal institutions

Informal institutions support or impede the development of adaptive capacity, but because they are often culturally embedded, they can be challenging to integrate into formal institutional arrangements. Although informal institutions can respond to changing circumstances, it can be difficult to facilitate such change or incorporate effective practices into larger plans because of social constraints on confronting cultural norms. Formal civil society organisations can play a key role in mediating the interface between these informal institutions and broader adaptation planning processes.

## Extension programmes

Institutions that provide information have considerable influence over household and local adaptation decisions and strategies, but few of these institutions are delivering information that takes climate factors into account. Agricultural extension programmes

in China and Nepal are providing information to farmers on certain types of tree crops, mostly based on their potential for high economic returns. This information is being reinforced by price signals coming from market institutions, which perhaps play the largest role in the decisions of farming households throughout the region. However, conditions in the areas studied are changing, and along with them the viability and productivity of different trees. As a result, farmers are making maladaptive choices. Farmers now need, but are not getting, information to help them select tree crops based on the changing conditions as well as economic factors; as a result, many are experiencing widespread losses from drought and other climate-related conditions. A similar situation exists with migration – households could make decisions that more effectively increase their resilience if they had information on climate trends that affect income opportunities, both in their home communities and work destinations. While provision of climate information is generally considered the responsibility of the government, local institutions could play an important role in providing information on current climate variability and extreme weather events.

### **Communicating innovations**

People are testing new approaches for adaptation to changing climatic conditions, which are enhancing their adaptive capacity, but institutions delivering services may not be capturing these innovations and communicating them to others who could benefit. The failure of knowledge generated by local adaptation responses to reach formal institutions could impede enhancement of adaptive capacity. There is evidence of farmers in China, Nepal, and Pakistan autonomously changing their cropping patterns to increase their resilience in an increasingly uncertain climate scenario. Because of poor communication feedback loops to agricultural extension programmes, their learning is not being disseminated through formal institutional channels. Adaptive research on crops grown under different agro-climatic conditions has not been promoted and little access to agricultural inputs by farmers impedes the process of enhancing adaptive capacity and livelihoods.

### **Downward spiral of vulnerability**

Vulnerability to climate change hampers access to systems, services, and institutions that could increase

adaptive capacity, creating a potential downward spiral of increasing vulnerability. In Assam, the risk of floods and their impact on people's income and livelihood options has made public and private agencies wary of providing services that could increase resilience. Banks are unwilling to lend money to self-help groups for fear that borrowers will not be able to repay their loans, and the government is reluctant to invest in infrastructure for public services such as education and health. The poor are the least likely to be able to access these crucial services through alternative channels.

### **Local institutions**

Local government institutions are better positioned than national institutions to have linkages with informal institutions, but upward channels of accountability, rigid operating procedures, and lack of resources can limit their ability to interface effectively. Government agencies agree to allocate and disburse financial resources at the local level. The process for informal institutions to access these resources to promote the adaptive capacity of the community in general and vulnerable groups in particular is yet to be assured. In Assam, local government institutions have democratic features and are in touch with local needs. However, they lack the resources to implement locally desired actions, and their decision-making processes are dominated by state agencies and the politically powerful, who often press for their own agenda.

# Conclusion and Recommendations

Communities in the region are already adapting to changes, including climate change. These autonomous adaptations require an enabling policy environment in the context of the uncertainty and complexity of climate change. The major challenge in establishing an effective policy environment for planned adaptation is that it is likely to require a long period of trial and error during which autonomous adaptation strategies will be the first line of defence for many vulnerable people. This study recommends some of the ways in which the adaptation policy environment can be supportive of local responses.

## **Develop effective institutional arrangements**

Adaptation planning should give greater attention to the development of effective institutional arrangements to support adaptation. This will require assessing the institutional systems essential to the development of adaptive capacity; the interfaces between the institutions within these systems; and the factors that make these interfaces more effective in delivering adaptive capacity.

## **Establish, designate, and strengthen the role of focal institutions**

A focal institution in the government needs to be established, designated, and strengthened to streamline and complement adaptation planning. The institutional arrangements should address the overlapping roles and responsibilities of each sectoral government agency, NGOs, and community-based organisations operating at different levels. Defining the working relationship among government institutions, NGOs, and local communities will help in translating policies into practice at the local level.

## **Disseminate climate information to service delivering institutions**

Local, national, and regional adaptation planning needs to identify institutions acquiring and analysing data and disseminating information that can contribute to adaptive capacity. Data and information sharing mechanisms need to be designed and

operationalised so that delivery institutions can access reliable climate data and information when designing adaptation interventions.

## **Capture demands and ensure service delivery**

People are becoming aware of the types of services and interventions they need from the government and other development actors to deal with climatic changes. Adaptation planning processes need to capture these demands and ensure that institutions are in place to deliver them.

## **Engage public participation**

Adaptation planning should not be a technocratic process. It needs to engage the public through participatory methods in order to respond to local needs; draw on local knowledge about climate conditions and methods to address them; and create synergies between public and private/formal and informal adaptation interventions. To enable these activities, there is a need to establish a working arrangement at the local level among government agencies, NGOs, and local communities engaged in implementing adaptation practices. This mechanism would create space for the discussion and negotiation of alternatives.

## **Build capacity at various levels**

Building the capacity of local people and communities to adapt to climate change requires drawing on the services and interventions of state and non-state, local and national institutions. Adaptation planning cannot be isolated in any of these domains.

## **Improve access to livelihood diversification**

Given the limitations of market institutions to adjust to changing conditions, alternatives are required from other formal or informal institutions to encourage climate-friendly behaviour by households and private sector actors, whose decisions are largely determined by price signals, which address only short-term

supply and demand factors. Further, to develop confidence among people engaged in adaptation, it is necessary to introduce livestock and crop insurance schemes and support for storage and transportation. There is a need to undertake local-level research on market responsive farm products and input, which will promote livelihood diversification. Both public and private sector institutions must take the initiative in this area. The public sector could provide part of the necessary financial and technical support to the private sector, including NGOs and community organisations.

### **Support community level responses**

The public sector and sponsors investing in adaptation to climate change should be aware of the adaptation strategies that people are pursuing and align their support with these strategies. For example, strategies that are based on labour migration allow families to invest more in children's education. Public investment that supports learning materials on the effects of climate change could

enhance the contribution of private remittances to household resilience. There are examples of climate resilience schemes in specific areas that are mature for replication or further investigation. Information on these community level responses must be collected, documented, and disseminated for adaptation. Private sector institutions including NGOs and community organisations should undertake these activities with the support of public sector and donor investment.

### **Disburse resources at the community level**

In order to implement adaptation programmes through local groups and community organisations, financial resources must be allocated at the community level. An effective mechanism for the disbursement and use of financial resources needs to be designed using a participatory approach. The mechanism should prevent undue pressure and protect against the misuse of funds.

Part 2

# Case studies



# Role of Local Governance in Strengthening Capacity to Adapt to Water Stress: Cases in Pakistan

Shahid Nadeem, Farid Ahmed, Mohammed Younis, Aga Khan Rural Support Programme (AKRSP)

## Introduction

The governance system in Chitral has evolved over the years: From 1590 to 1969, Chitral was an independent princely state with the rulers playing a dominant role in the provision of services and management of natural resources. With the end of princely status in 1969, Chitral became a district of Khyber Pakhtoonkhwa Province (the former North West Frontier Province) and state functions were taken over by government departments with negligible participation by communities. Until 2001, the governance system of the district was mainly provincially driven with limited or no participation by communities. In 2002, under the Local Government Ordinance 2001, district government was introduced, and the government departments were meant to devolve power to the district level. However, to date, the federal and provincial government agencies have not devolved power to their local counterparts and are operating parallel to the district line departments.

This study is a continuation of the research conducted in Chitral district under the programme 'Local Responses to Too Much and Too Little Water in the Greater Himalayan Region' (AKRSP 2009). Assessment of the impacts of water stress and flash floods on livelihoods and documentation of adaptation strategies were among the major objectives of the previous study. From the research it emerged that traditional water distribution and management practices were the most pervasive and effective strategies for the efficient use of the district's limited water resources and for reducing vulnerability to climate extremes (AKRSP 2009). Moreover, the research showed that traditional institutions in Chitral had become an important medium for the management and distribution of water resources, enhancing the adaptive capacity of local

## Key findings

- Local-level institutions, through effective water resource management, have been an important driving force for enhancing local adaptive capacity to water stress.
- Improving the indigenous system of water governance, with the support of non-governmental organisations, has proven that the replication of these systems by government organisations will increase the sustainability of these interventions and the adaptive capacity of the local people.
- There is a disconnect between sectoral and local-level planning in water management. A proper strategy to translate water sector policies into local-level planning would facilitate development initiatives to address local adaptation needs.
- Coordination among water sector organisations in the study area is required to minimise the impacts of climate change, especially in relation to droughts.
- Government organisations have well defined mechanisms, both internal and external, for ensuring accountability and transparency at all levels of implementation and management. Proper enforcement of these rules and regulations and a reduction in the currently rampant malpractices will increase the effectiveness of development interventions.
- Political influence in government water sector planning and financing should be minimised, and development interventions should be supported to reach vulnerable communities and thus reduce their vulnerability.

communities. The study indicated that further research was needed on the relationship between community-based institutions and local adaptation, specifically on the survival of local water governance systems in the study area. It also revealed that the ratification of rules and regulations related to new development interventions by the Government of Pakistan was posing new challenges to community-based institutions. Furthermore, the research showed that in most of the study areas, multiple management systems were thriving, with little influence on one another.

## Research objectives

This study aimed to:

- understand past and current local governance systems for water management;
- examine the capacity of local institutions to adapt to changing climatic and environmental conditions;
- understand the effect of water sector interventions initiated by government and non-governmental agencies on the functioning of local institutions and the adaptive capacity of local communities; and
- recommend strategies for good local governance systems for water management that will strengthen people's adaptive capacity.

## Research methodology

Data were collected using a range of tools including key informant interviews and focus group discussions. Focus groups varied in size from 10 to 15 people with emphasis on the inclusion of all age groups and

**Table 2: Details of focus group discussions**

Governance system	No of focus group discussions	Participants	Villages
Indigenous	4	49	Gaht, Nogram, Warijun, Kushum
Modern	2	24	Saht, Drasun
Government-managed	2	18	Denin, Morilasht

classes (Table 2). The information collected from the focus group discussions was validated in open-ended discussions on major issues with key informants. In addition, interviews with government officials (from Tehsil Municipal Administration, Department of Irrigation and Agriculture) and local government representatives were also conducted to obtain in-depth information on water governance systems. The study was conducted with the facilitation of village-based institutions (village and local support organisations) to gather accurate and reliable data within a short time period. Lack of access to government data during the survey was a major limitation of the study.

A set of research questions were framed according to the objectives of the study, and an attempt was made to address these questions by analysing and interpreting the information and data obtained from primary and secondary sources (Table 3).

## Scope of the study

This study focused on local governance systems to document past and current local water governance systems and assess capacity to adapt to changing

**Table 3: Research questions and objectives matrix**

Research questions	Research objectives*			
	1	2	3	4
What kind of water governance systems, particularly local institutions, exist for water management (including the management and maintenance of physical structures) in Chitral?	X			
What are the characteristics of the water governance system (accountability, transparency, equity, and inclusiveness, etc.), and what role does the governance system (including local institutions) play in sustainable water resource management? (If not what are the constraints?)		X		X
What external factors (policies, political power, etc.) influencing the functionality of the local water governance system?		X	X	
What can be done to improve local governance mechanisms for water sector management so as to enhance people's adaptive capacity?				X

\* 1 = Understand past and current local governance systems for water management; 2 = Study the capacity of local institutions to adapt to changing climatic and environmental conditions; 3 = Understand the effect of water sector interventions initiated by government and non-governmental agencies on the functioning of local institutions and the adaptive capacity of local communities; 4= Recommend strategies for good local governance systems for water management that will strengthen people's adaptive capacity.

climatic conditions. It also looked at the impact of government and non-government initiated water sector interventions on the functioning of traditional institutions and how they affect the adaptive capacity of local communities.

Based on the objectives, the research was divided into two main parts. The first part dealt with documenting the strengths and weaknesses of the water governance system in Chitral and analysing its influence on the adaptive capacity of communities. The second part examined existing policies, institutional arrangements, implementation mechanisms, and investments to assess implementation mechanisms in relation to existing policies. Cause and effect analysis was also conducted to emphasise the effect of policies on local adaptations.

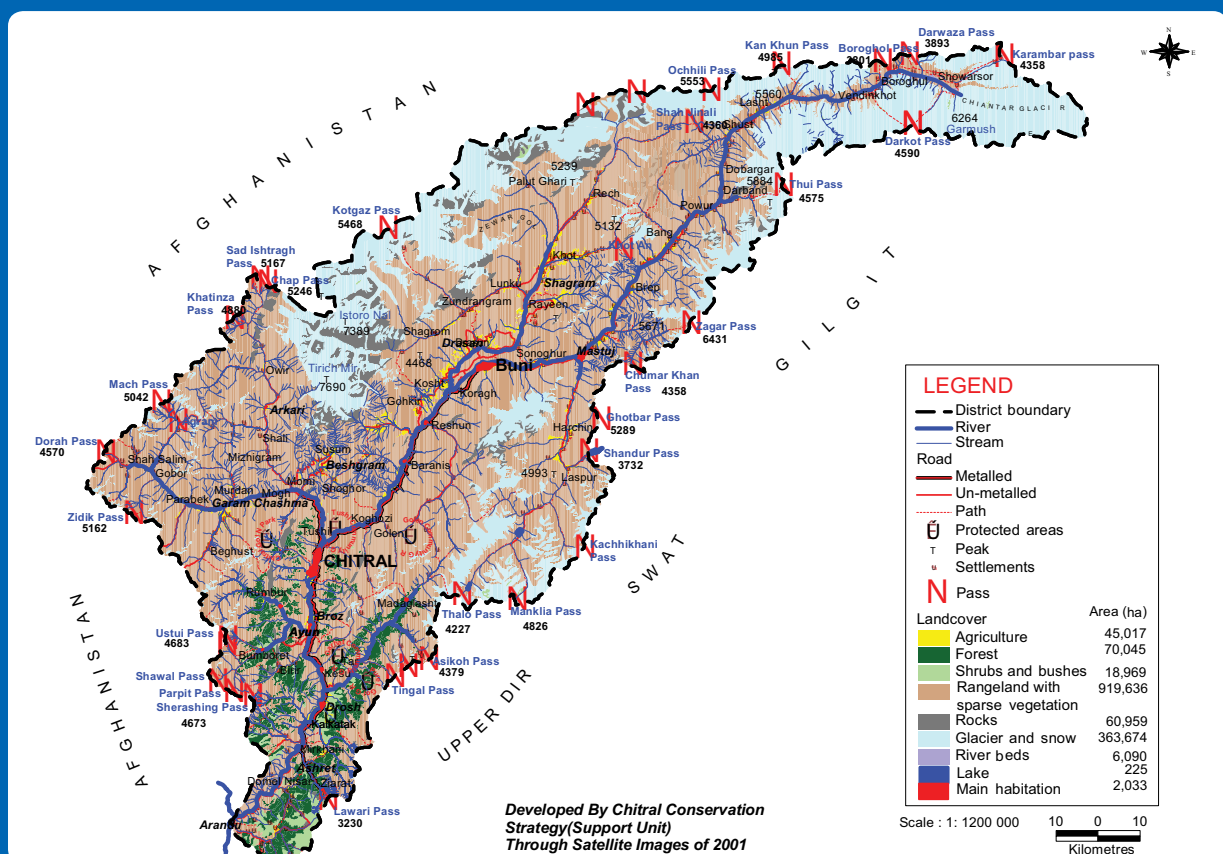
## Study areas

The study covers two major local water governance systems practised in Chitral district. Mulkhow Union Council, a water scarce area, was selected to explore community-managed water governance

systems, both indigenous and modern; and Denin and Koh union councils were selected to study government-managed systems. Mulkhow was also one of the main study sites selected to assess impacts and adaptation to water stress. Strong indigenous institutions have emerged in this area, as the key driving force in shaping adaptations through efficient and effective water resource management (Nadeem et al. 2009).

Situated in the extreme northwest of Khyber Pakhtoonkhwa Province, Chitral is a geographical entity consisting of the upper Kunar River basin; locally, the river is called Chitral River (Figure 6). The district stretches over an area of 14,850 square kilometres and shares boundaries with Afghanistan in the north and west, Gilgit-Baltistan in the east, and Dir and Swat districts towards the south (AKRSP 2009). Administratively, the district is divided into two tehsil municipal administrations, consisting of 24 union councils. A tehsil municipal administration is a middle tier of the district government whose main functions include delivery of municipal services, the development and management of small projects, land use planning administration, and monitoring. A

Figure 6: Map of Chitral district, Pakistan



Source: IUCN 2005

union council is the lowest level of district government whose main functions are to identify and prioritise local-level issues and development needs, local-level development planning, the maintenance of data on socioeconomics, and monitoring of the implementation process.

The population of Chitral district is around 385,000, with 48,000 households (with average household size of 7.9 persons). The male population is 162,082 (50.85%) while the female population is 156,607 (49.15%). About 9.6 per cent of the district population live in urban areas and 90.4 per cent in rural areas (Government of Pakistan 1998). The region was ruled by the local hereditary ruler under Pakistan until it became a district of the Frontier Province of Pakistan in 1969. Muslim people constitute the majority (99 per cent; 30 per cent Ismaili and the rest Sunni). Ethnic minority groups include semi-nomadic Muslim Wakhis and Gujurs and the non-Muslim Kalasha people (IUCN 1998, 1999).

The entire region lies in the monsoon shadow and receives very little rain. Variations in the frequency and duration of rains are the main reasons for prolonged droughts affecting the socioeconomic conditions of inhabitants, especially in the northern part of the District. Precipitation ranges from 600 mm per annum in the south to 200 mm in the north (IUCN 1999, p 5). The bulk of this precipitation comes in the form of snow during the winter. Almost all of the land under cultivation depends upon surface irrigation water originating from glacier melt.

The main source of income in the district is subsistence agriculture, with average land holding of less than 1 hectare. While 90 per cent of the population is engaged in farming, 75 per cent of household income is derived from off-farm sources. Agriculture is wholly dependent on surface irrigation through a network of small irrigation channels. Perennial streams fed by glacial melt and natural springs are the only source of irrigation and drinking water. Until 1969, water resource management in Chitral was predominantly led and devised by the ex-rulers and their representatives; water and irrigation infrastructure was constructed and managed by governors and their appointees from the respective areas using forced labour. Under this system, water was divided among different clans according to social status, quantity of land, and affiliation/relationship with the royal family. Later, land and

water were equally divided among the descendents, and this provided the basis for the emergence of local water governance in the area.

## Results and discussion

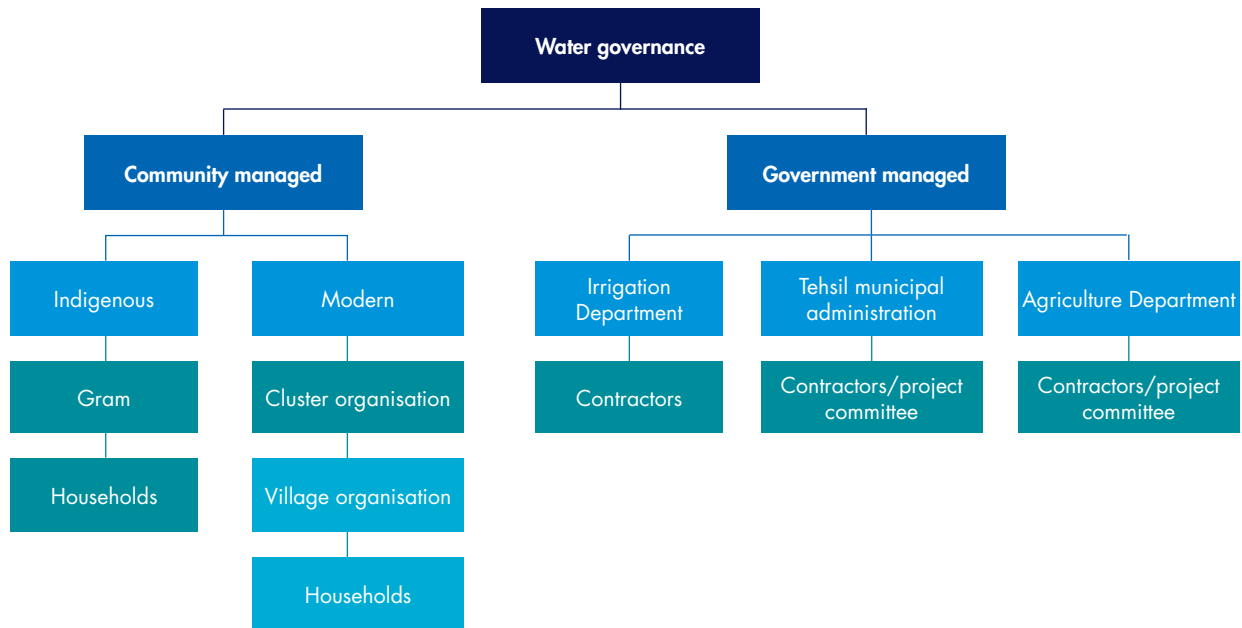
The water governance system in Chitral is an important factor in the sustainability of water management, especially in times of water scarcity. Local communities are managing the meagre amount of water through local institutions, which are important factors in local adaptation. The effective functioning of these governance systems is assessed according to the principles of good governance. Two types of local water governance systems are in operation in Chitral for the management of water resources: community-managed and government-managed (Figure 7).

### Community-based versus government-managed water governance systems

Community-based water governance is predominant in the Mulkhow area of Chitral. Within this system, informal institutions have emerged as key to enhancing adaptation through collective water resource management and the reinforcement of existing adaptation practices (such as upgrading traditional ponds to concrete structures, the development and lining of irrigation channels, water supply schemes, and siphon irrigation systems). The community-based water governance systems in Mulkhow can be categorised into two types, i.e., indigenous and modern.

The indigenous system of water management evolved from the governance system installed by the ex-rulers of Chitral. Under this system, the rights of individuals are defined and water is distributed as per these rights. This governance structure caters to both macro and micro level needs of water resource management. At the macro level, representatives of villages make arrangements together for the distribution and management of water between villages. At the village level, the 'gram' (the smallest unit in a community), consisting of representatives of each tribe/clan, enforces these decisions. Under normal circumstances, water distribution starts in mid-March, depending on climatic conditions and the availability of water in streams. Once the distribution time is finalised, the quantity of water is assessed and a timetable for water distribution developed as per people's water rights. The timetable is then shared with the community and displayed in mosques.

Figure 7: **Community-managed and government-managed water governance systems in Chitral**



Source: Field research

Maintenance of the water resource infrastructure is conducted by the community. Equal distribution of water and routine maintenance of irrigation channels is ensured through a person called a 'mirzhoi', who is paid in cash or kind (usually grain during the harvesting period). Large-scale maintenance work is the collective responsibility of all water users. Under the 'mon' system every person in a gram must take part in repairing the channel. The system makes provision for contribution in cash or kind if a person cannot physically take part in the maintenance work. Communal water harvesting structures called 'chat' are constructed where water from perennial streams and springs is stored and later used according to the predefined distribution system.

The modern system of water governance is a modified version of the indigenous system with village and cluster organisations as its formal institutional structure. The cluster organisation comprises one or two members from each village organisation. This governance structure and system is based on the concept of participatory development interventions, introduced by NGOs (especially the Aga Khan Rural Support Programme) in the mid-1980s. Today,

these village-based organisations provide the basis for the development of modern water distribution and management systems in the region. Under this system, the distribution of water among villages is the responsibility of the cluster organisation. Village organisations are responsible for ensuring water supply to member households. After winter, the channel is renovated and every household has to contribute labour, cash, or in-kind support. The cash contribution is on a daily wage basis, whereas contribution in kind is in the form of materials for the construction of the channels. It is mandatory for every member household to contribute to the maintenance work in order to be eligible for water allotment. The allotment of water is based on the amount of time contributed by households and the village, which is decided by mutual consensus after completion of the work. Thus, a household contributing more time receives more water; the same principle applies to the distribution to villages. As in the indigenous system, a mirzhoi is appointed to ensure the equal distribution of water and to maintain the irrigation channels. Apart from managing water resources, this system has the capacity to increase the resource because of its dynamic characteristics, whereas the

indigenous system has a predefined management system with no room for improving water resources.

Since the merger of Chitral, the government has taken several initiatives to improve water availability in the area. The government-led water management governance structure is rather complex as several government institutions and departments are involved at the district level, namely, the Irrigation Department, On-farm Water Management, Agricultural Engineering (Ministry of Food and Agriculture), Tehsil Municipal Administration, and the Public Health Engineering Department. The Irrigation Department is mainly responsible for the construction and maintenance of irrigation channels. Around 15 projects have been completed and are managed by this department. Distribution channels are made by the department with little or no participation by the community. Water is distributed on the basis of area of cropped land. Bi-annual fees are charged for services ranging from 200 to 2,000 Pakistan rupees (about USD 2 to 22) depending on the type of crop (orchard, cereal crop, or forest trees). The user fee for cereal and orchards is less than for forested areas, in line with the government policy to ensure food security. Contractors are responsible for the annual maintenance of water infrastructure and the community has no say or role in this regard. There is no provision for emergency maintenance and the allocation of emergency funds follows a complex procedure. As a result, the community members do the repair work as they cannot afford to wait and risk crop failure.

The water governance systems discussed above play a key role in influencing adaptive capacity to water stress. These governance systems are analysed using the key characteristics of good governance to determine how they affect local-level adaptation (Table 4).

The comparison of water governance systems clearly reveals that community-based systems are enabling the local people to respond to water stress. The community-based water resource management system has strong community participation at all levels of planning and decision making. This strong, transparent, and accountable mechanism has improved access to water during stress periods. On the other hand, the government-managed system lacks transparency and accountability, resulting in limited community participation in the planning and management of water resources and limited support for local adaptation needs.

## Policy implications

This section explores the linkage between the policy environment and local adaptation needs. A cause and effect analysis of water sector policies, institutional mechanisms, and implementation practices was carried out to explore how policies support local-level institutions in strengthening local adaptive capacity.

The policy environment is complex and unclear. There is little coherence in the policy framework, with three tiers of policy making: federal, provincial, and district. At the federal level, the major policies available include the Draft National Water Policy 2005, National Environment Policy 2005, National Drinking Water Policy 2009, and Sanitation Policy 2009 (Ministry of Environment, 2005a, 2005b, 2009a, 2009b).

These policies are premised on the participation of communities at all levels of management; the conservation of water resources; increasing the coverage of water supply and treatment facilities; the decentralisation of planning, development, and management to the local level; and the inclusion of all stakeholders. However, in the absence of any strategy or implementation guidelines to implement these policies in a way that suits the local conditions, these policies are largely ineffective when it comes to reducing water stress. Despite the fact that water is a provincial subject, there is no separate policy for meeting the water needs of the increasing population. The exception is the Provincial Agricultural Policy 2005, which makes provision in its sectoral guidelines for reducing water losses during farming and increasing water volume for distribution (North West Frontier Province Government 2005). Because policy guidelines and planning for the sustainable development of the water sector are lacking at the local level, the results of interventions are difficult to show at the district level.

The institutional arrangements for water sector policy formulation and the implementation of programmes are complex and involve numerous organisations from national to district levels with varied roles and responsibilities. Water sector policies are mainly framed by institutions at the national level that have no linkages with the provincial and district government. The Department of Planning and Development, Department of Irrigation, and Department of Food and Agriculture deal with policy

Table 4: Characteristics of water governance systems that influence adaptive capacity to water stress

Characteristic	Community-managed		Government-managed
	Indigenous	Modern	
Participation	All beneficiary households are involved in the process of decision making through the gram, a traditional social unit.	Cluster/village organisations are involved in all decision making.	Communities have no role and only token representation in decision making.
Transparency	All water resource management and distribution related rules and regulations and decisions are taken collectively and shared with the beneficiaries.	All water resource management and distribution related rules and regulations and decisions are taken collectively and shared with the beneficiaries through the cluster/village organisations.	Decisions about funds and on the management and distribution of water are not shared with communities.
Accountability	<p>The accountability of beneficiary households is ensured through their role in the maintenance of the water system.</p> <p>Everyone has predefined rights in the distribution of water. In the case of non-compliance, the offending party is convicted and a replacement nominated to ensure efficient distribution.</p>	<p>Maintenance is strengthened as it is linked to allotment rights based on the extent of participation by member households.</p> <p>Member households are allocated water according to their level of participation in maintenance work. This is ensured by the local communities making someone responsible for maintaining the distribution of water resources.</p>	<p>Maintenance work is done through regular contractors who are not accountable to local communities.</p> <p>The nominated person is accountable only to the relevant government department.</p>
Flexibility	<p>Water rights are fixed among users.</p> <p>Female-headed households are given exemptions in relation to maintenance work and allowed to use the water.</p>	<p>Water rights are changeable depending on community participation in maintenance work.</p> <p>Local communities at the village level relax the conditions for female-headed households who are allowed to use water without contributing to maintenance work.</p>	<p>Water rights are predefined by the government and are not changeable.</p> <p>The system lacks flexibility as no consideration is given to female-headed households in the allocation of water.</p>
Equity	<p>The system does not ensure equity as some people have more rights than others, despite the same level of participation in maintenance work.</p> <p>Both small and large landowners have to contribute equally during construction and maintenance.</p> <p>Water allocation between villages is not equitable. During longer days, the upper riparian community receives water for longer periods; during shorter days, the lower riparian community receives water for shorter periods.</p>	<p>Everyone participates in system maintenance as per their water requirement. People with more land have to contribute accordingly in labour, cash, or kind. The amount of contribution forms the basis for their water allocation.</p> <p>An extra hour of water is allocated to end users to compensate for evaporation and seepage loss, thereby ensuring equity in the allocation system.</p>	Even though the distribution of water is equitable, the community is unable to benefit optimally because of lack of proper monitoring and enforcement.

making and planning for the sustainable development of water resources in Khyber Pakhtoonkhwa Province. There is no separate policy at the provincial level for the sustainable development of water resources. After the devolution of power in 2001, the Chitral District Government emerged as an important

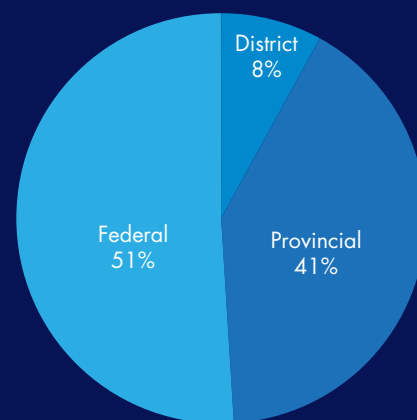
stakeholder in the management of water resources. It has been granted the power to legislate and develop plans through councils established at the district, tehsil, and union levels. The provincial departments decentralised at the district level include the Public Health Engineering Department and the Agricultural

Department (only water sector). At the district level, these departments are financially and administratively accountable to the Chitral District Government. At the provincial level, they are responsible for policy making and the planning of natural resources.

Water sector investments are also an important determinant in understanding current practices in line with policy guidelines and are helpful in assessing policy implementation. Government sector interventions are undertaken either as a part of Annual Development Programmes or as direct allocations by the district, provincial, and federal governments. The data collected from the executing agencies (Tehsil Municipal Administration and the Public Health Engineering Department) reveal that almost 51 per cent of total investment is from the federal government, whereas the provincial government accounts for 41 per cent and the district government only 8 per cent. The federal and district governments allocate funds to their representatives, and these funds are used as per their direction. The provincial government apportions 51 per cent of total funds through regular Annual Development Programmes and 49 per cent through direct

Traditional water harvesting structure, Mulkhow, Pakistan

Figure 8: Financial allocations



allocation. As a result, these funds are channelled to areas of interest, which, in some cases, leads to duplication and overlapping of activities. The district government contributes the smallest share of development funds, even though executing agencies have been devolved to the local level (Figure 8).

Lack of proper planning and operational mechanisms to strengthen local adaptive capacity is the main cause of ineffective policy implementation, which



in turn limits local adaptation capacity (Figure 9). On the other hand, poor planning at the local level has proved to be one of the major issues, resulting in ineffective institutional mechanisms for water sector development. Lack of knowledge of water policies, unavailability of provincial or district-level implementation guidelines, scarce financial resources, a high level of political influence, and lack of prioritisation of issues are the reasons behind poor planning at the local level.

Lack of proper adaptive planning at the local level has resulted from broad guidelines without any implementation strategy for translating recommendations at the local level. The public sector lacks knowledge of local water sector issues and policies. Therefore, planning and distribution do not meet with actual needs, especially the increased need of people for water.

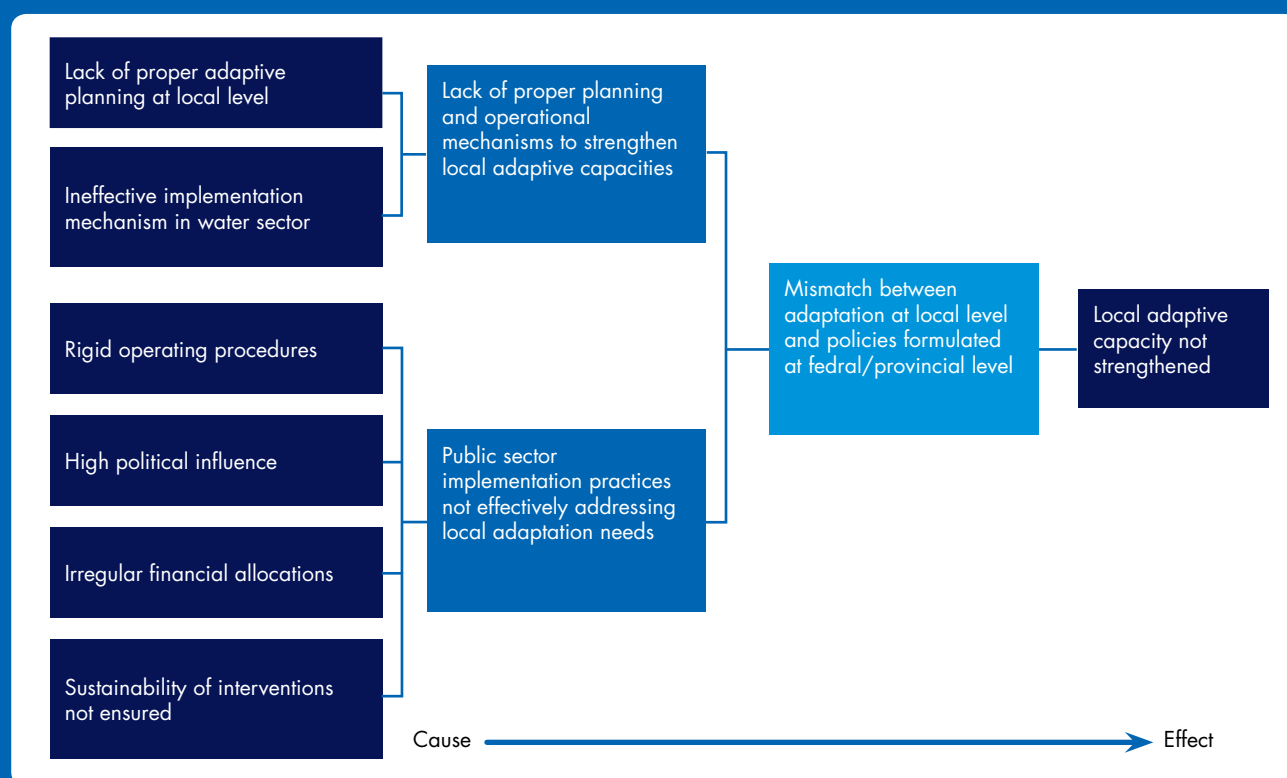
Ineffective implementation mechanisms have arisen from the complex institutional arrangements, absence of effective coordination mechanisms, and the politically influenced and irregular financial allocations and planning process. As a consequence,

allotments appear to be erratic, without the proper assessment or prioritisation of needs. The sustainability of interventions is not adequately considered. Rigid operating procedures limit the possibility of partnership development between government and NGOs to jointly address local adaptation needs.

Lack of community participation is a key characteristic of the public sector working pattern. The negligible involvement of communities has resulted in limited support for the implementation of projects. It has also contributed to the vulnerability of interventions to influence by power brokers.

High political influence and interference infiltrates all areas, from finance to the planning and implementation of public sector interventions. This has affected the credibility of public sector organisations and hampered the performance of professionals. The disbursement of development funds is dependent on national or provincial elected representatives, and line agencies are mere conduits for the transfer of funds. Fund allocations do not follow the priority needs of communities. As a result, most development interventions in the water sector end in failure.

Figure 9: **Causes of ineffective implementation of policies**



Source: Field research



Collective canal management, Mulkhow, Pakistan

Implementation by public sector agencies is constrained by lack of finances — a result of budgets that are either earmarked for provincially planned projects or allocated to elected representatives. These representatives are free to hand out funds to gain popularity among people, rather than to target the real needs of communities. As a result, local public sector agencies have very little say in the planning of projects and allocation of funds.

The sustainability of interventions is not ensured because local expertise is not acknowledged. Disregard of existing locally established and effective mechanisms for the management of water resources has eroded community interest in, and ownership of, the interventions. It has also created tension within communities in some cases. The contracts assigned by the government do not include the maintenance and repair of projects after completion.

## Conclusion and policy recommendations

The study has revealed the strengths and weaknesses of both community-based water resource management

and government-managed systems. Government agencies have well defined mechanisms, both internal and external, for ensuring accountability and transparency at all levels of implementation and management. However, poor implementation of rules and regulations and other malpractices are rampant within government organisations, hampering the effectiveness of interventions. In addition, existing policies have not proven to be very effective in improving the system because of lack of proper implementation mechanisms; hence, water-related problems result even after huge investments are made. Water sector investment is not taking place through proper planning at the local level, so interventions overlap. Consequently, the interventions only partially accommodate local-level adaptation needs.

Effective water governance has a key role to play in shaping local capacity to adapt to water stress in the study area. Based on local knowledge, the community-level institutions in the study area have been effectively addressing water shortages by ensuring the judicious management and use of water resources. However, there is a disconnect between water sector policies and local-level water sector

development planning. Lack of an implementation strategy and short- and long-term action plans at the local level hampers the effective implementation of local adaptation to water stress. Weak institutional arrangements in the government sector combined with ill-defined functions have limited local adaptive capacity. As a result, government practices have marginalised traditional local institutions and have made communities more vulnerable to the risks emerging from climate change. The recommendations listed here aim at strengthening local adaptive capacity by addressing the issues that emerge from the key findings of the study.

- Adopt a participatory approach in order to develop an integrated water sector policy to address community needs through the participation of relevant stakeholders at national, provincial, and district levels.
- Develop an effective implementation strategy for existing national/provincial policies and sectoral guidelines aimed at fostering the sustainable development of water resources.
- Coordinate with community institutions when developing plans for local-level interventions to improve local governance of water resources. Recognition of the existing role of community institutions that are actively managing scarce water resources is crucial to ensuring the sustainability of any project in the area.
- Coordinate with relevant stakeholders for integrated water resource management to incorporate local expertise related to water into development interventions.
- Enhance the capacity of public sector staff to take into account policy dynamics and climate change scenarios when planning and implementing development interventions in the area.
- Prioritise the equitable and sustainable distribution of water resources through proper planning. Financial allocations should be made through Annual Development Programmes to reduce the seepage of funds to non-prioritised areas. Areas that are facing acute water shortages should be prioritised to enhance the adaptive capacity of local communities in the area.



# Tree Crops as an Adaptation to Climate Variability: Cases in China, Nepal, and Pakistan

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## Introduction

Changes in climate and weather patterns are having a dramatic impact on ecosystem-based livelihoods, especially in agriculture, a key source of income for all countries in the Hindu Kush Himalayan region. One factor contributing to household vulnerability is the use of monoculture production systems, which lead to reliance on one crop for income. Agricultural diversification, particularly when undertaken in relation to environmental or economic risks, has the potential to increase household adaptive capacity under climate change (Smit and Skinner 2002) and contribute to agro-biodiversity and the sustenance of vital functions, structures, and processes in agro-ecosystems (Mijatovic et al. 2011). It supports adaptive genetic processes among crops, spreads risk and vulnerability to stress, and can contribute to the stable provision of ecosystem services. Agricultural diversification also shelters households from other impacts, such as decrease in the market value of cultivated crops. Diversification has been a fundamental coping strategy in traditional agricultural systems in the region, and has been supported by a great deal of research into modern cultivation systems. However, with increasing market development, the monoculture approach has replaced traditional agricultural diversification in some areas. Current approaches and knowledge in agriculture, particularly monoculture, systems need to be re-examined for their viability in the context of climate change, and most likely enhanced and adapted to suit the growing uncertainty and increased risks posed by global climate change.

The integration of trees into cultivated land, or agro-forestry, is one approach to agricultural diversification that has been shown to provide a range of potential benefits. Agro-forestry systems are a tool for income diversification and can benefit

## Key findings

- In the study areas, markets and government policy have more impact than climate change awareness on the diversification of agriculture using tree crops, and have played a key role in enhancing the adaptive capacity of the studied communities.
- Policy environments and institutions are not yet responsive to the pace of change experienced by agricultural communities or to their new needs for highly adaptive and resilient systems.
- Climate change and variability increase uncertainty and risks, as well as promoting opportunities in livelihood systems, particularly for people dependent on agriculture for their livelihood.
- Monoculture systems in the study areas have proven particularly vulnerable to both economic and climatic shocks and shifts, whereas diversified production systems, including through the use of tree crops, have provided some amount of protection from such impacts.
- In the event of extreme stress, as was experienced in the study area in China, trees are affected to varying degrees depending on their species and age, and households are affected according to the range of tree species planted. For example, walnuts not only survived in larger numbers than agricultural crops, depending on their age, but also had high yield in 2010.

ecosystem service provision. Many tree varieties are resilient to various forms of climate-related stress. The diversification of income sources is central to economic diversification, and is outlined as a key strategy for developing national adaptive capacity under National Adaptation Plans of Action (NAPAs) and the Nairobi Work Programme. Existing research has shown a range of potential benefits of trees in agro-ecosystems, particularly regarding their role in soil, hydrological functions, and ecosystem service provision. Trees also contribute to income generation and food security. However, their capacity for reducing vulnerability and risks at the household level and across landscapes and climate zones remains virtually unexplored.

This chapter documents the results of three case studies completed in China, Nepal, and Pakistan. It examines the significance of trees on farms in creating resilient livelihoods at the household level. It also examines to what extent current policy frameworks support the use of trees in enhancing the adaptive capacity of agricultural communities and production systems.

## Research objectives

This study aimed to:

- improve understanding of the impacts of climate change and climate variability on farm tree crops and of the potential for tree crops to support adaptation to climate change;
- identify and document cases where tree crops have contributed to improved climate resilience for farming households and communities, or where, conversely, tree crops have suffered from climate change;
- improve understanding of the policy context in which tree crops are used as a tool for agricultural diversification to achieve more resilient farming communities in the Hindu Kush Himalayan region; and
- share experiences and learning among different countries within the region and leverage findings towards improving national adaptation strategies.

## Research methodology

The methodology for analysing the role of trees on farms as an adaptation strategy initially involved gathering secondary data and analysing published literature and previous studies. The secondary data included meteorological observations, government

policies, event related press releases, and land use and agricultural production data. Rapid rural appraisals involving key informants, group interviews, transect walks, crop calendars, field observations, and household questionnaires were then carried out in the study areas in China, Nepal, and Pakistan. These field studies were based on a standardised field research methodology, including a shared questionnaire format with slight modifications made by the research teams in each country according to the national and study site contexts. Sites were selected based on the representativeness of the major agro-ecosystems in the area, with consideration given to the role of trees in local livelihoods, climate and elevation gradients, and the existence of water stress and other climate change impacts. Questionnaire surveys were carried out in three villages in China, eight village development committees in Nepal, and along three area-based transects in Pakistan. Respondents were primarily engaged in agricultural livelihoods, with the majority of respondents in Nepal and Pakistan being male heads of household. Finally, a quantitative analysis was accomplished using descriptive statistics and ANOVA (analysis of variance) tests in Microsoft Excel and SPSS software.

Compiling and analysing the findings of this study was complicated by the notable differences in climate events experienced, production systems, and resulting approaches to adaptation. Because of the recent extreme drought in China, many immediately present impacts were negative and became the respondents' focus during interviews. Furthermore, the effects of the drought could not be fully measured at the time of the study, as the summer harvest and the harvests from many tree crops (e.g., walnuts, which are harvested in September and October) had not yet been completed. Drought was experienced in sites within each country study, but those experienced in Nepal and Pakistan did not compare in severity to the drought in Baoshan Municipality, China, and therefore did not dominate responses to questions as much as in the China study. The Nepal and Pakistan studies focused more on gradual climate change and the impacts of climate variability. Both contexts offered valuable insights into the impacts of climate-related stresses on agricultural productivity, tree crops, and livelihoods.

Other differences included a higher level of awareness of the impacts of climate change in Nepal and a trend of decreasing involvement of younger generations in agriculture in Pakistan. The use of trees

also varied significantly across the study sites, with fuelwood use being much more influential in Pakistan than in the other two countries. National policies emerged as a driving factor behind the presence of trees on farms in China, but did not play as significant a role in the other countries. The translation of the questionnaire from its original English into local languages in each country and adjustments to the phrasing of questions also required special consideration.

A set of research questions were framed responding to the objectives of the study, and an attempt was made to address these questions by analysing and interpreting the information and data from primary and secondary sources (Table 5).

## Scope of the study

The study focused on exploring agricultural diversification using trees on farms as a response that supports people's adaptation to change, particularly climate-related change, in the HKH. The use of trees on farms is an adaptation of significant importance as trees mitigate the effects of extreme climate, buffer against weather-related production losses, secure land productivity through nutrient recycling and improved soil fertility, and provide direct income through tree-based products. The mountain communities of the greater Himalayan region integrate trees into productive landscapes through agro-forestry practices. This study highlights the links between tree crops and local adaptation to climate change, and attempts to quantify the role of tree crops in

mountain landscapes, livelihood management, income generation, and productivity. All of the study sites chosen are predominantly agricultural areas and provide different examples of the role of trees in farming systems. Comparing the three country case studies revealed regional connections and commonalities in impacts, responses, and influencing factors, as well as contrasting approaches to adaptation based on each study area's unique conditions (Table 6).

## Study areas

Research in Yunnan, China, was carried out in three villages in Baoshan Municipality – Haitang, Shuiyan, and Xinzhai – which range from high to low elevation. Baoshan is one of the foremost agricultural production areas in Yunnan. It also has long-term experience in tree crop cultivation. More recently, the Sloping Land Conversion Programme (SLCP) and a range of other government programmes have targeted Baoshan for afforestation, reforestation, and the planting of a number of tree crops.

In Mustang district of Nepal, four village development committees were selected from cold temperate zones and four from alpine zones. A range of crops are cultivated in Mustang, which is also a micro-climatic niche for the cultivation of temperate fruits. Historically, lower elevation farms within the district engage in fruit production more than those in higher elevation areas; but in recent years the climatic suitability of certain crops has been shifting. In the case of apples, suitability at lower elevation has been

**Table 5: Research questions-objectives matrix**

Research questions	Research objectives*			
	1	2	3	4
What are the perceived and observed impacts of climate change on tree crops?	X			
What are the roles of trees in climate change adaptation?		X		
What are the motivations and incentives for farmers to plant trees?			X	
What are the objectives of the government in launching tree planting programmes?			X	
What are the contributions of trees on farms to supporting resilient livelihoods and adaptation to climate change?	X	X		
How does the existing policy context affect the use of trees in adaptation?			X	
How can trees on farms contribute to national adaptation strategies?				X

\* 1 = Improve understanding of the impacts of climate change and climate variability on farm tree crops and of the potential for tree crops to support adaptation to climate change; 2 = Identify and document cases where tree crops have contributed to improved climate resilience for farming households and communities, or where, conversely, tree crops have suffered from climate change; 3 = Improve understanding of the policy context in which tree crops are used as a tool for agricultural diversification to achieve more resilient farming communities in the Hindu Kush Himalayan region; 4 = Share experiences and learning among different countries within the region and leverage findings towards improving national adaptation strategies.

Table 6: **Agro-climatic zone, crops and climate change stress**

Country	Major crops		Temperature trend	Major stress as perceived by the community
	Cash crops	Tree crops		
China	Coffee, paddy rice, maize, tobacco, pears, barley, potatoes, and beans	Walnuts, pine, pears, persimmons, plums, Sichuan peppers, camellia, and coffee	Increasing	Water shortages in spring, hail in summer and autumn, and droughts
Nepal	Naked barley, barley, buckwheat, wheat, maize, beans, potatoes, mustard, peas, and vegetables	Apples, pears, peaches, plums, apricots, and walnuts	Increasing	Water shortages in spring, decreasing snow, erratic rainfall, and increasing fogs, frost, and hailstorms
Pakistan	Maize, wheat, fruit, vegetables, fodder	Walnuts and cherries	Increasing	Avalanches, off-season snow and rainfall, erratic rainfall, frost, hailstorms, droughts, and floods, unexpected cold and warm weather, cold spells in spring, high and increasing temperatures, unpredictable changes in temperature

declining, while upper elevations are now entering into apple production.

Three areas were examined in Pakistan: Miandam in Khyber Pakhtoonkhwa Province (formally North West Frontier Province), and Neelum and Bagh in the Azad Jammu and Kashmir. While agricultural production is a focus in the study areas, the contribution of agriculture to total production in the wider region is declining. Households in each area are reliant on trees both as income sources and for household consumption. Fuelwood is the primary source of demand for tree and forest products, followed by fruit and nut trees grown to provide cash income, and fodder for livestock. Forests and orchards also support the collection of non-timber forest products and honey production.

Across all three country study areas, trees are an integral part of production systems and contribute to livelihoods. In addition to providing fruit and nut crops, they provide other benefits such as fuelwood and non-timber forest products, for example, medicinal plants. Tree systems also support other species communities within agro-ecosystems; for example, orchards contribute to bee and honey production in Pakistan. Tree crops thus diversify the services and functions of production systems.

## Results and discussion

Definite changes in climate have occurred and affected the production systems in each study area.

A rise in temperature was an observation common to all three countries. On the other hand, no trends in precipitation were clear from the meteorological data, and, correspondingly, farmers' perceptions were mixed. Decreasing snowfall in the uplands of Pakistan and Nepal and visible reductions in mountain snow cover were observed in both countries. This has had strong implications for water availability, as both the Nepal and Pakistan study sites contain areas that rely primarily on water from snowmelt. Extreme weather events are a growing concern. The drought experienced in Baoshan in 2009/10 was the worst reported in 100 years. Frequent hailstorm incidents were reported in both Nepal and Pakistan. A rise in temperature and increasingly erratic rainfall were observed in all three countries, and were blamed by farmers for the increase in pests and diseases. In summary, farmers are experiencing changes that may increase uncertainty and the risk of climate-related shocks. The impacts on production systems invite a re-examination of how they provide resilience against risk events and long-term change.

### Resilience of diverse tree crops to climate change

The impacts of climate change on tree crops often differed from the impacts on agricultural crops. In China, where drought severely affected agricultural production and livelihoods, the role of trees on farms was evident in estimated changes in yield. The yields of spring crops dropped significantly in 2010, with yield losses of 70 to 100 per cent (with the exception

of wheat in Shuiyan). Average tree crop yield losses were much lower than losses for agricultural crops. The only exception was coffee, which is grown only in Xinzhai village and is cultivated in monoculture plantations. On the other hand, respondents estimated that yield of walnuts had increased 20 to 30 per cent across the study area. In a time of greatly reduced incomes from agricultural production, such a rise in productivity for some tree crops has been particularly important to overall household resilience.

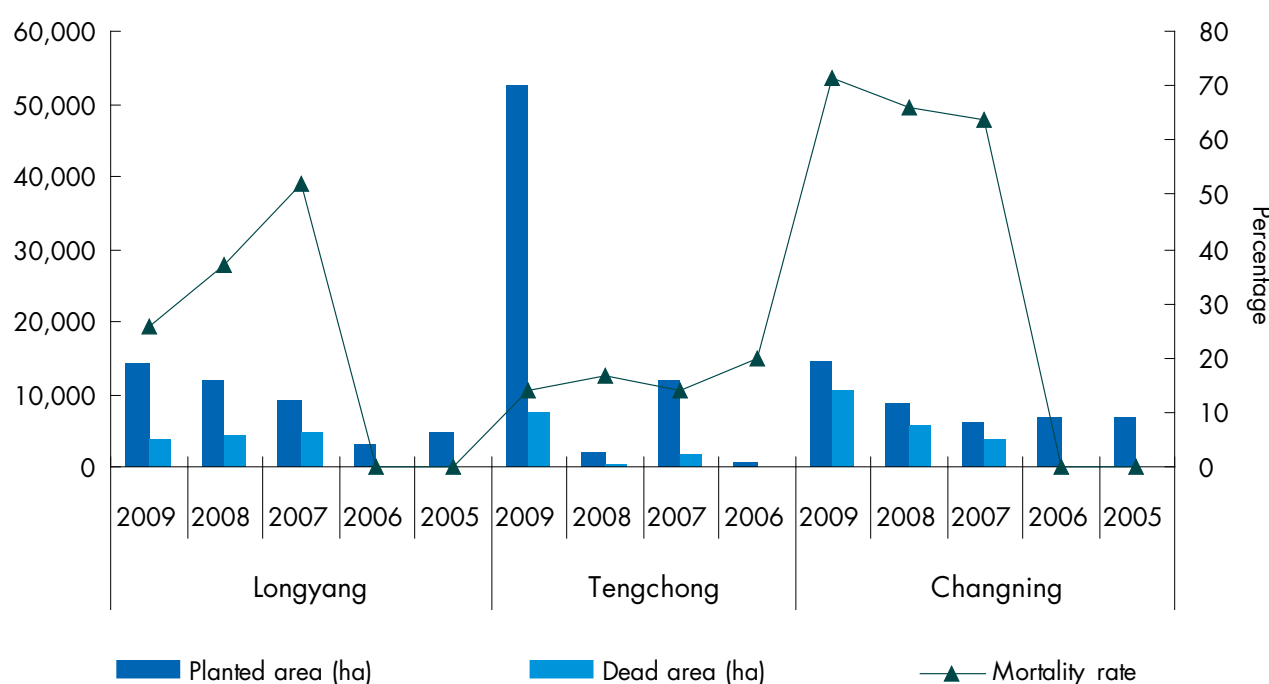
While annual agricultural crops that do not produce yield are simply lost investments, many trees whose yields drop during periods of drought will flower and produce a crop the following year, reflecting the robustness of tree species in the face of climate change. The age of the trees strongly affects the survival of certain species, particularly walnuts.

Farmers in both Haitang and Shuiyan observed that, of walnut trees planted in 2007/08, only 10 to 20 per cent died in the 2009 drought, while about 40 to 50 per cent of those planted in 2009 died in the drought in 2010 (Figure 10). However, nearly 100 per cent of walnut trees planted five or more years ago survived the drought and nearly all Sichuan

pepper trees, very few of which were newly planted, survived.

Thus, in the event of extreme stress, like that experienced in the China study area, trees are affected in different ways depending on their species and age, and the effects on households depend on the range of species planted. In support of these findings, walnuts not only survived in larger numbers than agricultural crops, depending on their age, but also had high yields in 2010. As with walnuts, Sichuan pepper trees had high survival rates, but experienced huge losses in yield. High tree mortality rates in coffee present perhaps an even greater loss to Xinzhai than the drought year's yield losses. Replacement trees take years before they mature to a productive age. For example, coffee requires 3 to 5 years before it begins to produce. Tree replacement represents a much higher household investment in most cases than the yield losses suffered from reduced tree crop harvests. Different trees, therefore, not only have different levels of resilience to drought in terms of yield, but function differently as long-term assets for households investing in them.

Figure 10: Drought impacts on walnuts in Baoshan according to tree age (2009–2010)



Source: Data provided by Baoshan Forestry Department, 2009–2010

## Monoculture versus agricultural diversification

The three villages in Baoshan coped very differently under drought. Although Shuiyan's tobacco and grain crops were highly affected by drought, government extension programmes specifically targeting tobacco growing areas were successful in reducing overall yield loss. On the other hand, household incomes in Haitang were somewhat sheltered by the diversity of their income sources and the resilience of their mature stands of walnut trees and non-timber forest products. Villagers in Xinzhai were forced by the widespread failure of coffee – one of the only crops and central sources of income for households in the village – to make vast investments in emergency measures such as the purchase or rental of water pumps.

The number of villagers forced into off-farm work increased. The year 2010 saw a new wave of women and men who had not previously migrated for work turning to off-farm opportunities for survival. While all three villages were affected by drought, those with a lower diversity of crop types, including trees, were forced to fall back on government support or other options for water and income.

In the Nepal and Pakistan study areas, gradual shifts in the climatic suitability of certain crops have created uncertainty about optimal crop types in different areas. In the face of this uncertainty, the integration of trees on farms has been one aspect of a wider diversification of agricultural production systems. In Nepal, apple production is moving upwards in elevation along the studied transects. As a result, farmers in some areas are benefiting from the new suitability of the changing local climate for the cultivation of apples, other fruit, and vegetables. Meanwhile, farmers in the lowlands of the Nepal sites who used to enjoy productive apple orchards

are experiencing decreases in productivity or complete shifts in the location of suitable growing areas.

In Pakistan, some areas in Bagh that previously cultivated apples or walnuts are finding that these crops have become only marginally profitable, while other areas are increasingly able to grow different trees, including almonds and cherries. In particular, increases in the occurrence of hailstorms have reduced walnut yields in Miandam. As gradual changes in these climate factors occur, farmers are being forced to explore shifts in crop types.

As previously grown crops become less suitable and productive in these areas, intercropping and more robust agro-forestry practices are gaining acceptance. In the higher altitude areas of Mustang, Nepal, apple trees are being integrated with the crops previously grown there, optimising land productivity. Corn is also being introduced across Mustang as a new form of crop diversification. Meanwhile, instead of replacing trees that are now less suitable with vegetable crops, farmers are often choosing to experiment with new tree crops.

The reduced yield of walnuts from hailstorms in Miandam has encouraged a shift to more resilient almond trees. And in some lower elevation areas of Mustang where apple productivity has dropped, walnut trees have been planted. Finally, factors within the production process, such as reduced labour inputs necessary for apples compared to some vegetable crops in Nepal, or lower vulnerability of walnuts to damage during transport in Pakistan, are added benefits.

## Adaptation strategies and their constraints as perceived by local communities

Beyond the response strategies respondents were engaging in, there were a number of adaptation strategies that respondents expressed the need for, or interest in, but that had not yet been implemented, were too grand in scope, or required too much financial investment for villagers to undertake by themselves. The questionnaire survey contained the question: "What measures would you like to implement to adapt to changing climate variables (e.g., variable rainfall patterns and amount, longer droughts, hotter temperatures)?" The responses are given in Table 7.

Apple trees in a barley field at 2,760 m above sea level, Jomsom, Mustang district, Nepal



Irrigation improvements were the primary adaptation option desired in all three study countries, and were also perceived by most of the respondents as requiring government support. It is not surprising that irrigation was a preferred option, as it is related to the other options cited including making capital available and improving infrastructure.

Respondents were then asked: "What are the main constraints/difficulties in implementing these adaptive

measures?" Their answers are summarised in Table 8. The main constraints were insufficient government support and lack of capital (money). Respondents in Nepal and Pakistan also emphasised the need for greater access to improved technologies, which was a significant difference in comparison with China. It should be clarified that while access to inputs was ranked as the primary constraint in Nepal, respondents desired subsidies for agricultural inputs, not necessarily just access to such inputs.

**Table 7: Adaptation strategies proposed by respondents to the questionnaire survey**

Adaptation strategy	Ranking		
	China	Nepal	Pakistan
Forecasting and dissemination of disaster information	4	8	5
Improved county or district irrigation facilities and management coordination	2	4	5
Disaster insurance	11	9	3
Extension services, such as drought-resistant technologies	5	3	2
Increased price for agricultural products	7	7	5
Improved individual irrigation	11	2	5
Access to interest-free loans	10	6	5
More access to government disaster relief subsidies	3	2*	5
Off-farm work opportunities	6	5	5
Irrigation water subsidies	8	4	4
Upgrading of rural power grids	8	10	5
Improved village-level irrigation facilities	1	1	1
Other strategy	11	11	5

Note: 1 refers to the highest number of respondents, 11 to the lowest. Rankings are likely to change depending on the type of stress experienced.

\* Subsidies not necessarily linked to disaster conditions.

**Table 8: Constraints on implementing adaptive measures**

Constraint	Ranking		
	China	Nepal	Pakistan
No access to government support	1	3	10
No access to credit	11	6	9
No access to inputs	7	1	7
No access to irrigated land	5	4	3
No access to irrigation system	4	5	8
No access to technology	9	2	2
No information on climate change and appropriate adaptations	10	9	4
No market access	12	7	5
No money	2	3	1
No water source	7	4	10
Shortage of labour	6	8	6
Other constraints	3	10	10

Note: 1 refers to the highest number of respondents, 12 to the lowest.

## Policy implications

In all of the sites studied for this case study, the integration of trees on farms was a common tool for agricultural diversification. In general, trees are integrated into agricultural systems as a result of individual farmers' preferences, market influences, or government policies and programmes.

Government policies and programmes are primary determinants of the extent and approach to integrating trees on farms, particularly in China. The mountains of Yunnan Province host the headwaters of China's largest rivers (the Yangtze and Lancang-Mekong). In China, the SLCP aims to convert 14.66 million hectares of farmland into forest land in an effort to curb soil erosion. The implementers of this programme have emphasised the use of 'economic trees' – trees that provide economic benefits as well as contribute to achieving the target environmental outcomes. For example, Baoshan Municipal Government initiated an expansion of walnut production, with the goal of planting over 30,000 hectares of walnut trees in the study county of Longyang district alone.

However, neither the SLCP nor walnut planting programmes promote diversification per se. Such heavy investment in a single tree crop assumes that future prices of walnuts will remain high. Diversification among tree crops has not been supported under this policy. Such policies also fail to account for shifts in the climatic suitability of certain crops. Whereas walnut planting promotion programmes in Baoshan provide technical support for planting, and even specific guidelines for the suitability of different walnut species at different elevations, shifts in climatic suitability under climate change, like that which has affected apple orchards in Nepal, are not considered.

In Nepal, agriculture and agribusiness promotion policies support seedling distribution and the development of transportation infrastructure to improve market access, both of which allow farmers in Mustang to expand apple orchards where suitable. However, shifts in the suitability of apple orchards from lower to higher elevations in Mustang district have not been fully integrated into such programmes, as seedling provision and improvements to market access are indiscriminately distributed throughout Mustang, despite the poor suitability of the climate for apple production in some areas. Nepal's NAPA

promotes agricultural diversification and the use of trees, but without considering the shifting suitability of diversified agricultural or agro-forestry systems.

In the Pakistan study areas, government policies and programmes have had minimal visible role in driving tree planting, but markets are central. Almond tree planting has been introduced, in part because of the lower vulnerability of almonds to hailstorms compared to walnuts; the higher price received for almonds was also cited by farmers as a central motivation for the change. Meanwhile, farmers continue to cultivate walnuts, apples, and almonds even in areas increasingly affected by stem borers and are currently experiencing significant yield loss in all three crops as a result. Thus, a number of drivers support and promote trees on farms, but profitability far outweighs other considerations and priorities. This is also the case in China, where, despite the impact of drought on coffee plantations in Xinzhai, Baoshan, and the encouragement by government extension workers' to switch to sugarcane, most villagers plan to replant coffee next year as the continued high market prices outweigh the risk of lost investment from drought. Finally, it was noted that farmers in Haitang in China planted walnuts and other tree species long before the SLCP or other government programmes promoted them, and the high profits from apples and other tree crops in Nepal were the primary reason cited by respondents for their use.

Policy and market factors dominate as drivers of the cultivation of trees on farms, but related programmes and policies are not responsive to the changing climate context. Policy makers and farmers in the study countries all appear to emphasise the economic benefits of trees on farms. But each type of tree shows a distinct level of resilience to different climate risks and provides different benefits for adaptive capacity under climate stress. Optimising the integration of trees in agricultural landscapes as a tool for increasing adaptive capacity depends on tree selection, planting location, and the role of different types of stress within production systems. Thus, the emphasis on tree crop planting for profit, both policy and market driven, comes at the expense of the diversification of production for building adaptive capacity.

Furthermore, the potential for changes in the climatic suitability of crops – like that which has forced lower elevation apple farmers in Nepal out of production and created new potential for apples at higher elevations – is not integrated into policies promoting

tree planting in the region. For example, walnut trees may not prove suitable for growth in the future at the elevations currently prescribed in China's planting policies. Even where programmes account for climate change, as in the case of Nepal's NAPA, economic considerations are prioritised and local experiences of shifts in crop suitability are not fully acknowledged.

Trees are longer-term investments than annual cash crops, as they take longer to mature and produce, have longer productive cycles, and are typically more resilient to stress. Policies and market signals largely fail to account for the risks and benefits of long-term investments – including investments in trees on farms and infrastructural improvements – because of a tendency to value short-term gains (i.e., profitability) over long-term benefits (i.e., agro-ecosystem resilience and stability). Community-level planning and decision making also contain these weaknesses, and respondents largely felt a lack of capacity in the implementation of certain types of long-term adaptation strategies. Improvements in crop varieties and water management infrastructure, particularly irrigation systems, were common demands across the study sites. The main constraint cited was lack of government support and lack of investment capital.

In conclusion, the resilience of different types of tree to different expected climate risks and under conditions of uncertainty is insufficiently accounted for in decisions on promoting tree crops or integrating trees on farm. In addition, government policies, agricultural and development support mechanisms, and markets lack the flexibility and consideration of climate change that would allow agricultural production systems to cope with rising uncertainty in the face of climate stress. Without more consideration of the impacts of climate change and climate variability on tree crops, communities will be unable to optimise the use of trees on farms within a wider strategy of agricultural diversification, to enhance their adaptive capacity.

## Conclusions and policy recommendations

While trees on farms may have significant effects on resilience to climate-related stresses and hazards, different trees play different roles in local response strategies. Likewise, different tree species may be more or less effective in enabling households to respond to climate change and variability. Trees provide a range of benefits for adaptation depending

on their characteristics under stress and their use as crops for income generation and for household consumption; more generally, they are also a valuable tool for diversifying agricultural landscapes. Integrating or expanding monoculture tree plantations may maintain or increase levels of vulnerability, while the use of multiple tree species can improve resilience in agricultural systems and household livelihoods.

Policies and market incentives have played a strong role in promoting the planting of trees on farms. But current market and policy paradigms do not account for long-term climate changes and the possibility of increased climate risks affecting the productivity and survival of trees. The following measures are recommended to strengthen the impact of national and local policies for adaptation to climate change and rural and agricultural development in the countries studied and the HKH region as a whole.

- Strengthen adaptation strategies by screening proposed policies and programmes to ensure that they do not increase small holders' vulnerability to climate variability and climate risks.
- Allocate resources and services provided by governments and NGOs to focus on decreasing vulnerability, supporting responses to risks, and supporting pathways to agricultural diversification that enhance household resilience.
- Capture the knowledge of farmers, local extension workers, and scientists on the response of tree crops to climate change and vulnerability, and develop tools for the screening of tree crops and agro-forestry systems for their potential to enhance climate resilience.
- Develop research on the prevalence of specific pests and disease, their agro-climatic associations, methods for prevention/treatment, and possible changes in the frequency of pest and disease outbreaks as a result of climate change.
- Provide opportunities, forums, and incentives to increase information sharing at the regional, national, and local scale regarding the implications of climate change for agricultural systems and regarding tools for adaptation, including agricultural diversification.



# Effectiveness of Flood Mitigation Infrastructure in Addressing Water Hazards: Cases in India and Nepal

Partha Das, Himadri Bhuyan, Aaranyak

## Introduction

Floods are the most common water-related hazard in the greater Himalayan region. The Brahmaputra River Valley in Assam, India, and the Koshi River basin covering parts of Nepal and India are two of the most severely flood-prone areas in South Asia (Box 2). Both of these basins are susceptible to the impacts of global warming and climate change (Gosain et al. 2010). Riverbank erosion and land degradation from widespread sand casting are two problems associated with flooding that have affected people's lives and livelihoods in many areas in these basins.

Government efforts to mitigate the impacts of floods through structural measures – mainly embankments – to protect people living along riverbanks from flood waters have met with mixed success. While they have protected some areas well, embankments sometimes breach, often because of improper management, resulting in catastrophic floods. Technical faults in their design, lack of quality control in construction and repair, and financial mismanagement have contributed to the overall poor state of embankments in Assam and their poor maintenance.

Embankments influence people's lives and their capacity to adapt. Properly maintained, these structures have protected people from floods and enabled communities to go on with their lives and social, economic, and cultural activities and even to achieve some measure of agricultural growth. Embankments have helped preserve social stability and strengthen institutions and traditions by providing people with respite from floods.

On the other hand, prolonged dependence on embankments has weakened communities' traditional coping and adaptive capacity, rendering them vulnerable to floods when the structures breach or fail.

## Key findings

- Embankments moderate floods but can also exacerbate them if they are not well managed and maintained. In the study area, embankments are an important strategy for protecting people from floods under the present flood management regime.
- Embankments influence people's capacity to cope with, and adapt to, floods. The magnitude of this influence depends on the extent and impact of flooding; the extent of people's dependence on these structures for protection; and the degree of protection these structures provide.
- Institutional and policy reforms are urgently needed to make the flood governance system more accountable and transparent, and more flexible and responsive to the needs of the most vulnerable communities.
- Local communities have developed capacities for coping with flood hazards in Assam based on their traditional knowledge and social support networks.

## Research objectives

This study aimed to:

- understand existing flood management systems, with a focus on embankments as a key flood mitigation strategy;
- examine the role of formal and informal institutions and policies at different levels and the response of communities to the prevailing flood management regime;

## Box 2: The Brahmaputra and Koshi River basins

The Brahmaputra River is one of the world's largest rivers, with a drainage area of 580,000 square kilometres. Originating from the great glacier mass of Chema-Yung-Dung in the Kailash range of southern Tibet (elevation of 5,300 m), it traverses China (1,625 km) and India (918 km) before passing 337 kilometres through Bangladesh and emptying into the Bay of Bengal through a joint channel with the Ganga River. It is the fourth largest river in the world in terms of discharge at the mouth, and ranks second among the most heavily sediment-charged rivers (Goswami and Das 2003).

The Koshi River originates in the Himalayan range at an altitude of about 7,000 metres in the Tibet Autonomous Region of China and 8,848 metres (Mount Everest) in Nepal. The river debauches through the plains at Chatra in Nepal and, after traversing a distance of about 50 kilometres, enters the Indian state of Bihar at Bhim Nagar, assuming a width of 6 to 10 kilometres. It is the third largest tributary of the Ganga River. The Koshi has a catchment area of 74,030 square kilometres, of which only 11,410 square kilometres is located in India; the remaining 62,620 square kilometres lies in Nepal and Tibet. The Koshi is a complex river system causing huge flooding, acute bank erosion, and migration of the channel every year. The sediment load carried by the river is extremely high; hence, its tendency to braid and shift course frequently. It shifted course by about 160 kilometres between 1723 and 1948 (Mishra 2008a).

- understand how proper governance of flood mitigation infrastructure can influence people's adaptive capacity; and
- recommend strategies to improve the governance of flood management structures and strengthen people's adaptive capacity.

### Research methodology

The research examined and analysed governance systems in the management of flood infrastructures, mainly embankments, in Assam, India and in the Koshi River basin spanning parts of Nepal and India. The study made extensive use of secondary

information, mainly through literature reviews, including official reports, to examine the state of flood governance in the research sites in India and Nepal. Participatory rural appraisal methods and tools, such as informal discussions, key informant interviews, transect walks, focus group discussions, and resource mapping, were used to draw out what the communities thought and felt about the governance of embankments in Assam.

The study also used institutional analysis, political power mapping, and multi-stakeholder analysis to understand the social, political, and ethnic relationships and processes that determine the

Table 9: Research questions-objectives matrix (X: highly relevant; x: relevant)

Research questions	Research objectives*			
	1	2	3	4
How have the formal flood management regime in general and embankments in particular helped in protecting people from floods?	X		x	
What is the policy regime and decision-making process for the construction, quality control, and maintenance of flood management structures such as embankments?	X	X	x	
To what extent do formal policy instruments and socioeconomic and political factors enable or constrain people's participation in flood mitigation decisions?	X	X	X	
How do local communities and their institutions, both informal and traditional, respond to the formal flood management regime?		X	x	x
How do embankments and their governance influence people's coping and adaptive capacity?		x	X	X
What can be done to improve formal governance mechanisms for flood management infrastructure in order to enhance people's adaptive capacity?	x	x	x	X

\* 1 = Understand existing flood management systems in Assam, India, with a focus on embankments as a key flood mitigation strategy; 2 = Examine the role of formal and informal institutions and policies at different levels and the response of communities to the prevailing flood management regime; 3 = Understand how proper governance of flood mitigation infrastructure can influence people's adaptive capacity; 4 = Recommend strategies to improve the governance of flood management structures and strengthen people's adaptive capacity.

response of people in rural societies to governance and their vulnerability to flood hazards. Key informants were chosen from among stakeholder groups in the areas of the study, including staff from government agencies, representatives from civil society, and local community people. Focus group discussions were conducted among communities living near embankments.

A set of research questions that conform to the objectives of the study were formulated and these questions were addressed by analysing and interpreting the information and data obtained from primary and secondary sources (Table 9).

## Scope of the study

The study examined the governance of embankments and its implications for people's capacity to cope and adapt to flood hazards in two sites in Assam, in the Brahmaputra River basin, and in the Koshi River basin covering Bihar in India and Sunsari and Saptari districts in Nepal. The flash flood prone Jiajhal River in Assam is known for its high silt content, frequently shifting channel, and intense erosive action. Its two

banks are embanked from the foothills to a distance of about 20 kilometres downstream. This entire stretch of the river and the neighbouring populations were considered in the study. Most of the major floods in recent years (such as those occurring in 1993, 1998, 2004, 2007, and 2009) were caused by breaching of the embankments. The Matmora dike along the Brahmaputra River breached over a length of 5 kilometres in 2007/08. The floods inundated the area continuously from 2007 to 2009 and filled vast areas of farmland with layers and layers of sand, destroying agriculture, the main livelihood of the people in the area. A stretch of 17 kilometres and the population living close to the dike were selected for study.

Interactions with local communities and field visits were conducted in Assam to collect primary data. Because of time and funding constraints, the study in the Koshi River basin was conducted by reviewing the relevant literature.

## Study areas

Two sites were selected for study in Assam (Figure 11): the Jiajhal River embankment in Dhemaji

Figure 11: Map of study sites in Assam, India

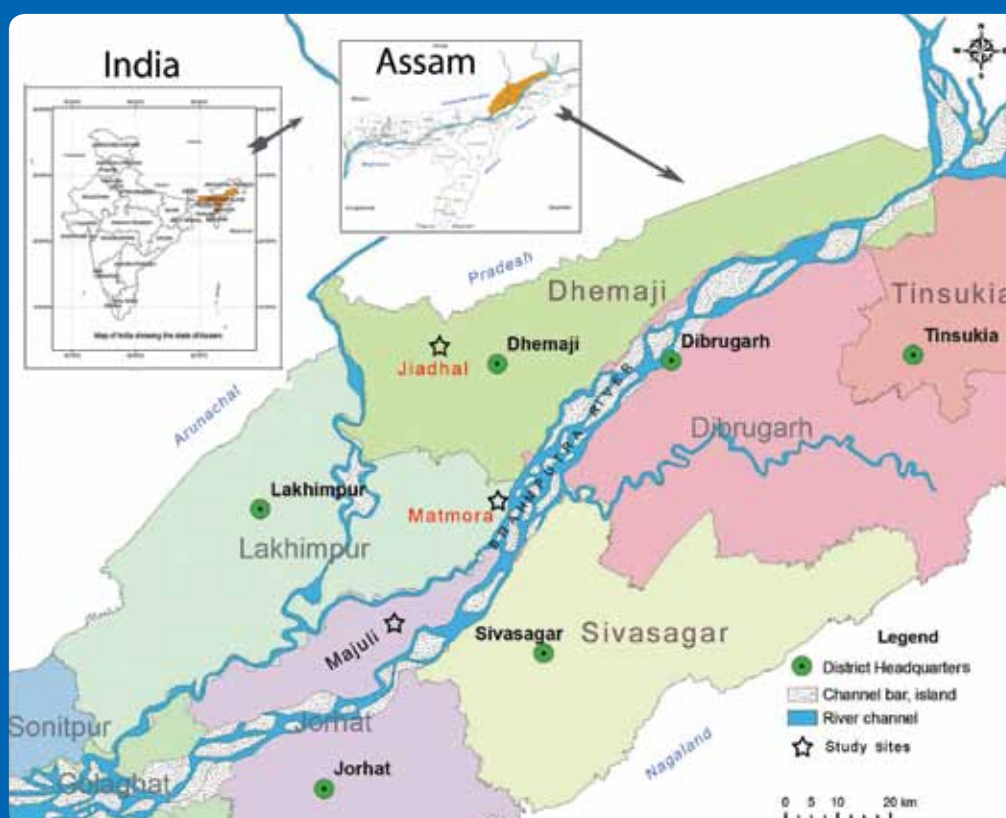
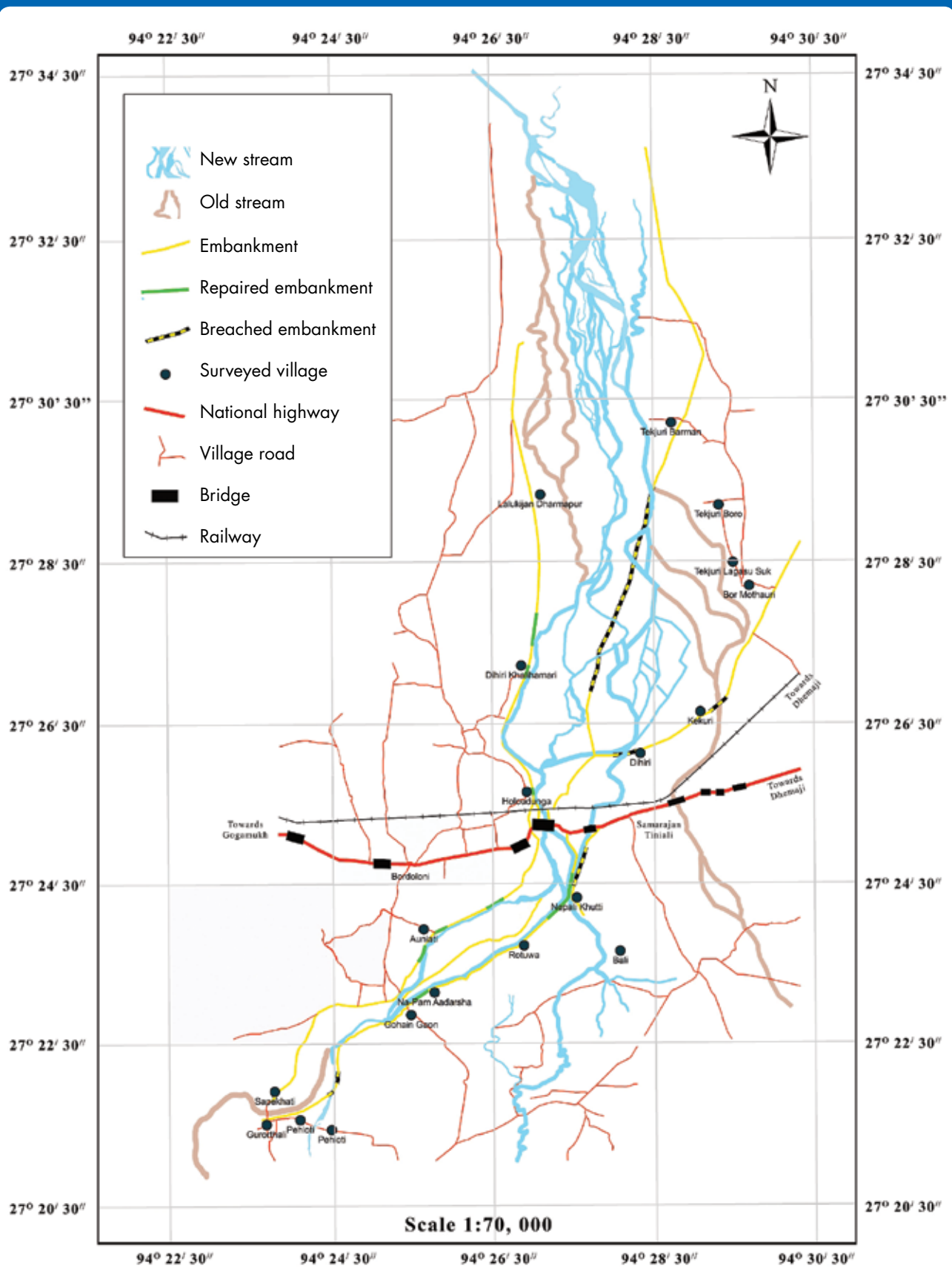


Figure 12: Map of Jiadhal embankment, Dhemaji district



district, and the Matmora dike along the Brahmaputra River in Lakhimpur district in Assam. Jiadhah, a north-bank tributary of the Brahmaputra River, originates in the hills of Arunachal Pradesh at an altitude of 1,247 metres and flows through the plains of Assam, draining a catchment area of 1,346 square kilometres to meet a distributary of the Brahmaputra.

The Jiadhah embankment and adjoining areas along Jiadhah River on both banks fall within Dhemaji district, in the eastern part of Assam on the north bank of the Brahmaputra (Figure 12). The stretch of embankment covered by Jiadhah dike on the left bank is 26 kilometres and by Kumatiya dike on the right bank is 19 kilometres. The study areas cover 7 panchayats (Barbam, Bishnupur, Bordoloni, Ghoguha,

Jiadhah, Misamari, Naruathan) and 20 villages (Auniati, Bali, Bor Mothauri, Dihingia, Dihiri, Dihiri Khalihamari, Gohain Gaon, Gurorthali, Holoudunga, Kekuri, Lalukijan Dharmapur, Na Kalita, Na-pam Aadarsha, Nepali Khuti, Pehioti, Rotuwa, Sapekhati, Tekjuri Barman, Tekjuri Boro, Tekjuri Lagasusuk) with a population of 22,481 (or 3,803 households).

The Matmora dike of Sissi-Tekeliphuta embankment along the Brahmaputra River falls in Lakhimpur district, in the eastern part of Assam (Figure 13). The stretch of embankment is 17 kilometres. The study area covers 3 panchayats (Kherkata, Matmora, Pub Dhakuakhana) – all on the north bank of the Brahmaputra River – and 10 villages (Arkep, Baghchuk, Bahir Kopchang, Bahir Tekeliphuta,

Figure 13: Map of Matmora dike, Sissi-Tekeliphuta, Lakhimpur district

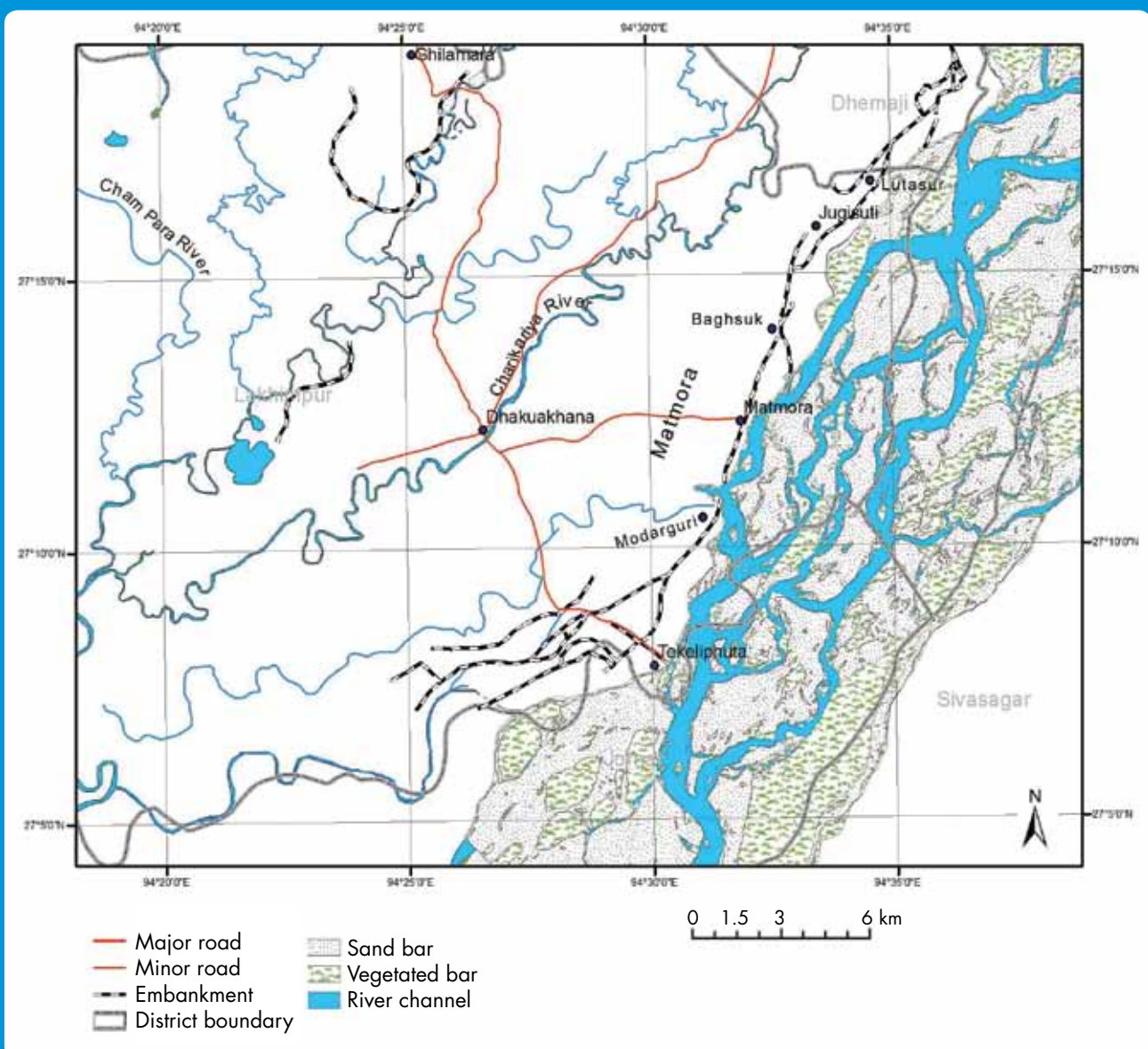


Figure 14: Map of Koshi basin spanning Nepal and India



Bandena, Janji Dangdhora, Lutasur, Mising Bali, Modarguri, Papung) with a population of 32,413 (or 5,403 households).

The study areas in the Koshi basin (Figure 14) lie on the border of India and Nepal. In India, the eastern embankment and adjoining areas in Khagaria, Saharsa, and Supaul districts of Bihar were considered. In Nepal, the western embankment and adjoining areas in Sunsari and Saptari districts were considered in the study.

## Results and discussion

### Use of traditional knowledge to cope with flood hazards in Assam

Corroborating scientific evidence (Box 3), local communities in the study sites in Assam reported having experienced floods and flash floods more frequently in the rainy season over the last 20 years. Flood waters are reported to carry more debris and sand in recent years. Local communities have developed indigenous coping strategies for floods and other water-induced hazards based on their

### Box 3: Scientific evidence of climate change

Temperature is increasing at an alarming rate in the Yarlung Zangbo River in the Upper Brahmaputra basin – by  $0.30^{\circ}\text{C}$  from 1971 to 2003 (You et al. 2007). This is significantly higher than the rate of increase in India's annual air temperature, which is about  $0.22^{\circ}\text{C}$  per decade (Kothawale and Rupa Kumar 2005). There is a clearly increasing trend in temperature at an average rate of  $0.06^{\circ}\text{C}$  per decade over the entire Brahmaputra basin (Immerzeel 2008). The Upper Brahmaputra River basin lost roughly 20 per cent of its water reserves bound in glaciers during the 30-year period between 1970 and 2000, which is equivalent to 175 cubic kilometres of glacier mass loss in the period and about 7 cubic kilometres of glacial mass loss per year (Frauenfelder and Kääb 2009). It is predicted that there will be an initial increase in flow in the Brahmaputra basin because of accelerated glacial melt until about the fourth decade of this century and an increase in mean rainfall upstream of the Brahmaputra basin of about 25 per cent (Immerzeel et al. 2010).

traditional knowledge and practices, such as building houses on stilts, planting more flood-tolerant crops, devising food storage systems suited to riverine environments, and developing social support systems (Das et al. 2009). However, these coping strategies have become less effective in recent years in the face of increasingly frequent and more virulent floods.

Present flood management practices dominated by structural interventions have failed to provide long-term protection. Embankments have failed frequently, with resulting floods putting the communities' lives and social order out of balance every year. Nevertheless, in the absence of alternatives, people have depended on these structures as the only means of flood protection. Much of the coping and adaptation strategies of the communities have therefore centred around these structures (Box 4).

### **Influence of embankments in people's decisions and coping strategy**

Communities continuously devastated for several years by recurring floods, such as those in Matmora, Assam, are finding it hard to return to normal life

using their own resources. They have lost their livelihoods to the floods, become more impoverished, and experienced a breakdown in social cohesion. Between 1968 and 1998, when the embankment used to provide security against floods and when these communities were able to cope better with occasional floods on the strength of their own resources, Matmora was a prosperous place (Das et al. 2009). Earlier, protection provided by the embankments helped these communities to make important decisions about alternative livelihoods. People invested in fisheries, planted certain crops, and sent their children to schools in affected areas depending on whether or not they expected the embankment near their settlement to keep them secure from floods in the next season.

It was when these and other measures failed to provide protection against floods and erosion that people were forced to migrate to other areas. In the process, communities became socially and culturally uprooted and more vulnerable, especially where resettlement and rehabilitation had not been properly planned and their needs adequately addressed. Migration to other areas has sometimes led to

#### **Box 4: Local innovation in living with rivers and embankments**

The Mishing people of Bahir Tekeliphuta village in Dhokuakhona, Lakhimpur district have been living outside embankments, exposed to the Brahmaputra River since 1950s, when the first embankments were built. The construction of the embankment physically divided the village in two: one part falling within the embankment, and the other outside of it. The people made an earthen highland in the part of the village that fell within the embankment, where they could take shelter from the floodwaters. Living in stilted houses, which is a cultural characteristic of this community, also protected them from being inundated by the floods.

People living along the banks of Jiadhal can predict when the river is about to flow in a certain direction, or when it will erode a certain section of the bank or embankment; they keep away from such vulnerable places. In Auniati and Na-Kalita villages on the Jiadhal River, families have moved near parts of the embankments that they see as strong or that have been recently renovated. Some of them live on the riverside of embankments to be able to cultivate fertile lands along the riverbanks. Although such a decision exposes them more to floods, they get a good harvest when a major flood does not happen. This is an example of risk trade-off where the risk of damage to households and property can be mitigated to some extent by the benefit of productive farming and by using the embankment as shelter if needed.

People living upstream of the road bridge on the Kumatiya River near Holoudonga village in Dhemaji have organised round-the-clock vigils on the embankments during the rainy season, and instantly repair breaches and potential breaches with local materials. The communities of Barmangaon and neighbouring villages located outside the left embankment of the Jiadhal towards the foothills regularly monitor the river's water levels and communicate this information to officials of the district administration and the Assam Water Resources Department, using modern communication channels such as mobile phones, in order to get rescue and relief in times of flood.

conflict with the government as well as between communities over ownership and occupation of land – an important resource that can help people to cope better in disaster prone conditions.

On the other hand, people's growing dependence on embankments has reduced their willingness and ability to fight floods. Floods triggered by breached embankments are often more devastating and cause more sand deposition than other floods. Uncertainty surrounding weak embankments and fear of floods has prevented communities from making important decisions and taking actions that would improve their condition and help them to adapt better.

In Matmora, for example, a breach in the dike has not been fully repaired and people are not eager to invest in the repair of their stilt houses. They know that floods will most likely damage their houses again. This inaction makes these communities more vulnerable to the next season's floods. Development interventions, especially infrastructure development, such as the construction of educational institutions, hospitals, and industry, as well as housing subsidies, are sometimes decided based on whether or not an area is well protected. Banks are reluctant to give loans to self-help groups in chronically flood-affected areas such as Matmora and Samarajan because they are uncertain about whether the seed money will be used well in this poverty-stricken area and are concerned about capacity to repay.

Although these structures sometimes fail, embankments have become an integral part of riverine landscapes, people's lives, and their adaptive processes. Embankments are not merely a technological and economic way of temporarily containing floods, they are a critical determinant of people's resilience. This is why it is important to ensure that embankments are properly constructed and managed through a forward-looking, progressive, and accommodating governance mechanism. Good governance of flood mitigation structures in general, and of embankments in particular, will go a long way in providing much needed respite from floods for these communities, which is essential for them to be able to develop adaptive measures and improve their adaptive capacity.

### **Views of embankments as a flood management measure**

In India, structural measures, which include embankments, revetments, porcupines, channel

improvement, canals, sluices, and retention ponds, among others, are the predominant approach to flood management. These structures are built for the combined purposes of flood control, riverbank protection, erosion control, drainage clearance, and siltation management. Non-structural measures – such as flood forecasting, disaster preparedness, rehabilitation and resettlement, watershed management, flood plain management and zoning, and flood proofing – also exist, but are not evenly implemented across vulnerable regions. Therefore, these measures are not considered effective in many places, including in the study areas.

Policy and actions on structural flood management in India can be traced back to the first flood management policy introduced in 1953, which envisaged a number of flood control measures on different time scales. In the short and medium-term, the policy prescribed the construction of embankments to provide flood protection. Other flood control measures such as storage dams and detention basins were planned for the longer term. Ironically, although experts, researchers, and commissions appointed by the Government of India suggested these other measures, only embankments were widely pursued and implemented. Embankments were promoted widely because they are cheap and easy to implement, and provide quick and visible results. But these structures have created a cycle of demand for more embankments, or the extension of coverage of existing ones, and have thus become the object of financial misappropriation by the section of the government dealing with their construction and with contractors.

Controversy over embankments has persisted in India for over a century and the debate over its technical, political, and philosophical aspects has sharply polarised research groups, civil society, policy makers, and the public in general. Many experts and civil society groups have opposed their construction for flood control and have advocated for a paradigm shift from structural to non-structural flood management and from flood management to drainage management (Dixit 2009). Some have demanded their demolition to let rivers flow freely, instead arguing for the empowerment of the communities to enable them to live with the wrath of the rivers (Mishra 2008b).

Nevertheless, many people prefer to look to embankments for flood protection, rather than be

defenceless against floods from open rivers. While the older generation in all the study sites (mostly elders 70 years old and above) acknowledge the ecosystem services provided by floods and the attendant problems with embankments, the younger generation cannot imagine life without embankments. This is the generation that grew up with embankments and that has been affected by floods whenever these structures have failed.

### Role of institutions and policies in governance of flood management

Flood management in India is governed by established institutions and specific policies at the central and state levels. The Indian Constitution earmarks water as a state subject, and state governments are assigned the key authority and responsibility for the management of water resources, including flood management. In practice, however, most of these institutions function rigidly and operate with little transparency and accountability and unclear commitment. Although flood management policies were intended to empower people to cope more effectively with flood hazards, they have not been translated into action on the ground, and therefore have not been as effective as they could be.

Flood management is almost entirely a government enterprise, without much scope for local participation by the communities affected by floods or by civil society organisations in planning and decision-making. Planning and decision-making are mainly carried out at the state level by the State Water Resources Department through a rigid hierarchical institutional mechanism that is neither transparent nor coordinative.

For example, the Technical Advisory Committee of the Assam Water Resources Department makes decisions on the technical aspects of the construction and maintenance of structural interventions meant for flood mitigation. The department comprises people from government departments and agencies, mostly from engineering disciplines, and lacks environmentalists, social scientists, and representatives from the local communities and civil society. There is a need to recognise the importance of the views of others, especially the villagers affected and other non-government stakeholders, in the planning process. Local communities, civil society, and local governance bodies have no role in this process (Figure 1.5).

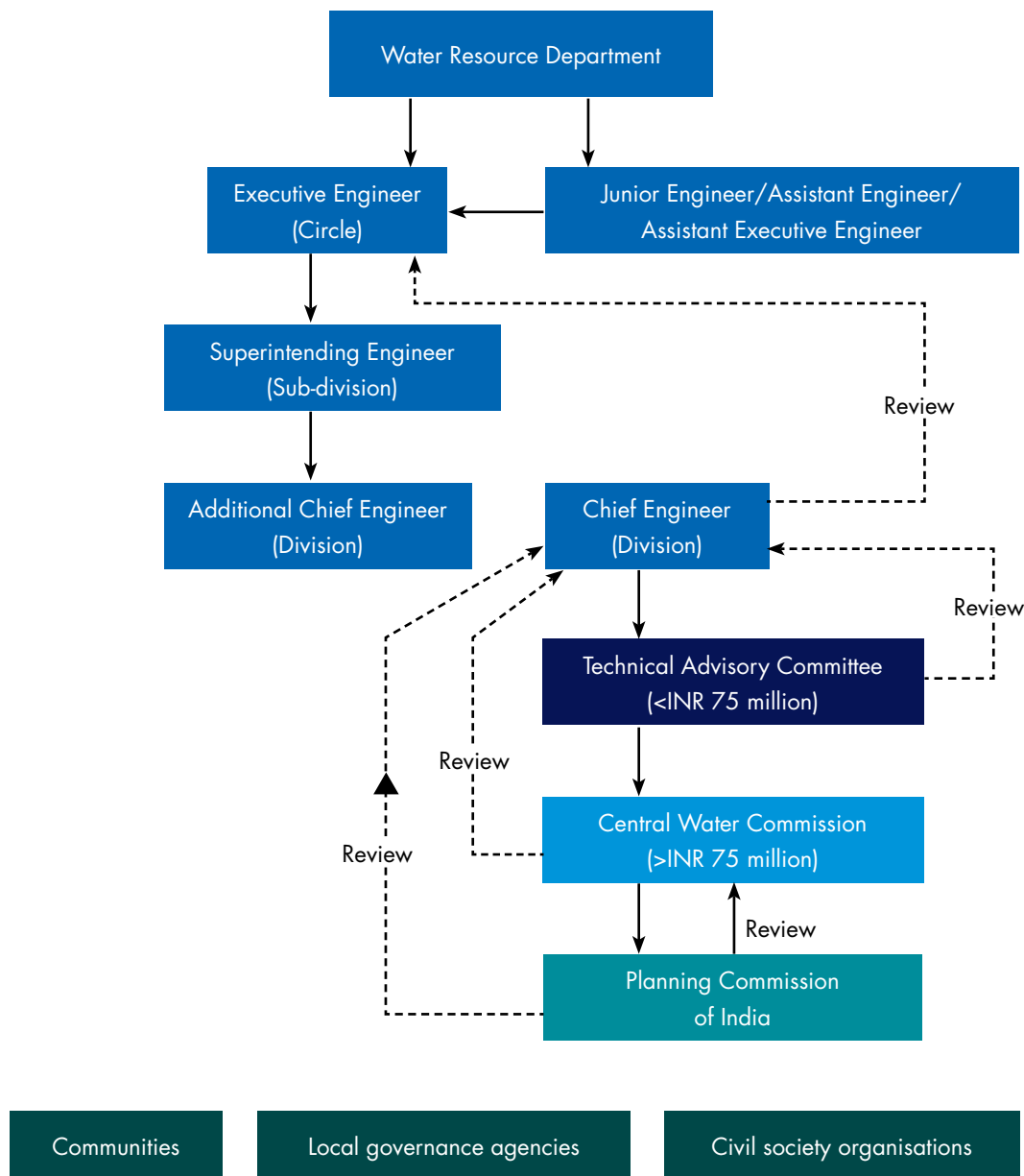
Inadequate maintenance of embankments and their appurtenances could be related to lack of financial resources and the current budgetary cycle, which does not allow for the construction or repair of structures to be completed before the onset of the rainy season. On the Jiadhal River near Auniati village in Dhemaji, the height of the embankment – one of the key factors in determining its protection against floods – is lower than designed because of insufficient funds in the Water Resources Department.

Financial mismanagement and lack of commitment to implementing flood control schemes by vested interest groups have resulted in substandard construction and maintenance, accounting for many of the floods triggered by the breaching of embankments. The recent floods in Dhemaji originating from the Jiadhal River (in 2007), and in Matmora (from 2007 to 2009) from the Brahmaputra River, were caused by the failure of embankments because of negligence, lack of monitoring, and poor maintenance. Because of weak coordination between the Water Resources Department, the Northeast Frontier Railways, and the Public Works Department of Assam, the combined effect of flood embankments, high roads, and railway

Embankment on Jiadhal river near Auniati village, Dhemaji



**Figure 15: Institutional mechanism for planning and decision making by the state Water Resources Department in relation to flood mitigation structures**



tracks has obstructed natural drainage systems and waterways, exacerbating flood hazards.

## Policy implications

In Assam, after the repeal of the Embankment and Drainage Act, 1953 (Government of India 1954) in 1989, no specific legally binding guidelines were drafted for implementing flood structures. Drainage development, which is an important complement

to embankments for reducing water logging and flooding, has not been given priority over the last three decades. The National Flood Commission (1980), the Task Force for Flood Management and Erosion Control (2004), and a host of other commissions engaged to assess and reform the flood control system have recommended important strategies. However, these recommendations have hardly been implemented at the local level.

The government is yet to adopt a holistic approach to flood management as envisaged in the National Water Policy 2002, the National Disaster Management Act 2005, and the National Policy for Disaster Management 2009. The Assam Water Resources Department and its flood mitigation activities are not well integrated in the disaster management approach of national and state authorities.

Local governance agencies – the Panchayati Raj institutions and the autonomous councils – are in place in the study areas. These agencies specifically cater to local development needs through decentralised and democratic governance. Although floods are among the main reason why local communities remain marginalised and poor, these agencies are not sufficiently empowered with the mandate or resources to deal with flood management. They often work under pressure to fulfil the interests of vested interest groups, within the government and outside. Although the Panchayati Raj institutions are supposed to reflect the voices of the people at the grassroots level in planning and decision-making processes, political influences and the dominance of state agencies over these bodies have suppressed their ability to translate the people's views and aspirations into concrete action on matters related to floods and disaster management.

Elections to the autonomous councils are not held regularly or democratically. In most cases, state control over autonomous councils is maintained by ad hoc bodies set up to run the administration, which usually comprise people with a clear allegiance to vested interest groups. The state government's control over the fund flow to autonomous councils constrains them from functioning autonomously. Although local agencies are responsible for small-scale work on embankments and irrigation, they are not a part of the decision-making system within the Water Resources Department. As autonomous councils are formed to cater to the development needs of particular communities, other communities are sometimes marginalised and deprived of benefits.

Prolonged suffering from floods and related hazards has compelled most local communities to resort to protest campaigns, resistance movements, and awareness drives, with the support of civil society groups and student organisations, to get the government's attention. Their demands include the proper maintenance of embankments; consultation

with local communities and the inclusion of their suggestions in the design, location, and alignment of embankments and other structures; and legal action against those exhibiting lack of commitment and transparency in the implementation of flood mitigation schemes. Communities outside the area protected by embankments stage protests with the support of the political elite to get the alignment of the embankment changed so that they are not left to face the river's wrath.

The State Government of Assam recently launched an initiative to improve flood and erosion management infrastructure and strategies with financial assistance and technical support from the Asian Development Bank. As part of this innovative project, new technologies and institutions are being piloted in Assam to strengthen flood and erosion management structures. Non-structural strategies for flood management using a disaster risk reduction approach are also being pursued. Non-structural activities include awareness raising, poverty reduction, and income generation integrated with flood management, among other things. Geo-textile fabric tube technology, used in constructing part of the Matmora dike, has raised the communities' hopes of getting more enduring protection against floods and erosion so they can adapt better. Geo-textiles are permeable geosynthetics used in foundations; they act as filters for soil, allow water to drain, and add strength to the soil. Long geo-textile or geocomposite tubes are used to build embankments called geodykes to control erosion and prevent flooding.

Poverty alleviation programmes under the Mahatma Gandhi National Rural Employment Guarantee Act, 2005 have helped people to survive in flood-ravaged areas where loss of traditional livelihoods has pushed

Geo-textile technology used in the Matmora dike



people into a cycle of poverty. This act provides for the enhancement of the livelihood security of households in rural areas in India by providing at least 100 days of guaranteed wage employment per year to households whose adult members volunteer to do unskilled manual work (Government of India 2005). In the study sites in Assam, the scheme grants employment in earth cutting, building roads, and constructing embankments and culverts. This has proved to be immensely useful to poor families, providing a resource that has enabled them to cope with damage and loss suffered from floods. Although there are irregularities in implementation, this scheme has the potential to become a major strategy for twinning flood risk mitigation and livelihood support in flood-affected areas.

The National Disaster Response Force created under the National Disaster Management Act, 2005 has provided considerable support for saving lives during floods. India's National Action Plan for Climate Change 2008 proposes to promote adaptation strategies especially in the field of agriculture. These policies, if properly implemented and coordinated, can go a long way towards improving flood governance to mitigate flood risk and enhance people's resilience.

In Nepal, the catastrophic flood in the Koshi River in 2008, which affected 3.5 million people in Bihar and 50,000 people in Nepal (Dixit 2009), was triggered by the breaching of the eastern embankment in Kusaha, Nepal, and was the result of institutional dysfunction and failure to ensure proper and timely maintenance of the embankment (Mishra 2008a). The Koshi Treaty, which was signed between India and Nepal in 1954 and amended in 1964, leaves much to be desired in terms of ensuring that the agencies concerned are transparent, proactive, responsive, and socially responsible. Flood management in the Koshi basin is coordinated by several agencies including the Koshi Project Authority stationed at the Koshi barrage in Birpur, the Bihar Water Resources Department at Patna, and the Government of Nepal with nodal centres in Kathmandu and other places. Among these agencies, the channels and processes of inter-governmental and intra-country communication are lengthy, indirect, complex, slow, and ineffective, with hierarchy and lack of transboundary cooperation being the main factors affecting communication within these institutional networks (Shrestha et al. 2010). Official communication channels only exist at the

national level, and the State Government of Bihar, which runs the Koshi project from India, has no direct communication with the Government of Nepal. This is a major obstacle to making quick decisions in cases of emergency.

Experts and civil society organisations are concerned about the Koshi project and the embankments; some favour demolishing all embankments, while others are fighting to obtain rehabilitation support for losses incurred in past floods. However, most of the communities want embankments to be properly constructed and maintained so that they function for flood protection. Younger people are accustomed to seeing rivers with embankments and find it hard to imagine living without them and coping with freely flowing rivers.

## Conclusion and policy recommendations

Embankments influence people's lives considerably in the flood prone areas of Nepal and India. People have demonstrated their capacity to engage in activities that minimise flood risks with a sense of the security provided by embankments. However, prolonged and absolute dependence on these structures has weakened the coping capacity of the people, often increasing their vulnerability to floods when embankments fail. Dependence on these structures cannot be reduced by dismantling embankments, without putting effective alternatives in place. The study found that the present generation is not ready to accept living on riverbanks without embankments, because the people are not accustomed to living with freely flowing rivers. Properly maintained and repaired structures provide immediate protection; however, they are not a permanent solution to floods. Floods cannot be managed by structural measures alone. The findings of this study indicate that structural measures should be complemented and supported by non-structural measures such as flood forecasting, disaster preparedness, watershed management, and flood plain regulation.

The embankments in most of the study areas were built haphazardly. Loopholes in the governance system have made flood infrastructure development a profitable business for vested interest groups, and the question of its desirability in some areas has been largely ignored. The present governance regime for dealing with floods is inadequately equipped to deal

with the onslaught of water hazards intensified by climate change. As embankments do not provide full flood protection, measures must be taken to reduce water logging, develop areas inside embankments to become economically productive, and provide proper support to enhancing people's resilience to possible hazards.

This study proposes that an alternative paradigm be developed and pursued to cope with flood hazards, which should include new policies and actions that minimise risks and enhance community capacity to adapt. Drainage development and non-structural measures for flood mitigation should be key areas of emphasis in this alternative model.

Only half of the flood-prone areas in Assam are protected by embankments. People in other areas have been living without these structures and are finding different ways of surviving and living with floods. People living outside embankments facing rivers, those living on the *chars* (river islands) in the Brahmaputra River in Assam, and large populations entrapped within embankments along the Koshi River in Bihar are enduring floods without these structures. Policies need to be framed to encourage risk reduction and coping practices that have worked. Programmes that ensure the provision of emergency subsidies – crop and livestock insurance, emergency loans, temporary employment, and proper health services – should be supported and ensured through policy and government programmes. This will build people's confidence to cope with floods, with or without these structures.

Improving the governance of flood mitigation structures for those who are protected by embankments, and empowering others through socioeconomic development to cope and adapt to floods in a better way, must be pursued side by side and in synergy. The following measures are recommended to strengthen the impact of national and local policies for adaptation to climate change through structural and non-structural measures.

- Upgrade the current flood management paradigm from structural measures alone to flood risk reduction and mitigation, with emphasis on increasing people's capacity to adapt to floods and related disasters, and on establishing and strengthening coordination among relevant government agencies, civil society, and vulnerable communities.
- Design specific government and non-government programmes through policy incentives that motivate people to adopt field-tested good practices, such as flood-resistant housing, flood-tolerant agricultural practices, soil reclamation and restoration, innovative agriculture on sandy soil, and the diversification of livelihoods based on community skills and resources.
- Institute reforms in state agencies such as the Water Resources Department, to improve flexibility, transparency, commitment, and coordination, and to ensure that local people participate in decision making and in the planning and implementation of flood management projects.
- Introduce appropriate legislation, guidelines, and policies that facilitate institutional reform, and set standards and guidelines for the construction and maintenance of flood mitigation infrastructure such as embankments.
- Empower and strengthen local governance bodies such as the Panchayati Raj institutions and autonomous councils through the provision of adequate financial resources and political autonomy to handle flood emergencies and disaster preparedness at local levels, free from political interference.



# Labour Migration as an Adaptation to Water Hazards: Cases in China, India, Nepal, and Pakistan

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## Introduction

Environmental migration is not new. Since time immemorial, people have been migrating to new places when challenged by difficulties in their environment. What is new in the last two decades is the growing understanding of the link between climate change, the environment, and migration, and its implications. Reports in the media increasingly highlight the potential challenges posed by the mobility of people exposed to stresses in the environment, intensified by climate change, across macro regions, mainly in the global south. Many of these reports have failed to recognise migration as a significant strategy for improving livelihoods in times of environmental and non-environmental change. But researchers, policy makers, and institutions at various levels are increasingly recognising the potential benefits that migration and remittances provide to recipient households and their origin communities. The United Nations High-Level Dialogue on Migration and Development in 2006 and the National Adaptation Plans of Action (NAPAs) being developed across many countries reflect this realisation. This is indicative of an inconsistency between popular reports and empirical evidence of environmental change, migration, and development (Barnett and Webber 2009; Iaczko and Aghazarm 2009; Tacoli 2009; Martin 2010; Warner 2010).

The present discourse on climate change and migration has its origins in the decades-old environmental refugee debate. The subject has been examined as part of the relationship between environmental stressors and migration (Kniveton et al. 2008; Perch-Nielsen et al. 2008). As early as 1990, the First Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) recognised that climate change can have significant impacts on human migration (IPCC 1990). More

## Key findings

- Labour migration is one of the livelihood strategies adopted by households in communities affected by floods, flash floods, droughts, and water shortages.
- The affect of water hazards on household assets is one of the factors influencing a household's decision to migrate.
- Labour migration as a response strategy varies according to the type and severity of the water hazard encountered by a household.
- Labour migration rates are higher in communities affected by rapid-onset water hazards than in those affected by slow-onset water hazards.
- Despite their relatively low volume, remittances have a significant impact on the quality of life of recipient households and on a household's ability to respond to water hazards.

recently, Working Group II of the Fourth Assessment Report of the IPCC identified areas affected by heavy precipitation, drought, tropical cyclones, and sea level rise as potential sites for human outmigration (IPCC 2007). Recent research suggests the potential redistribution of the human population as one of the outcomes of climate change intensified environmental stressors.

Environmental stressors such as rapid-onset water hazards (floods and flash floods) and slow-onset water hazards (droughts and water shortages), or a combination of both, could be important determinants

of migration. Alternatively, these stressors may even act to restrict migration by reducing the ability of households or individuals to undertake migration. Depending on the context, climate change is foreseen as accentuating these environmental stressors. Population movement could be over short or long distances, and for short or long periods (Locke et al. 2000; Barnett and Webber 2009). Environmental migration can take several forms, notably:

- displacement: the uprooting of people temporarily or permanently from their origin communities;
- labour migration: people moving to other places for work;
- household migration: entire households moving to another location; or
- community resettlement: entire communities being resettled in another place.

Assessing the influence of climate change on migration requires a better understanding of the relationship between environmental stressors and migration, and the impact of environmental stressors on livelihoods. It also entails understanding why people choose particular response strategies including migration, the agency (or freedom of choice) of the migrant in the decision to migrate, the choice of destination, the migrant profile, and use of remittances.

The full version of the study summarised here has been published separately (Banerjee et al. 2011).

## Research objectives

This study aimed to:

- understand migration behaviour in communities affected by water hazards, using current climatic variability as a proxy for future climate change impacts;
- assess whether labour migration is a positive livelihood choice in communities affected by water hazards;
- assess the potential of labour migration as a strategy for adaptation to water hazards; and
- assess the policy implications of labour migration as a strategy for responding to water hazards.

## Research methodology

To assess the relationship between water hazards and labour migration, it is important to understand how households respond to perceived impacts. This response is often based on the vulnerability of

individual households to water hazards as well as their capability to respond. The structure of a society determines the extent to which it is vulnerable. Differences in vulnerability to water hazards within or between communities are the result of different levels of exposure to water hazards which, in turn, are affected by inequalities among households in access to assets such as land and housing, social networks, and the extent to which households are prepared to cope. Prevailing social, economic, cultural, and institutional systems have an effect on this coping ability (Cannon 1994; IPCC 2001; Adger 2006). Similarly, the impacts of water hazards on household responses are mediated by a host of factors, such as livelihood vulnerability, socioeconomic conditions, and institutional structures; these factors influence the ability of a household to respond to an environmental stressor. Depending on capability, households can adopt one or more strategies to adapt their livelihood to the hazards. Migration is only one of several livelihood options a household can turn to in response to the stresses and shocks that water hazards bring. Household assets and intervening factors such as transport, communication, and institutional policies all influence the decision to migrate (see Curson 1989; Cannon 1994; IPCC 2001; Adger 2006; Brown 2007; Mcleman and Smit 2006; Kniveton et al. 2008).

The focus on vulnerability in the current discourse has made migration seem to be a failure to adapt to environmental stresses, rather than a way of enhancing adaptation. Migration is seen as a manifestation of a household's lack of adaptive capacity, or a last resort. Such a perception assumes that human beings are mainly driven by external shocks rather than being individuals who can and do make use of available options to improve their livelihoods or create new ones. However, documentation on migration illustrates how migrants consistently display initiative to resolve the challenges they are confronted with. For instance, labour migrants often seek to diversify household income and reduce risk to household livelihoods from stresses in their environment. The NAPAs of Bangladesh, Cambodia, Eritrea, Ethiopia, Gambia, Haiti, Mali, and Uganda recognise migration for work as a strategy employed by households to respond to the impacts of flood and drought. In fact, migration should not be seen only as a last resort. It is not the poorest who migrate; migration requires certain resources including the financial means, social network, and access to information, supporting

infrastructure, and institutions. Hence, migration may not be an option for some households. Environmental stressors can also slow down long-distance migration by depriving a potential migrant of the necessary resources to be able to make the move. Without an assessment of actual and potential capabilities, a vulnerability assessment is incomplete (Stark and Lucas 1988; Skeldon 2002; Stern 2006; Kniveton et al. 2008; Barnett and Webber 2009; Iaczko and Aghazarm 2009; Martin 2010; Schade and Faist 2010).

This study looks at both household vulnerability and capability in order to assess patterns of labour migration in the context of water hazards. A model was developed for the study based on the Sustainable Livelihoods Approach and the New Economics of Labour Migration Approach to examine the relationship between water hazards and labour migration.

The Sustainable Livelihoods Approach attempts to link environmental stressors with the strategies households adopt to reduce their vulnerability. It purports that a household asset base is composed of a variety of natural, physical, financial, human, and social resources. Assets are complementary in nature; no single asset is sufficient to yield all livelihood outcomes that a household seeks. A loss of one asset could be offset by other available assets. The Sustainable Livelihoods Approach recognises the influence of institutions and policies that operate at different levels (international, national, regional, and household) in shaping livelihoods. The Sustainable Livelihoods Approach acknowledges the vulnerability of livelihoods to shocks and stresses and the different

strategies people use to respond to them (Carney 1998; DFID 2000; Kniveton et al. 2008).

The New Economics of Labour Migration Approach, on the other hand, provides insights into household-level decision-making processes. The decision to migrate often involves migrating and non-migrating household members. The household overcomes constraints and spreads the risk inherent in its limited size by broadening the geographical space within which it operates. The costs and returns of migration are shared by the migrant and the household, which expects remittances in return for its initial investment in the migration of a household member (Stark and Bloom 1985; Stark and Lucas 1988; Faist 2000; Kniveton et al. 2008).

This study sees labour migration as a livelihood strategy that diversifies household income. A set of research questions were framed responding to the objectives of the study, and an attempt was made to address these questions by analysing and interpreting the information and data obtained through primary and secondary sources (Table 10).

## Scope of study

Labour migration is an important livelihood strategy in the Hindu Kush Himalayas and is one of many possible ways that people respond to environmental and non-environmental changes. The study focused on the relationship between water hazards and migration for work. There is little understanding of the process through which a water hazard and its impact actually influence the decision to migrate for work. This is because it is not easy to isolate the

**Table 10: Research questions-objectives matrix**

Research questions	Research objectives*			
	1	2	3	4
In water hazard affected communities, what is the relative importance of the perceived impact of water hazards on the decision to migrate for work?	X	X	X	X
In water hazard affected communities, how does the household context influence the decision to migrate for work? How does local context influence this migration decision?	X	X	X	X
Who are the labour migrants? Where do these migrants go? What occupations do labour migrants have in the destination communities?	X	X	X	X
What impacts do remittances have on household capacity to respond to water hazards?		X	X	X
What impacts does labour migration have on gender roles in migrant households?	X			

\* 1 = Understand migration behaviour in communities affected by water hazards, using current climatic variability as a proxy for future climate change impacts; 2 = Assess whether labour migration is a positive livelihood choice in communities affected by water hazards; 3 = Assess the potential of labour migration as an adaptation strategy to water hazards; 4 = Assess the policy implications of labour migration as a response strategy to water hazards.

impacts of water hazards from among the many other factors (such as globalisation, other climatic changes, and demographic processes) that influence people to seek work elsewhere. The benefits and disadvantages of labour migration have not been completely understood. There is a knowledge gap on environmental migration in general, and in the mountain setting in particular.

The field assessments were conducted only in the origin communities. In these communities, the study covered both migrant and non-migrant households. The following working definition of migrant households and labour migrants was adopted:

*If during the past 20 years, any member of the household has lived anywhere other than in the origin community for more than two months at a time because of work related reasons, then the household is a migrant household and the migrant household member is a labour migrant.*

Households not conforming to this definition were referred to as non-migrant households. Information

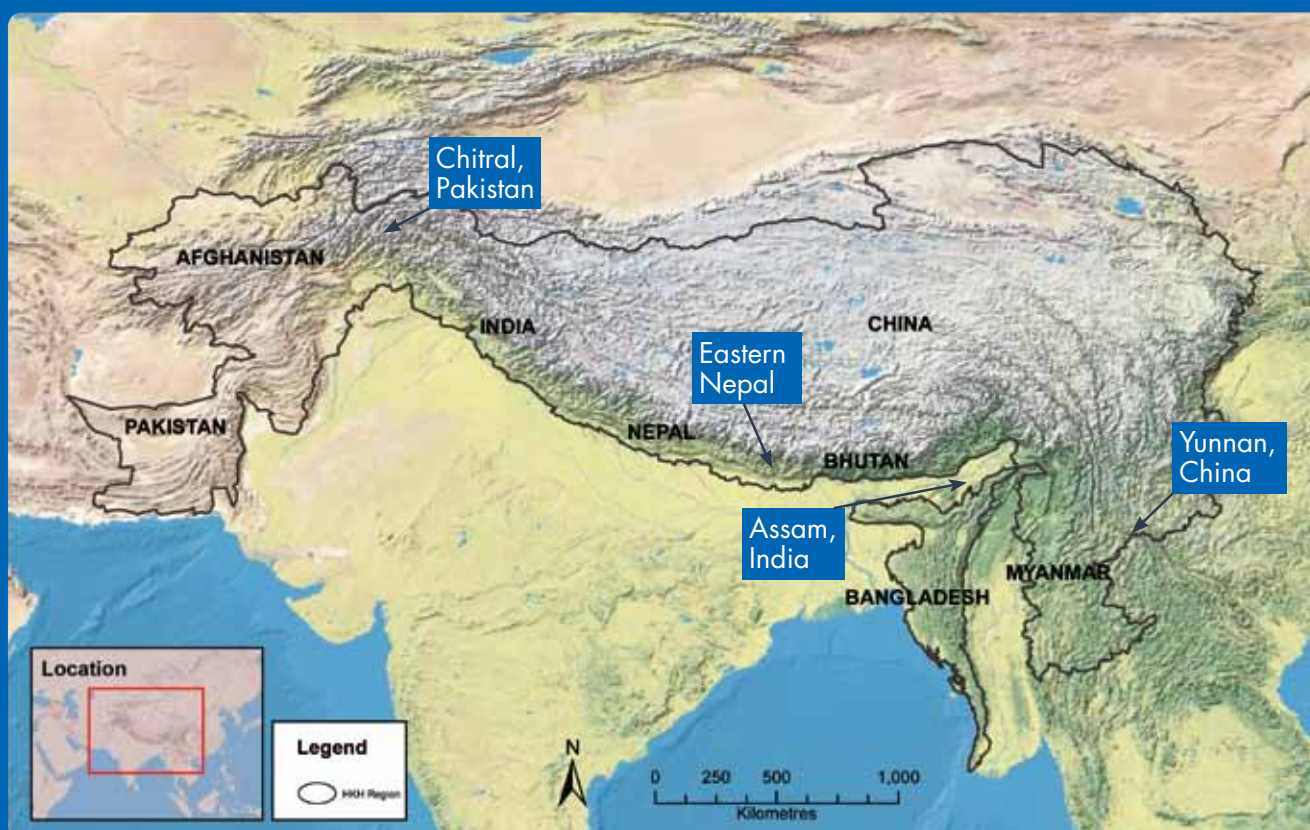
on household assets, the determinants of migration, remittances, and conditions in the destination communities were gathered from present migrants, returned migrants, and non-migrant members of migrant households. Non-migrant households were asked about household assets, remittances, and reasons for not migrating.

For the purposes of this study, water hazards are classified as 'rapid-onset hazards', such as floods and flash floods, and 'slow-onset hazards', such as droughts and water shortages. The impacts of rapid-onset hazards are more explicit and pronounced over a short period of time compared to slow-onset hazards. The difference in lag time, that is, the time between the onset of a hazard and when its impacts are actually felt in a household, is longer for slow-onset hazards.

## Study areas

The field assessment was conducted in selected mountain and foothill communities in Yunnan Province of China, Assam in India, eastern Nepal, and Chitral district of Pakistan (Figure 16). The 43 communities

Figure 16: Study area in the Hindu Kush Himalayan region



Source: ESRI

**Table 11: Percentage distribution of surveyed households across different field sites**

Country	Province/state/district	Surveyed households		
		Migrant (%)	Non-migrant (%)	Total
China	Yunnan	60	40	363
India	Assam	71	29	336
Nepal	Dhankuta, Sunsari and Saptari	69	31	365
Pakistan	Chitral	62	38	239

studied during the field assessment were selected in consultation with the key informants based on two major criteria:

- a history of water hazards, namely, floods, flash floods, droughts, or water shortages; and
- a history of labour migration.

The research design incorporated both quantitative (i.e., household survey and community questionnaire) and qualitative (i.e., key informant interviews and focus group discussions) research methods. The household survey covered 1,303 households in 43 communities across the 4 countries studied (Table 11).

The primary objectives of the study were to understand the influence of water hazards on migration behaviour and assess the impact of remittances on the adaptive capacity of recipient households. Thus, labour migrants and migrant households were the main focus of the study. Based on the working definition of a migrant household, and in consultation with key informants, all the houses in each of the communities studied were classified into two major groups: migrant and non-migrant households. The households within these two groups were then randomly selected for the household survey. For the analysis, the proportion between migrant and non-migrant households was weighted based on the real distribution of these two groups within the communities. Community-level information was recorded using a community questionnaire. Key informants, such as community elders, migrants, and female members of migrant households, were also interviewed. Community perceptions of the relationship between water hazards and labour migration were captured through focus group discussions.

## Limitations of the study

### Representative scale

The research findings represent a meso-region, not the entire countries of the areas studied. Research findings from Assam, for example, are representative of areas in the Eastern Brahmaputra basin, not of India as a whole. As the study covered a wide area within the Hindu Kush Himalayas, the findings may be representative of mountain regions within the Hindu Kush Himalayas affected by similar types of water hazards.

### Current climate variability

Current climate variability is often used as a proxy indicator for future climate change impacts. To a certain extent, the influence of climate variability on the decision to migrate is useful in understanding the potential impacts of climate change intensified water hazards on this decision. However, the future effects of climate change intensified climate stressors seem to be much more complex than the impacts of current climate variability. Not only will climate change intensify water hazards in the future, their impacts will be complicated by population growth and by changing economic, social, and political conditions.

### Water hazards and various forms of migration

Water hazards can induce various forms of migration: displacement, labour migration, household migration, and even community resettlement. This study focused on the relationship between water hazards and labour migration; other forms of migration are not covered.

### Influence of water hazards on the decision to migrate

As the study did not have control sites, it is difficult to quantify the relative importance of the influence of water hazards on migration behaviour compared to the other determinants of migration. Instead, it focuses on the differences in migration behaviour between communities affected by rapid and slow onset water hazards. 'Water hazard' is an umbrella term used to refer to both rapid- and slow-onset water hazards.

### Response to actual or anticipated water hazards

The communities surveyed have a long history of water hazards. Many households in these areas are

responding to actual hazard experience; others are responding to anticipated future hazards. This study does not make a distinction between the two.

## Results and discussion

The findings of the study are based on descriptive statistics, probabilities calculated from robust probit regression analysis, and information gathered in the key informant interviews and focus group sessions. Probabilities were calculated from regression analysis (see Banerjee et al. 2011).

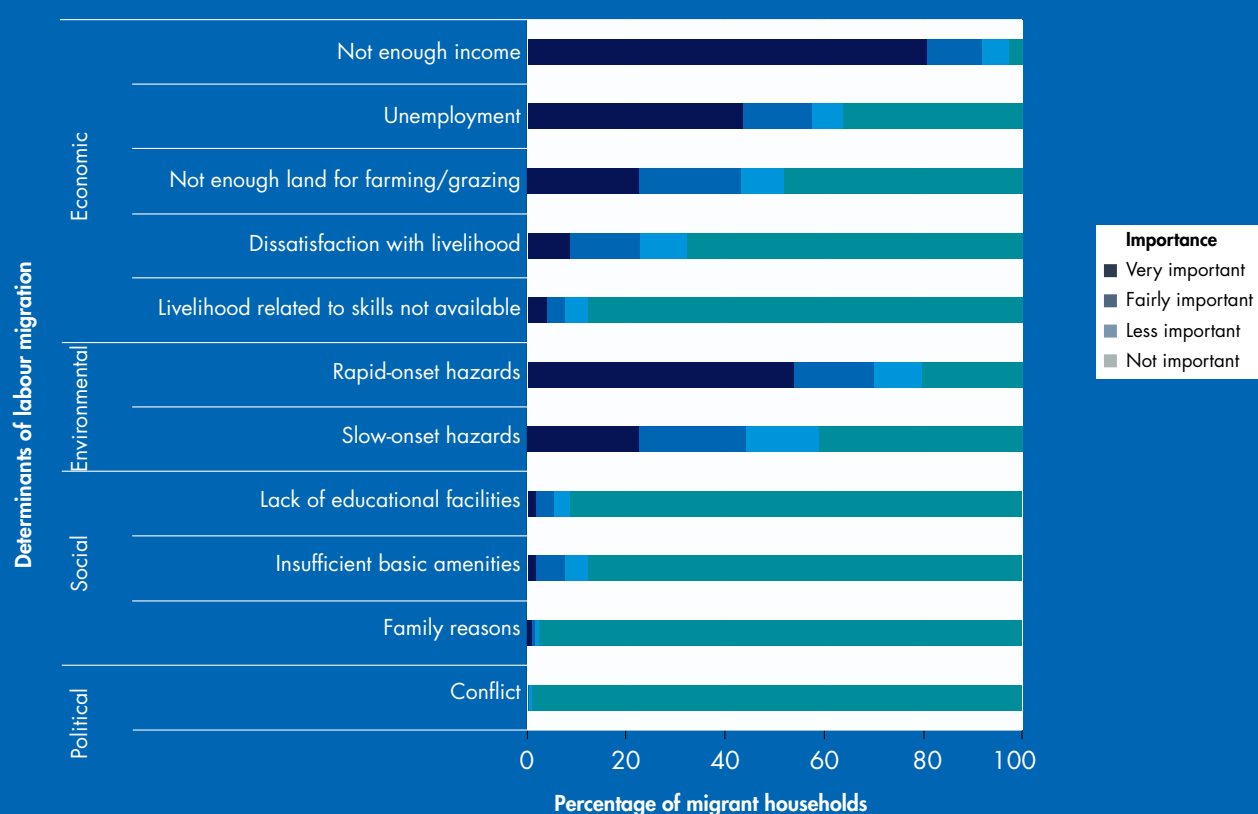
### Relative importance of the perceived impact of water hazards on the decision to migrate for work

Labour migration is driven by many causes, rarely by a single reason (Kniveton et al. 2008). The study found that the influence of water hazards was only one among many reasons why people migrated for work in the Hindu Kush Himalayas. Nearly 80 per cent of migrant households surveyed considered water hazards to be an important influence on the decision to migrate for work. But, even in these migrant households, non-environmental reasons,

such as not enough income, unemployment, dissatisfaction with livelihoods, and lack of livelihood opportunities related to skills in the origin community, were important determinants of labour migration. In fact, the majority of migrant households perceived economic reasons to be more important than other reasons for migration, including the influence of water hazards (Figure 17). Equally, non-environmental determinants were also found to be sensitive to the impacts of rapid- and slow-onset water hazards.

In other migrant households, the decision to migrate was not influenced by water hazards for several reasons. Some household members had migrated before a water hazard occurred, and some migrated before the impacts of a hazard on the household's livelihood could be felt. For others, the impact of the water hazard was not severe enough to make them consider migrating for work. In addition, water hazards did not affect certain households within a community. Labour migration has always taken place in these communities, and many migrants still leave for the same reasons that their predecessors did, without additional influence from water hazards.

Figure 17: Determinants of labour migration and their perceived importance in the migration decision, Hindu Kush Himalayan region, 2010



The influence of water hazards on household decisions to migrate varied depending on the type of water hazard encountered. Rapid-onset water hazards such as floods and flash floods were perceived to have a comparatively higher influence on the decision of households to migrate than slow-onset hazards (Figures 18 and 19). The study found that labour migration was likely to be higher in communities affected by rapid-onset water hazards than in those affected by slow-onset water hazards. In addition, labour migration was likely to be higher in communities affected by very severe slow-onset water hazards than in those affected by less severe ones.

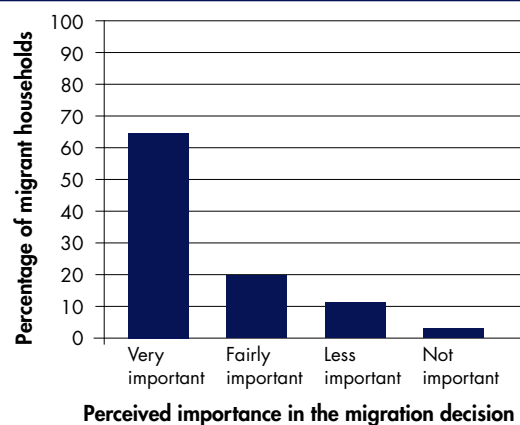
Interestingly, in the communities exposed to floods and flash floods, members of households whose agricultural land had been damaged were less likely to migrate for work than members of households whose agricultural land had not been affected. Possible reasons could be that those households are 'tied' to the land in times of hazard to reduce flood damage, or that they receive government compensation as an alternative source of income. Further, members of households that had depended on natural hazard-prone livelihoods in the past (e.g., farming or animal husbandry) showed less likelihood of migrating for work during droughts or water shortages. Possible reasons could be that household assets are tied up in natural hazard-prone livelihoods or that additional labour is needed to conduct agriculture and animal husbandry in these areas. However, more research is needed to clarify the reason for these effects.

While the complexities in the influence of water hazards on migration behaviour are recognised, as well as the multi-causal nature of migration, it is clear that water hazards do influence the decision to migrate for work in the communities studied. However, in the majority of households surveyed, water hazard was only one of many determinants of labour migration.

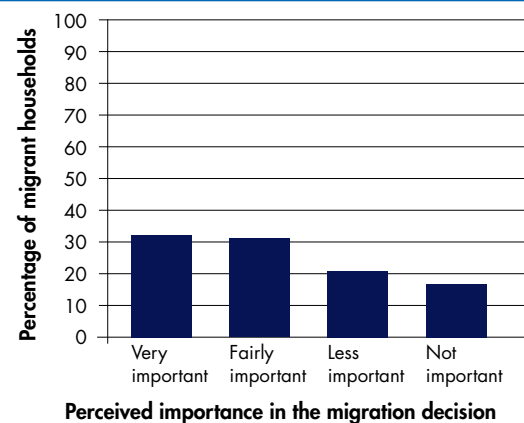
### Influence of household context on the decision to migrate for work

The relationship between water hazards and labour migration is not linear and is often mediated by a host of other factors including the perceived extent of the impacts of a water hazard on livelihoods and the household asset base (natural, social, physical, financial, and human assets) and intervening factors such as transport, communication, and institutional policies. Water hazards exacerbate existing household vulnerabilities. In the majority of surveyed households, the primary means of livelihood (agriculture and animal husbandry) were hazard-prone activities. The disruption of the primary means of livelihood by water hazard reduced household income. As the level of development in the communities studied and their surrounding areas is generally low, there is a general lack of alternative livelihood opportunities. Households might not be able to replace the loss of their primary means of livelihood with an alternative livelihood in their local area. The challenge posed by lack of alternative livelihood opportunities was compounded

**Figure 18: Perceived importance of rapid-onset hazards in the migration decision, Hindu Kush Himalayan region, 2010**



**Figure 19: Perceived importance of slow-onset hazards in the migration decision, Hindu Kush Himalayan region, 2010**



for some households by the growing household size. Depending on the household assets and the intervening factors, one or more members of a household were likely to migrate for work under such circumstances. The decision to migrate was, generally, a proactive household strategy to diversify income and reduce the risks posed by water hazards to existing livelihoods.

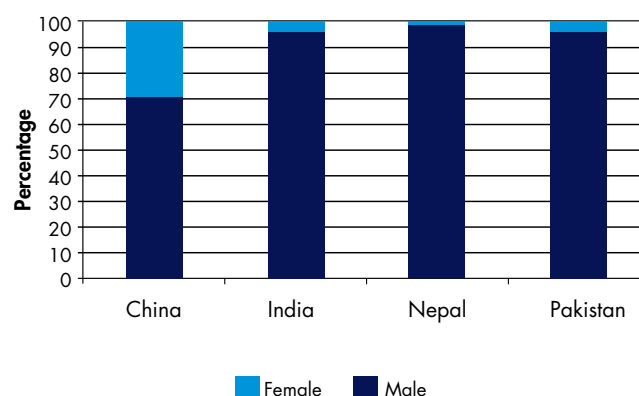
Migration requires the means and access to certain resources. The option of labour migration may not be available to some households for economic and non-economic reasons. In the studied communities, lack of resources (28%) prevented some households from migrating for work as a response to water hazards. Family obligations (19%), acceptance of losses from water hazards as a cost of locational benefits (8%), lack of additional household members (7%), lack of skills (3%), and health problems (3%) were other reasons given for not migrating for work.

At the same time, certain households responded to the impacts of water hazards without recourse to migration for other reasons. For example, households whose primary means of livelihood in the origin community was secure did not migrate for work (9%); some were aware of the risk of water hazard but did not expect a disaster (8%); some did not anticipate any or serious losses (6%); and others who expected serious losses were either planning or had undertaken loss reduction measures (5%).

### Who are the labour migrants?

Labour migrants across the communities surveyed in the four countries were predominantly male, young, and of working age. The mean age at first migration was around 25 years. Among those surveyed, the communities in China had the highest percentage of female labour migrants (30%) (Figure 20). Conservative social norms, traditional division of labour between men and women, and women's overall lack of education and exposure explain the low percentage of female labour migrants, particularly in the communities studied in India, Nepal, and Pakistan. About 90 per cent of migrant workers had some form of basic education: 36 per cent had obtained primary education and 37 per cent secondary education. Most of the migrants surveyed were from lower middle or lower income classes.

Figure 20: Distribution of labour migrants by gender, Hindu Kush Himalayan region, 2010



### Migration destination

Labour migration across the communities surveyed was predominantly internal, that is, the labour migrants remained within their country of origin (Table 12). Among the communities studied, it was only in Nepal where three-quarters of migrant workers surveyed moved to a regional or an international destination. The following are the possible reasons for this: Firstly, the potential migrants in Nepal are willing to migrate abroad, either to a regional or an international destination, if the expected income in the destination is sufficiently high. Secondly, the cost of migration to neighbouring India is not substantial because of the open border policy, social networks (relatives and friends), cultural similarities between India and Nepal, and the short distance to the urban centres in north India. Finally, India, China, and

Table 12: Type of destination community on first migration for surveyed labour migrants, Hindu Kush Himalayas, 2010

Country	Distribution of surveyed labour migrants by type of destination community			Number of labour migrants surveyed (first migration episode)
	Internal (%)	Regional (%)	International (%)	
India	100.0	0.0	0.0	321
China	100.0	0.0	0.0	264
Pakistan	96.8	0.5	2.7	186
Nepal	25.7	45.2	29.1	230

**Table 13: Urban-rural differential in the destination of surveyed labour migrants by episode of migration, Hindu Kush Himalayas, 2010**

Migration episode	Urban-rural differential in the destination of labour migrants (%)					Number of labour migrants surveyed
	Village	Rural	Town	City	Urban	
First migration	8	8	37	55	92	994
Second migration	11	11	30	59	89	234
Third migration	17	17	25	58	83	65

Pakistan, compared to Nepal, have more livelihood opportunities in their urban centres because of the better state of their economies.

The majority of migrants moved to urban areas to seek employment. During the first migration episode around 92 per cent of the surveyed labour migrants moved to a town or a city (Table 13). The same pattern was observed among migrants with second and third migration episodes. The general urban orientation of labour migration reflects regional inequality in development and urban centred growth within these countries.

### Occupations of labour migrants in destination communities

The overwhelming majority of labour migrants were wage employees in either secondary (industry, manufacturing, and construction) or tertiary (service industry) sectors in the destination communities (Figure 21). Most were either unskilled or semi-skilled workers who consequently end up in low-paying jobs such as in factories or as construction labourers, drivers, security guards, carpenters, tailors, chefs, waiters, cleaners, and shop assistants. This, however, meant that most of the migrants switched from the hazard-prone primary sector jobs (such as agriculture and livestock farming) to the generally less hazard-prone secondary and tertiary sector jobs, which indicates sectoral diversification.

### Impact of financial remittances on household capacity to respond to water hazards

Generally, the amount of the remittances was low (on average USD 178 per transaction). Among communities surveyed, the mean volume of remittance per transaction ranged from USD 80 in the communities studied in Assam in India to USD 286 in those studied in Nepal. A little over half of surveyed

recipient households (51%) reported receiving remittances on an irregular basis. In India and China, 76 per cent and 73 per cent of households, respectively, did not receive remittances on a regular basis. Insufficient savings because of low income and high living expenses in their destination was the main reason cited for irregular remittance transfers.

Despite the relatively low volume and the irregularity of remittance transfers, remittances constituted a significant proportion of household income in the Hindu Kush Himalayas. On average, more than half of recipient households' income (62%) was from remittances. Remittances also contributed significantly to household welfare, contributing to basic needs (food, housing, consumer goods) as well as to long-term investments such as in the health and education of household members (Figure 22).

The major share of remittances was spent on basic needs, particularly food. In especially poor recipient

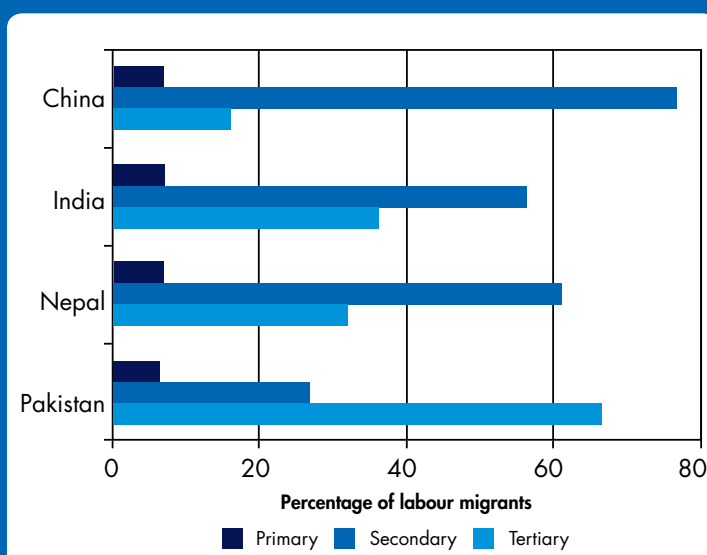
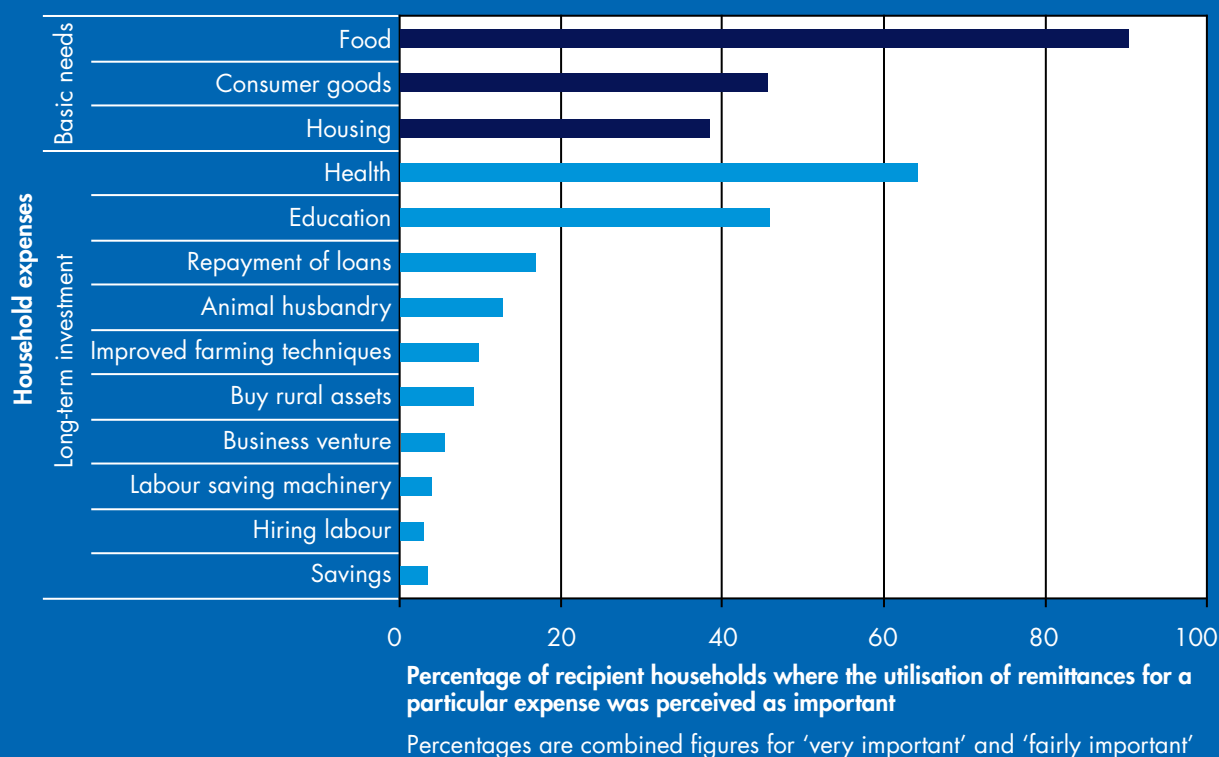
**Figure 21: Distribution of labour migrants in destination community by sector, Hindu Kush Himalayan region, 2010**

Figure 22: **Perceived importance of remittance utilisation in various household expenses, Hindu Kush Himalayan region, 2010**



households, such consumption has the potential to improve the health of household members through better nutrition and better provision for other basic needs. Improved health enhances human resources in recipient households. In fact, spending on health and on education was perceived as important in 64% and 46% of recipient households, respectively. This can also improve the quality of life and human assets in the recipient households. Only a small percentage of recipient households, however, received enough remittances to be able to set aside some for long-term income-generating investments such as business ventures, rural assets, and savings. The following are some specific examples.

Shahina Bibi lives in the Madak Lasht village, Chitral district, Pakistan. During the winter season her husband Sayed Hakim migrates to the city of Karachi in the Sindh province of Pakistan. There he works in the fishing industry. On average he sends 5,000 Pakistan rupees (around USD 59) every month. Sometimes it increases in case of emergency. These remittances are used for food, education, health, clothing, and repayment of the loan taken to meet the expenses of migration.

Jin Meixin is 47 years old. He lives in Bai Cai village, Longyang district, Yunnan province, China. He is a farmer in his village. He migrates to the city of Bao Shan in the same province for work between November and March. In Bao Shan, he cuts logs. During the agricultural busy season he returns to help his wife plant and harvest crops. Every month he carries home about 500 Yuan RMB (around USD 76). The money he brings back is spent on food, clothing, consumer goods, agricultural inputs, and education. He believes agricultural inputs such as seeds and fertiliser are the most important expenses.

The benefits of financial remittances are not limited to recipient households. Almost 72 per cent of recipient households spent the major share of remittances within their community. Remittances spent within the origin community on basic needs contribute to the household income of some non-recipient households. Around 38 per cent of recipient households perceived the use of remittances to build a new house or improve an existing house as important. Use of remittances on labour intensive goods and services such as construction creates a demand for local services, which indirectly benefits the origin community.

## Impact of labour migration on gender roles in migrant households

Gender norms in the migrant households are either intensified or changed significantly by migration (MigrationDRC 2009). Labour migration in the Hindu Kush Himalayas is a gendered phenomenon, with mostly men migrating and the women staying behind to take care of the household. This has both positive and negative effects on gender roles in migrant households.

The majority of women reported being happy about the migration of a household member, which they perceive and accept as necessary for the sustenance and better future of their households, although some women were unhappy about long separations from migrant household members. Male migration, particularly migration of the husband, increased the decision-making power of some women in nuclear and joint families. In some households, decision-making power did not change because of the presence of other male household members. In traditional communities, household roles are predefined, and do not usually change with male migration.

*I am happy with the migration of my husband, because remittances sent by him to the household can be used for the daily expenses. It is a guarantee for our subsistence.*

Wife of migrant,  
Taokong village, Yunnan, China

Predominantly male migration has increased the drudgery of women in migrant households in the HKH region. These women have taken on an increased role both within and outside the household. Besides performing daily household tasks, they have had to replace male migrants in agricultural activities, animal husbandry, forestry, and accessing markets. At times, male migration has had an adverse effect on the health of some women from migrant households; the increased workload and separation from spouses was detrimental to women's health, leading to physiological stress and psychological tension. In the communities surveyed in Pakistan, women were dependent on male members to visit medical centres.

Generally, women did not report feeling insecure because of the migration of male household members. The reasons for this included the presence

of other male members in a household, strong social networks of relatives and neighbours in the same community, and good public security.

## Labour migration as a positive response

One of the main objectives of the study was to assess whether labour migration is a positive livelihood choice in water hazard affected communities based on three criteria: decision-making processes, income at destination, and financial remittances. The basic assumption is that labour migration is a positive response by a migrant household to the impacts of water hazards if all of the following are true:

- the migrant household made a proactive decision to send one or more members of the household to work elsewhere;
- the migrant is satisfied with the decision to migrate;
- the migrant earns more in the destination than in the origin community;
- the migrant household is satisfied with the financial remittances; and
- the financial remittances contribute to household welfare including providing or supplementing basic needs or helping the recipient household to make long-term investments.

**Decision making process:** As the focus of this study was only on labour migration, all of the migrant households surveyed had made some form of proactive decision regarding migration for work. This implies that the households had the prerogative to decide whether or not to send household members to work somewhere else. For most households in the communities studied, the impacts of water hazards exacerbated existing vulnerabilities due to lack of alternative livelihoods in the local area and absence of social security cover. The majority of migrant households surveyed (86%) reported that they had no other livelihood options in the local area to respond to the water hazards except to migrate for work. The pattern was similar in communities affected by rapid-onset and slow-onset hazards. In these circumstances, the migrant households were not mere passive victims of water-induced disasters. Through the migration of one or more household members for work, these households actively attempted to resolve the challenges brought about by the impacts of water-induced disasters. The labour migrants from a great majority of migrant households surveyed (79%) were satisfied with their decision to migrate for work.

**Income in destination communities:** Remittances reduced the risk to overall household livelihood by diversifying it in three ways: by source of income, by sector, and by geography. First, remittances diversified the sources of household income in the origin community. Labour migrants from an overwhelming majority of the households surveyed (93%) were earning more in their destination than they had in their community of origin. Second, the different types of occupation in the destination led to the sectoral diversification of household livelihoods. The majority of the migrants were employed in secondary or tertiary sectors (93%), which are usually less prone to natural hazards. This reduced the risk to household livelihoods by diversifying the means of livelihood of households in the origin community, which were heavily dependent on the primary sector and therefore vulnerable to natural hazards. Third, the capacity of a household to spread risk is constrained by its geographic size. The migrant households overcame this limitation by broadening the geographic space within which household members operated. The means of livelihood in destination and origin communities are generally not affected by water hazards at the same time. Labour migrants from 78 per cent of surveyed households were not affected by water hazards in the destination communities.

**Financial remittances:** The literature indicates that remittances act as a safety net for recipient households in the aftermath of natural disasters (Clarke and Wallsten 2004; Suleri and Savage 2006; Yang and Choi 2007; Mohapatra et al. 2009). Financial remittances have an immediate and direct impact on a household's response to water hazards. The impacts of remittances are numerous: First, remittances diversify the sources of household income. They provide an income stream that is not undermined by a natural disaster. The means of livelihood in the destination and origin communities are generally not affected by water hazards at the same time. This reduces the risk to livelihoods posed by water hazards. Second, remittances contribute to household welfare by contributing to basic nutrition needs, improving living conditions, and contributing to purchasing power for consumer goods; they also contribute to long-term investments in health and education. Third, remittances ensure immediate relief for households experiencing livelihood shocks from water hazards. For instance, they are used to buy food during lean periods. In 43 per cent of recipient households surveyed where the migration

decision had been influenced by water-induced disasters, the volume of remittances increased during or in the aftermath of a disaster. Fourth, remittances aid in recovery in the aftermath of water-induced disasters. They are used to rebuild livelihoods, reconstruct houses, meet health expenses, and procure household goods to replace those lost in water-induced disasters. Fifth, remittances contribute to disaster preparedness. For instance, they are used to improve or strengthen housing quality, procure irrigation facilities in drought-affected households, and buy boats for households affected by floods.

In the context of water hazards and the lack of alternative livelihood opportunities in and around the communities surveyed, the findings suggest that remittances are often a major, and sometimes the only, source of household income. The majority of labour migrants were satisfied with their decision to migrate and with their income in the destination community. Financial remittances provided immediate and direct relief to households during or in the aftermath of water-induced disasters, as well as contributing to household welfare in general. The majority of recipient households were satisfied with the remittances they received and perceived them as an insurance or security against future water hazards. Thus, migration for work is a positive livelihood response to water hazards for the majority of the households in the communities studied in the Hindu Kush Himalayas.

*Suren Lahan (age 25) from Chokham village in Assam worked in Dibrugarh town for one and a half years. With the remittances he has been able to buy a boat, which he uses during floods to move his family and belongings to safer locations.*

## Policy implications

Over the last decade, the concept of adaptation has gained prominence in climate change discourse, particularly within the UNFCCC negotiation agenda. The Third Assessment Report of the IPCC defines 'adaptation' as: "adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2001).

The importance of adaptation strategies has been highlighted in the Copenhagen Accord. There has been a gradual recognition of the role of migration

in adaptation (see IOM 2007, 2009, and 2010; Martin 2009). A growing consensus suggests that migration is an important strategy in reducing vulnerability to environmental and non-environmental stressors because it provides an opportunity to diversify income. In many cases, migration not only increases a household's resilience to water hazards, it also enables individuals and households to accumulate assets (Levina and Tirpak 2006; Laczko and Aghazarm 2009; Tacoli 2009; Barnett and Webber 2009). Hence, bringing together climate change, development, and migration perspectives has become a priority agenda among policy makers.

In this study, the focus was on patterns of labour migration, which is one of many forms of mobility, in communities exposed to rapid- and slow-onset water hazards. In the communities in the study areas, labour migration was found to be a positive response to the impacts of climatic variability, that is, to the effects of water hazards. Particularly during periods of water-induced disasters, remittances can be a disaster-free source of income for recipient households. In general, remittances are a relatively stable source of household income during natural disasters, macroeconomic or financial crises, and armed conflict (Mohapatra et al. 2009). In this way, labour migration and remittances 'moderate the harm' caused by water hazards. In all of the migrant households surveyed in the four countries studied, labour migration is an 'autonomous' strategy pursued by households of their own accord to diversify income. It is an expression not just of existing vulnerabilities, but of a household's capability to increase life's opportunities or create new possibilities for earning a living actively using the assets at its disposal. Labour migration positively contributes to several determinants of adaptive capacity, notably to financial resources, access to information, social resources, human capital, and infrastructure. Remittances have a significant potential to affect non-recipient households through the multiplier effects of remittance expenditure. In the communities studied, recipient households were spending a large proportion of remittances to purchase goods and services from local sources. However, the investment impact of remittances is limited because of their low volume, lack of supporting infrastructure, and lack of initiative. The knowledge and skills brought back by migrants contribute indirectly to the adaptive capacity of migrant households and, in some instances, those of potential migrant households. Thus, in the context of the IPCC definition of adaptation, labour migration

seems to be a potential strategy for adaptation to the impacts of water hazards for the majority of households in the Hindu Kush Himalayas.

The impacts of remittances are also important to national economies. At present, there are no disaggregated data on remittances available for the mountainous areas of the Hindu Kush Himalayas. The national figures on remittances for the countries studied indicate the potential of this source of capital (Table 14), even though these figures only show remittances received from international migrants. International remittances can largely offset trade deficits in middle and low income countries, contribute to sovereign creditworthiness, and provide a stable source of foreign currency earnings (Ratha et al. 2010). For example, in Nepal, remittances from international migrants are a major pillar of the national economy, contributing 22.9 per cent of GDP in 2010. It is noteworthy that there is little information available on the patterns of remittances sent by internal migrants, either for mountainous regions in general, or for the countries of the HKH region in particular. As the number of internal migrants is much higher than the number of international migrants, further studies need to focus on internal remittances as well.

United Nations agencies, national climate programmes, academics, and policy makers have used different definitions of adaptation, which could lead to varying interpretations of this term (Levina and Tirpak 2006). Limited understanding of the relationship between labour migration and the environment complicates assessment of the circumstances under which labour migration is an adaptation to the impacts of environmental hazards. Further understanding of the linkages between climate change and migration, and agreement on common terminology, will further support the development of

**Table 14: International remittances received in countries studied**

Country	Remittances received in 2010 (billion USD)	Remittances as percentage of GDP in 2009
India	55.0	3.9
China	51.0	1.0
Pakistan	9.4	6.0
Nepal	3.5	22.9

Note: Includes only remittances from international migrants.  
Source: World Bank 2011

migration policies to enhance the adaptive capacity of households. The reasons for migration and the net effect of environmental stressors on migration behaviour will continue to form an important part of the environmental migration discourse. However, in the context of labour migration, remittances are the most tangible link between migration and a household's adaptive capacity. In the communities studied, the migrant workers, irrespective of whether their migration decision was influenced by water hazards or not, sent remittances home in the aftermath of a water-induced disaster. Remittances play an effective role in the adaptive capacity of recipient households.

The impact of migration and remittances on social, economic, and gender inequality and on community cohesion are still ambiguous. The nature of such impacts depend on the selectivity of the migration process, on its temporal and spatial scales, and on value judgements (de Haas 2007). The extent to which remittances could be leveraged to improve the conditions of recipient households and the origin community depends on the general development conditions in the community and surrounding areas. Moreover, the fervour of development optimism should not hide the fact that remittances are personal flows of money from migrants to their friends and families. There is a limit to which such flows can be directed to community welfare, and they should not be viewed as a substitute for official development funds. Many poor households do not have access to remittances, and public funding is necessary to address the needs of such households (de Haas 2007; Ratha 2007). As migration requires resources, it is not an option available to everyone; the most vulnerable people are often not able to migrate. Within a socio-environmental context, migration behaviour depends on income, social networks, gender relations, and the perceived alternatives to migration (IOM 2010).

Continued efforts are required to understand the role of remittances in the adaptive capacity of recipient households and origin communities in the context of generic development, and to understand the role of the institutional environment and equity.

## Recommendations

Migration is not without its risks to the migrants and to the non-migrating members of a household. Yet for millions of people around the world labour migration is a significant livelihood strategy. Migration usually

contributes to the improvement of the lives of migrants, their household, and the origin community. Thus, there is a need to create a supportive physical and social environment to allow people to freely exercise their right to stay and right to move. The following recommendations are made to support labour migrants from water-hazard affected migrant households in the HKH region.

- Mainstream all forms of labour migration, internal as well as international, in national policy.
- Facilitate the development of vocational skills among community members, regardless of whether or not they remain in their origin communities. This will contribute to diversification of household livelihoods.
- Manage skilled migration to increase the chances of a successful migration.
- Create and facilitate investment opportunities for remittances in origin communities to enhance the contribution of remittances to the development of recipient households and their communities.
- Strengthen formal and informal means of social protection for migrants and the households they leave behind.
- Enhance knowledge generation and dissemination on the role of labour migration as a livelihood strategy.

# References

- Adger, W (2006) 'Vulnerability.' *Global Environmental Change* 16(3): 268–281
- Agrawal, A (2010) 'Local institutions and adaptation to climate change.' In Mearns, R; Norton, A (eds), *Social dimensions of climate change: Equity and vulnerability in a warming world*, pp 173–198. Washington DC, USA: The World Bank
- AKRSP (2009) 'Assessing local adaptation strategies to too much too little water: A case study of Chitral Pakistan.' In *Local responses to too much and too little water in the greater Himalayan region*, pp 13–60. Kathmandu, Nepal: ICIMOD
- Banerjee, S; Yves-Gerlitz, J; Hoermann, B (2011) *Labour migration as a response strategy to water hazards in the Hindu Kush–Himalayas*. Kathmandu, Nepal: ICIMOD
- Barnett, J; Webber, M (2009) *Accommodating migration to promote adaptation to climate change*, Policy Brief prepared for the Secretariat of the Swedish Commission on Climate Change and Development and the World Bank World Development Report 2010 Team
- Brown, O (2007) *Climate change and forced migration: Observations, projections and implications*, Human Development Report Office Occasional Paper. Geneva, Switzerland: United Nations Development Programme
- Cannon, T (1994) 'Vulnerability analysis and the explanation of "natural" disasters'. In Varley, A (ed), *Disasters, Development and Environment*, pp 13–30. Chichester, UK: John Wiley and Sons
- Carney, D (ed) (1998) *Sustainable rural livelihoods: What contribution can we make?* London, UK: Department for International Development (DFID)
- Christoplos, I; Rodriguez, T; Schipper, ELF; Narvaez, EA; Mejia, KMB; Buitrago, R; Gomez, L; Perez, FJ (2010) 'Learning from recovery after hurricane Mitch.' *Disasters* 34(2): S202–S219.
- Clarke, G; Wallsten, S (2004) *Do remittances protect household in developing countries against shocks? Evidence from a natural disaster in Jamaica*, Mimeo. Washington, DC, USA: World Bank
- Curson, P (1989) 'Introduction.' In Clarke, J; Curson, P; Kayastha S; Nag, P (eds), *Population and Disaster*, pp 1–23. Cambridge, UK: Basil Blackwell
- Das, PJ; Chutiya, D; Hazarika, N (2009) *Adjusting to floods on the Brahmaputra plains, Assam, India*. Kathmandu, Nepal: ICIMOD
- de Haas, H (2007) *Remittances, migration and social development: A conceptual review of the literature*, Social and Policy Development Programme Paper No 34. Geneva, Switzerland: United Nations Research Institute for Social Development
- DFID (2000) *Sustainable livelihoods guidance sheets*. London, UK: Department for International Development
- Dixit, A (2009) 'Kosi embankment breach in Nepal: Need for a paradigm shift in responding to floods.' *Economic & Political Weekly* 44(6): 70–78
- Dixit, A; Upadhya, M; Dixit, K; Pokhrel, A; Rai, DR (2009) *Living with water stress in the hills of the Koshi Basin, Nepal*. Kathmandu, Nepal: Institute for Social and Environmental Transition
- Dovers, SR; Hezri, AA (2010) *Institutions and policy processes: The means to the ends of adaptation*. Wiley Interdisciplinary Reviews: Climate Change 1(2): 212–231
- Eakin H (2000) 'Smallholder maize production and climatic risk: A case study from Mexico.' *Climatic Change* 45: 19–36
- Faist, T (2000) *The Volume and Dynamics of International Migration and Transnational Social Spaces*. Oxford, UK: Oxford University Press
- Frauenfelder, R; Käab, A (2009) *Glacier mapping from multi-temporal optical remote sensing data within the Brahmaputra river basin*. Paper presented at 33rd International Symposium on Remote Sensing of Environment, 4–8 May 2009, Stresa, Italy. [http://folk.uio.no/kaeab/publications/299\\_R.Frauenfelder.pdf](http://folk.uio.no/kaeab/publications/299_R.Frauenfelder.pdf) (accessed 14 December 2011)
- Government of India (2005) *Mahatma Gandhi National Rural Employment Guarantee Act, 2005*. New Delhi, India: Government of India <http://rega.nic.in/rajaswa.pdf> (accessed 20 September 2010)
- Government of India (1954) *Assam Embankment and Drainage Act, 1953 (Act No. 1 of 1954)*. New Delhi, India: Government of India <http://faolex.fao.org/docs/pdf/ind4229.pdf> (accessed 20 June 2010)
- Government of Pakistan (1998) *District Census Report Chitral*. Islamabad, Pakistan: Bureau of Statistics, Government of Pakistan
- Gosain, AK; Shrestha, AB; Rao, S (2010) *Modelling climate change impact on the hydrology of the Eastern Himalayas. Climate change impact and vulnerability in the Eastern Himalayas*, Technical Report 4. Kathmandu, Nepal: ICIMOD
- Goswami, DC; Das, PJ (2003) 'The Brahmaputra River, India: The eco-hydrological context of water use in one of world's most unique river system.' *Ecologist Asia: Special issue on large dams in northeast India: Rivers, forests, people and power*, 11(1): 9–14
- ICIMOD (2009) *Local responses to too much and too little water in the greater Himalayan region*. Kathmandu, Nepal: ICIMOD

- Immerzeel, W (2008) 'Historical trends and future predictions of climate variability in the Brahmaputra basin.' *International Journal of Climatology* 28: 243–254
- Immerzeel, WW; van Beek, LPH; Bierkens, MFP (2010) 'Climate change will affect the Asian water towers.' *Science* 328: 1382–1385
- IOM (2007) *Expert seminar: Migration and the environment*, International Dialogue on Migration No 10. Geneva, Switzerland: International Organisation for Migration
- IOM (2009) *Migration, climate change and the environment*. Geneva, Switzerland: International Organisation for Migration. [http://www.iom.int/jahia/webdav/shared/shared/mainsite/policy\\_and\\_research/policy\\_documents/policy\\_brief\\_envmig.pdf](http://www.iom.int/jahia/webdav/shared/shared/mainsite/policy_and_research/policy_documents/policy_brief_envmig.pdf) (accessed 14 December 2011)
- IOM (2010) *Disaster risk reduction, climate change adaptation and environmental migration: A policy perspective*, IOM Policy Paper on Migration, Climate Change and the Environment. Geneva, Switzerland: International Organisation for Migration
- IPCC (1990) *Impact assessment of climate change*, Contribution of Working Group II to the First Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press
- IPCC (2001) *Impacts, adaptation and vulnerability*, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press
- IPCC (2007) *Impacts, adaptation and vulnerability*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press
- IUCN Pakistan (1998) *Pastoralism among the Wakhis of Chitral*. Chitral, Pakistan: IUCN, CN-CCS Support Unit Chitral Pakistan
- IUCN Pakistan (1999) *Irrigation sector paper*. Chitral, Pakistan: IUCN, CN-CCS Support Unit Chitral Pakistan
- Kandlikar, M; Risbey, J (2000) 'Agricultural impacts of climate change: If adaptation is the answer, what is the Question?' *Climatic Change* 45: 529–539
- Kniveton, D; Schmidt-Verkerk, K; Smith, C; Black, R (2008) *Climate change and migration: Improving methodologies to estimate flows*, IOM Migration Research Series No 33. Geneva, Switzerland: International Organisation for Migration
- Kothawale, DR; Rupa Kumar, K (2005) 'On the recent changes in surface temperature trends over India.' *Geophysical Research Letters* 32(L18714): 4
- Laczko, F; Aghazarm, C (2009) 'Introduction and overview: Enhancing the knowledge base.' In Laczko, F; Aghazarm, C (eds), *Migration, Environment and Climate Change: Assessing the Evidence*, pp 41–112. Geneva, Switzerland: International Organisation for Migration
- Levina, E; Tirpak, D (2006) *Adaptation to climate change: Key terms*. Paris, France: Organisation for Economic Co-operation and Development
- Locke, C; Adger, W; Kelly, P (2000) 'Changing places: Migration's social and environmental consequences.' *Environment* 42(7): 24–35
- Martin, S (2009) 'Managing environmentally induced migration.' In Laczko, F; Aghazarm, C (eds), *Migration, Environment and Climate Change: Assessing the Evidence*, pp 353–384. Geneva, Switzerland: International Organisation for Migration
- Martin, S (2010) *Climate change, migration and adaptation, Study Team on Climate-Induced Migration*. Washington, DC, UK: The German Marshall Fund of the United States
- McLeman, R; Smit, B (2006) 'Migration as an adaptation to climate change.' *Climatic Change* 76: 31–53
- Migration DRC (2009) *Making migration work for development*. Brighton, UK: University of Sussex, Development Research Centre on Migration, Globalisation and Poverty
- Mijatovic, D; Bordoni, P; Eyzaguirre, P; Fox, E; Hutchinson, S; van Oudenhoven, F; Hodgkin, T (2011) The use of Agrobiodiversity by indigenous and traditional agricultural communities in: Adapting to climate change. Satoyama Initiative case study. Internet document: [http://satoyama-initiative.org/en/case\\_studies-2/group\\_agriculture-2/the-use-of-agrobiodiversity-by-indigenous-and-traditional-agricultural-communities-in-adapting-to-climate-change/](http://satoyama-initiative.org/en/case_studies-2/group_agriculture-2/the-use-of-agrobiodiversity-by-indigenous-and-traditional-agricultural-communities-in-adapting-to-climate-change/) (accessed 6 August 2010)
- Ministry of Environment (2005a) *National environment policy*. Islamabad, Pakistan: Government of Pakistan, Ministry of Environment
- Ministry of Environment (2005b) *Draft national water policy*. Islamabad, Pakistan: Government of Pakistan, Ministry of Environment
- Ministry of Environment (2009a) *National drinking water policy*. Islamabad, Pakistan: Government of Pakistan, Ministry of Environment
- Ministry of Environment (2009b) *National sanitation policy*. Islamabad, Pakistan: Government of Pakistan, Ministry of Environment
- Mishra, DK (2008a) 'Bihar floods: The inevitable has happened.' *Economic and Political Weekly*, 6 September 2008
- Mishra, DK (2008b) *Trapped between the devil and deep waters: The story of Bihar's Kosi River*. New Delhi, India: Peoples' Science Institute, Dehradun and South Asia Network on Dams, Rivers and People (SANDRP)
- Mohapatra, S; Joseph, G; Ratha, D (2009) *Remittances and natural disasters: Ex-post response and contribution to ex-post preparedness*, Policy Research Working Paper 4972. Washington, DC, USA: World Bank

- Nadeem, S; Elahi, I; Hadi, A; Uddin, I (2009) *Traditional knowledge and local institutions support adaptation to water-induced hazards in Chitral, Pakistan*. Kathmandu, Nepal: ICIMOD
- North West Frontier Province Government (2005) *Agricultural policy*. Islamabad, Pakistan: Government of Pakistan
- Perch-Nielsen, S; Battig, M; Imboden, D (2008) 'Exploring the link between climate change and migration.' *Climatic Change* 91: 375–393
- Poteete, AR; Ostrom, E (2004) 'An institutional approach to the study of forest resources.' Workshop in Political Theory and Policy Analysis, Indiana University. <http://www.indiana.edu/~workshop/papers/W011-8.pdf>
- Ratha, D (2007) *Leveraging remittances for development*. Paper presented at Brainstorming Session on Migration and Development, 27 February 2007, Brussels, Belgium
- Ratha, D; Mohapatra, S; Silwal, A (2010) *Outlook for remittance flows 2010–11: Remittances flows to developing countries remained resilient in 2009, expected to recover during 2010–11*, Migration and Development Policy Brief 12. Washington DC, USA: World Bank
- Schade, J; Faist, T (2010) *Conference on Environmental change and migration: From vulnerabilities to capabilities*, 5–9 December 2010 Bad Salzungen, Germany. [www.uni-bielefeld.de/tdrc/ag\\_comcad/downloads/envimig2010\\_confnote.pdf](http://www.uni-bielefeld.de/tdrc/ag_comcad/downloads/envimig2010_confnote.pdf) (accessed 14 December 2011)
- Shrestha, RK; Ahlers, R; Bakker, M; Gupta, J (2010) 'Institutional dysfunction and challenges in flood control: A Case study of the Koshi flood 2008.' *Economic & Political Weekly* 45(2): 45–53
- Skeldon, R (2002) 'Migration and poverty.' Paper presented at the conference on African Migration and Urbanization in Comparative Perspective, 4–7 June 2003, Johannesburg, South Africa
- Smit, B; Skinner, MW (2002) 'Adaptation options in agriculture to climate change: A typology.' *Mitigation and Adaptation Strategies for Global Change* 7(1): 85–114
- Stark, O; Bloom, D (1985) 'The new economics of labor migration.' *American Economic Review* 75(2): 173–178
- Stark, O; Lucas, R (1988) 'Migration, remittances and the family.' *Economic Development and Cultural Change* 36(3): 465–481
- Stern, N (2006) *The Economics of Climate Change: The Stern review*. Cambridge, UK: Cambridge University Press
- Suleri, A; Savage, K (2006) *Remittances in crisis: A case study of Pakistan*, Humanitarian Policy Group Background Paper. London, UK: Overseas Development Institute
- Tacoli, C (2009) 'Crisis or adaptation? Migration and climate change in context of high mobility.' *Environment and Urbanization* 21(2): 1–13
- Warner, K (2010) *Assessing institutional and governance needs related to environmental change and human migration*, Study Team on Climate-Induced Migration. Washington, DC: German Marshall Fund of the United States
- World Bank (2011) *Migration and remittances factbook 2011* (2nd ed.). Washington, DC: World Bank
- Yang, D; Choi, HJ (2007) 'Are remittances insurance? Evidence from rainfall shocks in the Philippines.' *World Bank Economic Review* 21(2): 219–248
- You, Q; Kang, S; Wu, Y; Yan, Y (2007) 'Climate change over the Yarlung Zangbo River Basin during 1961–2005.' *Journal of Geographical Sciences* 17(4): 409–420





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