Loss & Damage

Loss & Damage:

The costs of adaptation in Punakha, Bhutan: Loss and damage associated with changing monsoon patterns

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CDKN
ICCCAD International Centre for Climate Change and Development
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Contents

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Acronyms/abbreviations

ACPC	The African Climate Policy Centre
BTN	Bhutan Ngultrum
CBDRM	Community Based Disaster Risk Management
CDKN	Climate Development Knowledge Network
DGM	Department of Geology and Mines
DoA	Department of Agriculture
GLOF	Glacial Lake Outburst Flood
ICCCAD	International Centre for Climate Change and Development
ICIMOD	International Centre for Integrated Mountain Development
IPCC	Intergovernmental Panel on Climate Change
LCAR	Land Cover Assessment Report
LDCs	Least Developed Countries
MCII	Munich Climate Insurance Initiative
MoAF	Ministry of Agriculture and Forests
NEC	National Environment Commission
NSB	National Statistics Bureau
UNECA	United Nations Economic Commission for Africa
UNU-EHS	United Nations Institute for Environment and Human Security
UWICE	Ugyen Wangchuck Institute for Conservation and Environment
WWF	World Wide Fund for Nature

Glossary of Bhutanese Terms

Ap	Term used to refer to a man
Aum	Term used to refer to a woman
Chhu	River
Chhukor	Water turn/rotation
Dzong	Administrative centre and the House of the Central Monastic Body
Dzongchhung	A smaller building in front of the main Dzong
Dzongkhag	District
Gewog	Sub-district
Je Khenpo	Chief Abbot
Lochhoe	Buddhist ritual
Soelkha	Buddhist ritual

Executive Summary

Background

People in the Himalayan region are confronted with changes due to global warming. Glaciers are melting, leading to changing river flows and an increased risk of floods (Richardson and Reynolds, 2000; IPCC, 2007; NRC, 2012). In addition, several recent studies have been pointing at changing rainfall patterns in the region (e.g., Ashfaq et al., 2009; Bhutiyani et al., 2010; Macchi et al., 2011). Although there is much uncertainty about the direction of these changes and their local manifestations, it is expected that altering patterns of precipitation will affect local livelihoods, particularly small-scale farmers. In Bhutan, shifting rainfall patterns will have direct consequences for the majority of the population, as most Bhutanese are subsistence-oriented farmers depending almost entirely on the South Asian monsoon rains for the cultivation of rice (NEC, 2011).

Farmers' measures are not enough to neutralize the negative effects of changing water availability and come with extra costs.

The research

As changes in water availability may become more pronounced in the future, and extreme events such as floods may occur more frequently, we need to understand how farmers are adapting to gradual changes and coping with extreme events. But this alone is not enough. In both scholarly debates and policy circles it is increasingly acknowledged that there are limits to adaptation and coping. It means that it is particularly important to pay specific attention to those cases where adaptation and coping measures are not successful or associated with costs and losses. This has become known as 'loss and damage' from climate-induced changes. At this point, empirical data at the household level is needed in order to inform decision-making to address loss and damage for the most vulnerable people in the world. To help fill this knowledge gap, we conducted a case study in Punakha district, Bhutan, exploring how people are adapting to slow-onset changes in water availability, their coping strategies after extreme events, and the residual loss and damage. We used a combination of qualitative and quantitative methods, including a household survey of 273 households and a wide range of in-depth individual and group interviews.

Gradual changes in water availability

Most farmers in Punakha district cultivate paddy on terraces, which are irrigated using rain-fed streams coming from the mountains. The paddy is planted and harvested during the summer monsoon period, when there is enough water in the streams, and the water in the irrigation channels is shared among households and villages. According to 91% of the respondents it has become increasingly difficult to access enough water for irrigation over the last two decades, because of decreasing and delayed monsoon rains. Farmers also mentioned changes in the timing of the summer monsoon rains. These local perceptions were confirmed by an analysis of rainfall data between 1990 and 2010 from six meteorological stations in the area same district. Of all the respondents who indicated that changes in water availability negatively affect their crop production, 89% take action in response. The most mentioned measures are: performing dedicated Buddhist rituals to request for rain; developing new, or modifying existing water-sharing arrangements between households and villages; working on the maintenance of irrigation channels to make sure water is used more efficiently; shifting from irrigated to rain-fed crops, for example cultivating maize instead of rice in part of the fields; buying irrigation water from upstream villages; and using a gasoline pump to carry water from the main river to the fields using long hoses.

Eighty-eight per cent of the farmers who take measures indicated that their measures are not enough to neutralize the negative effects of changing water availability. What's more, the measures come with significant extra costs. There are several 'new' monetary expenses that arise due to changes in water availability. The rental of a water pump, for example, costs approximately US$160 per acre per season, while buying the right to access irritation water from another village may cost US$70 per acre per season. But there are non-monetary costs as well. Sixty per cent of the respondents mentioning water sharing as an adaptation measure, indicated that this is associated with increased tensions between households and villages. Several cases of violent

conflict and vandalism were reported. This may for example happen when one village finds out that another village has broken the water-sharing arrangement by secretively diverting an irrigation stream to their fields during the night. Another cost is the time invested in the maintenance of the irrigation channels. For a household with one acre of paddy fields, maintenance work would normally take one or two days in the summer season, while this can increase to more than fifteen days of work when water is scarce. Last but not least, the cultivation of non-irrigated crops instead of irrigated rice is seldom the preferred option for farmers. Not only because rice is the staple food, but also because the yields of non-irrigated crops are less secure and the income per acre can be up to eight times lower compared to paddy rice.

The 1994 Glacial Lake Outburst Flood

To explore people's coping strategies after an extreme event we focussed on a large flood that occurred in 1994 when the dam of a glacial lake burst, resulting in a so-called Glacial Lake Outburst Flood, or GLOF. The 1994 flood is engraved in the memory of the Bhutanese people, because it destroyed a part of the age-old Punakha *Dzong* (Palace of Great Happiness). When we asked respondents about the impact of the flood, this was usually the first thing mentioned. A relatively small part (15%) of all the household-heads living within 300 meters of the main river indicated to be affected by the GLOF themselves, which is partly due to the geography of Punakha valley, with sharply inclined slopes on both sides of the river. At the household level, the most severe immediate effect of the flood was the loss of a part of the annual paddy harvest, which was washed away by the flood. To cope with this, affected farmers asked for food or money from neighbours and friends and reduced expenses. Many affected farmers also said they had to look for additional income, for example through sharecropping arrangements. For 12% of the respondents the GLOF caused a permanent loss. These were the farmers who lost part of their agricultural lands for good, as they got covered with a fine layer of river sand and stones, or were washed away completely. The government compensated at least half of them. Today, farmers are not much concerned with the risk of future floods. They point at the attempts of the government, which has taken several measures both to decrease the risk – for example by artificially lowering the water level of the Thorthormi glacial lake – as well as to prepare people for disasters through a national awareness campaign.

Conclusions

Small-scale farmers in Punakha district experience difficulties in accessing sufficient irrigation water to cultivate their paddy fields and have been adopting a variety of measures to deal with this. The measures, however, are considered insufficient, and have their own costs. We argue that these costs should not only be conceived in monetary terms, but also in terms of time, social-cohesion and livelihood security.

We argue that, in contrast with extreme events such as floods, gradual changes in water availability are an easily overlooked area for interventions. Efforts are needed to secure access to water by small-scale farmers, for example by investing in research on, and development of collective and private water-services, like water-storages, water pumps and irrigation systems.

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1. Introduction

1.1 Project background

Academics and policy makers are increasingly aware that not all impacts of climate change can be addressed by current mitigation and future adaptation efforts. Vulnerable people in developing countries suffer disproportionately from the adverse impacts of climate change caused primarily by developed countries. Their capacity to cope with extreme weather events and adapt to slow-onset climatic changes is limited. The impact of climate change beyond coping and adaptation has come to be known as 'loss and damage'. In 2010, the 16th Conference of the Parties (COP 16) of the United Nations Framework Convention on Climate Change (UNFCCC), recognized that joint international efforts were needed to better understand and address such losses and damages.

This report looks at loss and damage associated with the adverse effects of extreme events and slow-onset climatic changes in Punakha district, Bhutan. It is part of a series of case studies that empirically assess such losses and damages among people in Africa, Asia and Oceania. These case studies are part of the Loss and Damage in Vulnerable Countries Initiative, which was initiated by the Government of Bangladesh and funded by the Climate and Development Knowledge Network (CDKN). The case studies are coordinated by the United Nations Institute for Environment and Human Security (UNU-EHS). Other partners in the consortium are GermanWatch, the International Centre for Climate Change and Development (ICCCAD) and Munich Climate Insurance Initiative (MCII). The African Climate Policy Centre (ACPC) of the United Nations Economic Commission for Africa (UNECA) funded the research in three African countries.

The case studies aim to support Least Developed Countries (LDCs) in the climate negotiations by providing scientific data about real-life experiences of loss and damage in vulnerable countries. There are large gaps in our knowledge about the impacts of climate extremes and slow-onset processes, particularly for communities in LDCs that are not (yet) able to cope with or adapt to such changes. The case studies take place in eight countries: Bangladesh, Bhutan, Micronesia, Kenya, the Gambia, Ethiopia, Burkina Faso and Mozambique. These investigate different aspects of climate change, such as variation in rainfall patterns, droughts, floods, glacier retreat, cyclones, sea-level rise, salinity intrusion and coastal erosion. The Bhutan case study examines both glacial retreat and changing rainfall patterns with special attention to impacts on small-scale farmers.

As Loss & Damage is a new concept in climate change research, no commonly accepted definition is available yet. However, to inform our research questions and methods, we used the following working definition: Loss and damage refers to adverse effects of climate variability and climate change to which people have not been able to cope or adapt. This includes inability to respond to climate stresses (i.e. the costs of inaction) and the costs associated with existing coping and adaptive strategies. Such costs can be economic or monetary, but also social and cultural. Loss and damage can involve direct costs, but it can also involve longer-term effects on the viability of livelihoods. The extent to which households, communities and societies incur loss and damage from climate change varies according to their level of vulnerability and resilience. The case studies recognize that loss and damage is also related to mitigation as the potential costs of future climate change depend to a large extent on the intensity of climatic disruptions, which depend on mitigation efforts globally.

Loss and damage refers to adverse effects of climate variability and climate change to which people have not been able to cope or adapt.

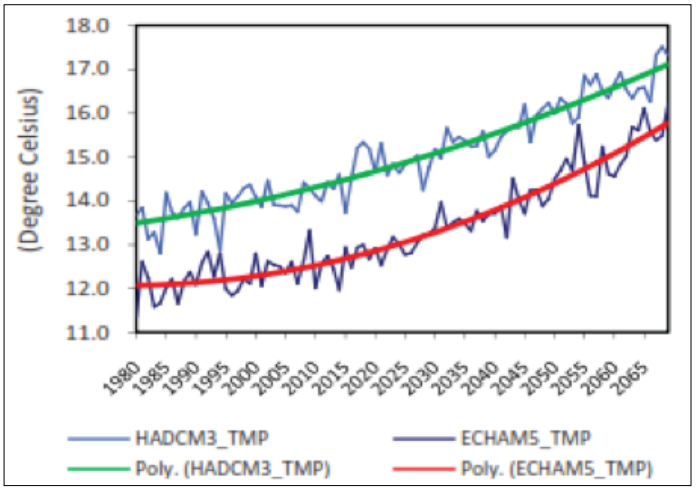
So far, efforts to assess losses and damages from climate change have focussed almost exclusively on material damage – usually expressed in quantitative terms – and loss of life or displacement resulting from extreme weather events. By contrast, the case studies in the Loss and Damage in Vulnerable Countries Initiative take a people's perspective, with ample attention to local perceptions and real-life experiences. Moreover, they expand the narrow focus on impacts of extreme events to include slow-onset climatic changes.

1.2 Climate change in Bhutan

Bhutan – the Buddhist Kingdom in the eastern Himalayas – has little more than 700,000 inhabitants and one of the smallest economies in the world. With a forest cover of almost 70%, limited industrialization and a surplus of hydropower production, the country is absorbing more carbon than it emits and thus functions as a net sink for greenhouse gases At the same time, however, the Bhutanese people are experiencing the consequences of global warming due to emissions elsewhere (NEC, 2011).

Much is uncertain about the ways in which global warming manifests itself in the Himalayas and how it may impact the various localities in the region (NRC, 2012).[1] In Bhutan specifically, there is a lack of historical records of rainfall and temperature. Reliable data is available for less than two decades. An analysis with data from 2000-2009 shows an increasing trend for both maximum and minimum temperatures and no apparent trends in the precipitation pattern, but the timespan of the analysis is too short to draw strong conclusions (NEC, 2011; MoAF, 2011b). The Second National Communication to the UNFCCC (NEC, 2011) reports on two climate models, using ECHAM5 and HadCM3Q0 A1B scenarios (Figure 1-1). Compared to 1980-2009, the mean annual temperature is projected to increase by 0.80^{0}C to 1.00^{0}C in 2010-2039 and by 2.00^{0}C to 2.40^{0}C in 2040- 2069 (NEC, 2011).

Figure 1-1 Trends of annual mean air temperature (°C) from 1980 to 2069 for Bhutan



Source: NEC, 2011. Trends according to PRECIS downscaled HadCM3Q0 and ECHAM5 scenarios.

The melting of glaciers and changing rainfall patterns due to global warming are expected to have serious consequences for agricultural production in Bhutan (MoAF, 2011a).[2] While arable lands cover only three per cent of the total land surface, agriculture is the main source of the livelihoods of about 70% of the population (NSSC, 2010) and climate change will thus have a direct impact on the majority of the population.[3] Changes in the availability of water for agriculture is seen as the most important threat for agriculture and the Royal Government of Bhutan identified water resources availability (in terms of quantity, quality and timeliness) as one of the principal climate pressures on broader human development in Bhutan (GNHC, 2011). Next to that, climate change is thought to lead to pest and disease outbreaks and increased occurrence of landslides. Moreover, receding glaciers and changing rainfall patterns are projected to affect the production of hydro energy (NEC, 2011).

[1] According to a recent study by Shrestha et al. (2012) the Himalayas have warmed by 1.5°C from 1982 to 2006, at an average rate of 0.06°C per year, but with variations in the rate of warming across seasons and ecoregions. According to the same study, the average annual precipitation- for the whole Himalaya region – has increased by 163 mm during the 25-year period.

[2] In addition to the consequences for the local economy, impacts are likely to be felt by people in downstream areas, as the Himalaya mountains form the headwaters of several of Asia's major river systems, including the Ganges, Mekong, Brahmaputra. Yangtze and Yellow River. Altered river flows due to glacier melt and changing precipitation can have serious consequences for roughly 1.5 billion people downstream who use these rivers as sources of drinking water and irrigation (IPCC, 2007; NRC, 2012).

[3] Although temperature rise could, in theory, make it possible to cultivate crops at higher elevations, Alam and Tshering (2004) argue that this is hardly feasible in Bhutan due to the steep slopes at higher altitudes.

In this report we will focus primarily on the impacts and responses at the household level of small-scale farmers. Below we will shortly address two main climate-induced changes with potential effects on local livelihoods, i.e., glacial melt, and changing rainfall patterns.

Glacial melt

Himalayan glaciers – covering about three million hectares or 17% of the mountain area – form the largest body of ice outside the polar caps and are the source of water for a large number of rivers. Glacial melt is expected to change the seasonality of these rivers, e,g, leading to earlier peak flows in spring time, and reduced flows in summer. Overall flows are projected to increase in the short-term, especially in winter and spring times, with higher chances of flooding. Eventually, however, the contribution of glacier melt will decrease over the longer term, decreasing the overall river flows. This is expected to have negative impacts on downstream irrigated agriculture in most South Asian countries (IPCC, 2007). In this way, according to Stern (2007, cited in IPCC, 2007: 483), glacier melt could negatively affect half a billion people.

Available meteorological data from the Bhutanese Department of Energy show that temperatures in Bhutan have been increasing over the past decades. At higher altitudes, temperatures have increased even more sharply than at lower altitudes (MoAF, 2011a). Based on monitoring results using satellite imagery of the Department of Geology and Mines (DGM), Bhutan's glaciers are receding at a rate of 20-30 meters per annum and according to DGM all the glaciers in the Bhutanese Himalaya could disappear within a few decades.[4] Glacial retreat may alter river flows, which could negatively affect current farming systems, and the possibilities for irrigated farming in the future (DoA, 2011). Moreover, glacial melt is leading to the growth of supra-glacial lakes. When such glacial lakes develop behind unstable ice-cored moraines, they have the potential to burst, leading to devastating floods downstream. This is especially the case when increasing temperatures contribute to the melting and destabilization of ice-cored dams. Such sudden floods are known as Glacial Lakes Outburst Floods or GLOFs, in short (Richardson and Reynolds, 2000). The Bhutanese National Environment Commission writes: *"Bhutan has 677 glaciers and 2674 glacial lakes. Glaciers in Bhutan are retreating rapidly by 8-10m per year for debris free glaciers and 30-40m per year for debris-covered glaciers. Due to the rapid melting, 25 glacial lakes are considered potentially dangerous with the threat of glacial lake outburst floods (GLOFs). Based on rates of glacial retreat, temperature trends in the area and trends in GLOFs in the region, threats from GLOFs are expected to increase in the future"* (NEC, 2011: 8).

GLOFs occurred in 1957, 1960, 1968 and 1994, with varying intensity and damage in the downstream valleys. The one that occurred on 7th October 1994, due to a partial burst at the Luggye Tsho glacial lake located in eastern Lunana, caused loss of life and property along the Punakha-Wangduphodrang valley. This last event triggered the awareness of policy makers and scientists about the risk of future GLOFs in relation to rising water levels in several glacial lakes due to rising temperatures. The National Environment Commission refers to an unpublished study conducted in 2002 by the Department of Geology and Mines together with the Institute of Geology of the University of Vienna in Austria. The study warns that a major GLOF of the Thorthormi Lake could occur by 2015, leading to discharge of about 53 million cubic meters (NEC, 2006). The United Nations Development Program and the National Environment Commission of Bhutan identified GLOFs as an imminent threat to large areas and populations of the country (UNDP-ALM, 2011).

Changing rainfall patterns

Rainfall patterns in the Himalayan region remain poorly understood, largely because of an inadequate meteorological and hydrological database. Also, fluctuations in precipitation are highly region-specific – making it difficult to identify general patterns and trends – and at higher altitudes it becomes even more complicated to understand how various factors such as wind direction, air pressure, temperature and moisture levels interact to deliver rains (NBC, 2011; see also The Economist, 2012). Still, there is evidence that rainfall patterns in the Himalayas are changing. In a recent study of four Himalayan areas by Macchi et al (2011) farmers indicate that the monsoon rains are increasingly erratic and delayed. Also, the Bhutan National Environment Commission reports on drying water sources throughout the country (NEC, 2011). Moreover, the Commission predicts

[4] According to a recent report by the National Research Council (USA), Himalayan glaciers are retreating at accelerated rate in the eastern and central regions of the Himalayas, while they seem more stable in the western Himalayas (NRC, 2012).

that rainfall will become more extreme, with more frequent episodes of high rainfall over short periods and larger differences in rainfall between the seasons, and that annual precipitation is likely to increase (NEC, 2011). This last point is contested, as several other analyses and models predict an overall decrease in rainfall in the Himalayas. Based on an analysis of available rainfall data between 1866 and 2006, Bhutiyani et al. (2010), for example, found a statistically significant decreasing trend in monsoon precipitation and overall annual precipitation. A sophisticated climate model developed by Ashfaq et al. (2009) predicts that climate change will alter the dynamics of the South Asian summer monsoon by decreasing summer precipitation, delaying the start of the monsoon season and leading to longer breaks between rainy periods. Clearly, it is extremely hard to predict how climate change will manifest itself in different localities within the Himalayan region, as it will depend on the local topography and microclimate factors.

Although evidence from meteorological sources is scarce, there are several anecdotal accounts of changing rainfall patterns in Bhutan (Lhendup, et al, 2011; Macchi et al., 2011, NEC, 2011). According to a climate change vulnerability assessment of biodiversity, livelihoods, and water conducted by the World Wide Fund for Nature (WWF) and Wangchuck Centennial Park, local people are experiencing more erratic rainfall and less snowfall, leading to changing water availability, with negative consequences for their agricultural practices (Lhendup, et al, 2011). Also, increasingly erratic rain showers will lead to more floods and landslides, which can wipe out roads, bridges and farmland (NEC, 2011).

1.3 Research focus and objectives

In this study we distinguish between two types of climate threats: gradual or slow-onset changes and extreme or sudden-onset events. Firstly, we will explore water availability for agriculture, which may be gradually changing as the result of altering rainfall patterns. Secondly, we explore extreme events and gradual changes related to the on-going retreat of glaciers in the Himalaya, i.e., increased risk of GLOFs and changes in the flow of glacial-fed rivers. Related to people's responses, we differentiate between adaptation, i.e., long-term responses to more gradual changes, and coping, i.e., short-term responses to unusual events.

As the occurrence of GLOFs is likely to increase (ICIMOD/UNEP, 2000) and the effects of gradual changes in water availability may become more pronounced in the future (e.g., Ashfaq et al., 2009), we need to understand how farmers are responding to these changes. But this alone is not enough. In both scholarly debates and policy circles it is increasingly acknowledged that there are limits to coping and adaptation. This means that it is particularly important to pay specific attention to those cases where responses are not successful and/or associated with losses or high costs. Loss and damage is a new concept in climate change research and no commonly accepted definition is available yet. In this case study we define loss and damage as the negative effects of climate variability and climate change that households have not been able to cope with or adapt to. At this point, empirical data at the household level is urgently needed in order to inform decision-makers to address loss and damage for the most vulnerable people. This has been the starting point of our research.

Through this case study we aim to understand how gradual and abrupt changes lead to loss and damage, and what combinations of policies can help limiting loss and damage at the household level. The study focuses on Punakha district – one of the districts affected by the 1994 GLOF. Besides that, it is one of the most important agricultural areas of Bhutan. While acknowledging that losses and damages are incurred at all scales, we focus exclusively on households. Other consequences, e.g., on the generation of hydro-energy, are therefore outside of the scope of this research.

The central question in this case study is: How do gradual changes in water availability and sudden floods (GLOFs) result in loss and damage at the level of agricultural households in Punakha valley? This question will be answered through the following set of sub-questions: (i) How did people cope with the 1994 GLOF and what is the associated loss and damage? (ii) What are the local perceptions regarding changing water availability in the glacial-fed river and rain-fed streams? (iii) How do people adapt to gradual changes in water availability and what is the associated loss and damage? And (iv) what can be done to reduce loss and damage from climate-induced gradual and abrupt changes?

Box 1-1 Research domains

In order to better understand patterns of loss and damage in Bhutan, we study the following four research domains:

- *Climate threats:* The two climate threats central in this study are the increased risk of GLOFs and the changing water availability for agriculture, which are influenced by glacial melt and changing rainfall patterns. This research uses social science methods to study the impacts of these climate threats. The question to what extent glacier melt and changing monsoon patterns are caused by anthropogenic climate change or global warming requires physical science methods and is beyond the scope of this research.
- *Societal impacts:* In this study we focus on two types of societal impact: (i) The effect of changing water availability in rivers and streams on crop production and other agricultural activities, and (ii) the effect of the latest large GLOF in Bhutan, which happened in 1994, on physical properties of households.
- *Responses:* We study how people have coped with the 1994 GLOF and how people have been adapting to more gradual changes in river and stream flows.
- *Loss & Damage:* Loss and Damage refers to the effects of glacial melt and changing rainfall patterns that people have not (yet) been able to avoid. This includes: (i) the inability to cope with the 1994 GLOF; (ii) the inability to adapt to changing stream flows; and (iii) costs associated with existing coping and adaptive strategies.

2. The research area

Punakha district, located in the Punakha-Wangduephodrang valley, is one of the 20 districts of Bhutan (Figure 2-1). The district covers a total area of 1,108 km^2, and consists of 11 sub-districts (also known as *blocks* or *gewogs*). Punakha town, 72 kilometres northeast of Thimphu, is the administrative centre of the district (NSB, 2010). It used to be the capital of Bhutan and the seat of government until 1955, when the capital was moved to Thimphu. The district is well known for the Punakha *Dzong*[5], also known as the Palace of Great Happiness, which was built in 1637. The large building contains the district's administration and is the winter residence of the Central Monk Body and its Chief Abbot (*Je Khenpo*). It is located at the confluence of the Pho-chhu and Mo-chhu rivers and during the 1994 GLOF, the *Dzongchhung* (a smaller building in front of the main *Dzong*) was seriously damaged, reportedly without harming the religious relics it contained. Work is currently in progress to protect the building from future flood damage by deepening the river channels and raising the embankments.

According to the Punakha District Annual Statistics of 2011, the district had a population of 17,715 inhabitants and a population density of 18 people per km^2 in 2005. An exact number of the population in 2011 was not available at the time of study, but is estimated to be around 26,000 people (NSB, 2011). The total forest coverage is about 87,978 hectares, consisting mostly of coniferous and broad-leaved trees. Twenty-two per cent of the total area of Punakha district is cultivable land (NSB, 2010). The lowest point in the valley is about 1,200 meters above sea level, while the highest point is 4,825 meters. Most cultivation takes place below 1,800 meters (Dorji et al., 1990).

The Pho-chhu River

The Pho-chhu River is one of Bhutan's major rivers. It originates in Gasa district near the border between Bhutan and Tibet, from where it flows southwards. At Punakha town it merges with the Mo-chhu River, coming from the northwest. In Dzongkha, the official language in Bhutan, "Pho" means "male", "Mo" means "female" and "chhu" means river or "water". The confluence of the two rivers is right below the Punakha Dzong, where the name of the river changes to Punatsang-chhu. The river continues through Dagana and Tsirang districts in Bhutan after which it enters India (where it is known at the Sunkosh) and finally joins the Brahmaputra River.

Punakha Dzong at the confluence of the Pho-chhu and the Mo-chhu rivers

Agriculture

Farmers in Punakha district produce a wide variety of non-irrigated crops, mostly in the winter months. These include wheat, mustard, buckwheat, persimmon, guavas, peaches, plums, pears, apples, chillies, radish, cabbages, green leaved vegetables and tomatoes. The most important crop in the district, however, is rice, cultivated on irrigated terraces (NSB, 2010). Punakha district contains one of Bhutan's largest contiguous rice cultivation areas. Small-scale farmers grow rice along the river valleys of the Pho-chhu, Mo-chhu and Punatsang-chhu in the summer months, when water from the monsoon rains is available in the irrigation channels. It is the most important crop in terms of area, production and employment. Also, rice is the most important crop for food, cash and barter (Dorji et al., 1990; NSB, 2010). All rice fields are irrigated. In 2009 the district had 138 functional government-constructed irrigation channels, with a total length of 413 km and the area covered by irrigation was estimated to be 8,155 acres (NSB, 2010).

[5] A *Dzong* is the religious, military, administrative and social centre of a district. Each district has its own *Dzong*, and each *Dzong* is divided in two parts; one part is allocated to the administrative function (the district government), and the other part is allocted to the religious leaders and monks. Most *Dzongs* in Bhutan date from the 17the century and are located at strategic locations as they also functioned as fortresses.

Figure 2-1 Map of Bhutan showing Punakha district

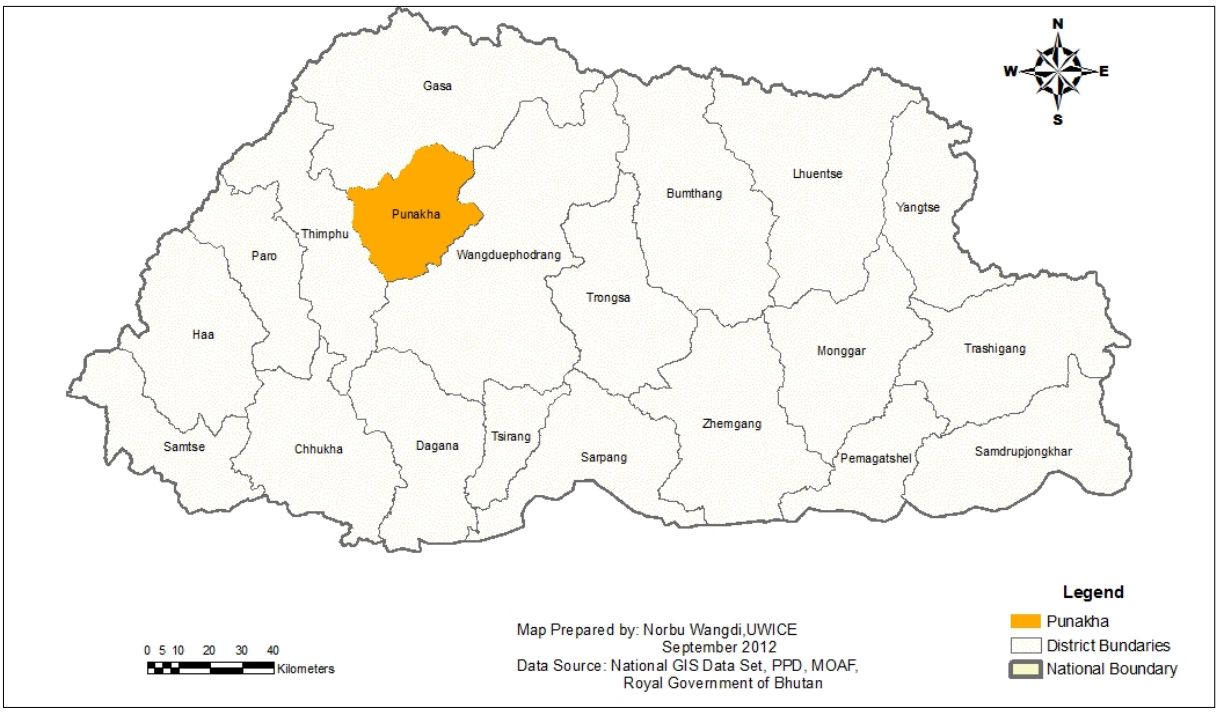
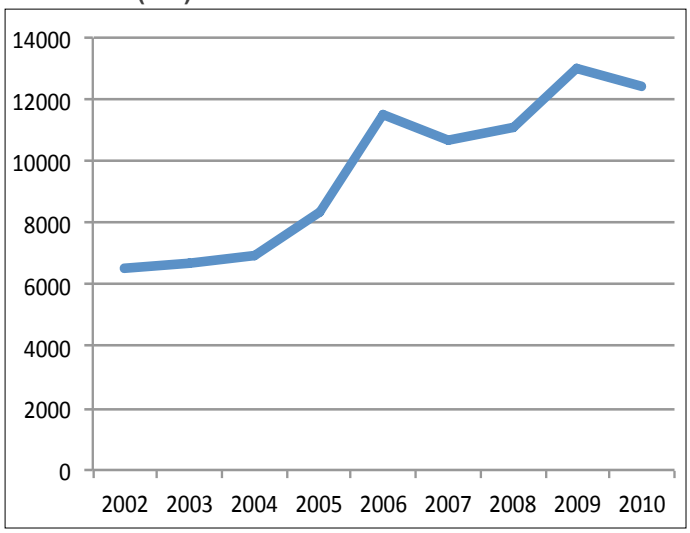


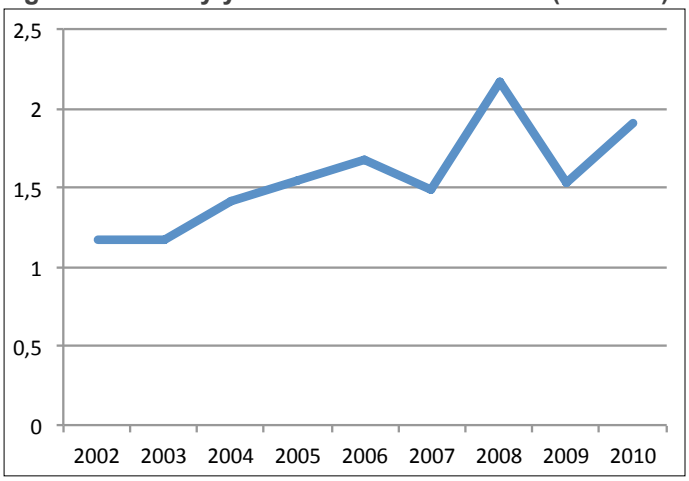
Figure 2-2 and Figure 2-3 provide data on paddy production and productivity for Punakha district. The figures suggest that production has been gradually increasing, mostly due to an increase in productivity per acre. According to government officials at Punakha district, the general trend is increasing due to improved seeds, fertilizers and agricultural intensification.

Figure 2-2 Paddy production in Punakha district 2002-2010 (MT)



Source: FAO Country-STAT Bhutan, http://www.rnrstat.bt

Figure 2-3 Paddy yields in Punakha district (MT/acre)



Source: FAO Country-STAT Bhutan, http://www.rnrstat.bt

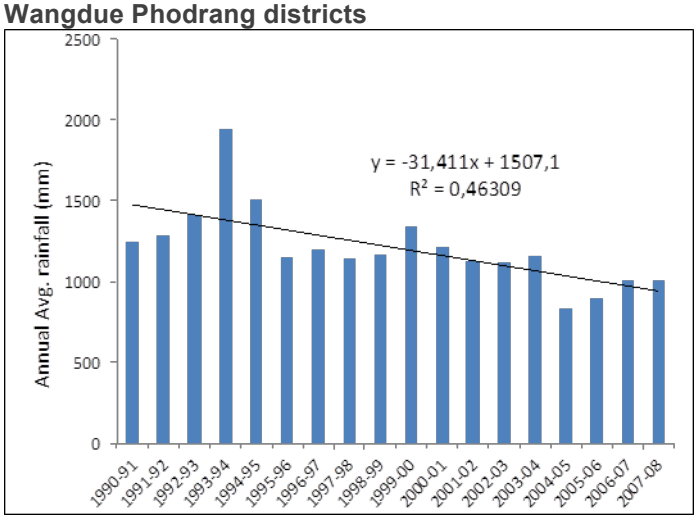
In addition to the introduction of better seeds, fertilizers, and intensification, rainfall levels may influence agricultural productivity. We therefore compared the rainfall data from two metrological stations with the paddy production data of the two sub-districts in which these stations are located (Guma and Shengana) but this yielded no significant relationship.

Climate and changing rainfall

The Punakha-Wangduephodrang valley is characterized by warm summers (from June to November), cool winters (from November to June), and monomodal monsoon-related rainfall. About 75% of the annual rainfall falls in the summer period (Dorji et al., 1990). Table 2-1 presents the maximum, minimum and average temperatures per month in 2010 and the average monthly rainfall for the same year, recorded at two meteorological stations in Punakha district – one located at the Punakha *Dzong* in Guma sub-district and one located in Shengana sub-district.

We obtained rainfall data from 1990 up to 2008, recorded at six meteorological stations: two in Punakha district (Punakha Dzong and Shengana) and four in the neighbouring Wangduephodrang district (Semtengang, Wangdue, Phobjikha and Nobding). The data shows a decreasing trend (Figure 2-4), which is significant (sig=0.00187). Punakha Dzong and Shegana recorded the largest decrease in June, the first month of the monsoon (Figure 2-5). Finally, Figure 2-6 shows the difference in rainfall between the 1990s and 2000s based on the average cumulative daily rainfall collected at the Punakha Dzong meteorological station.

Figure 2-4 Annual average rainfall in Punakha and Wangdue Phodrang districts



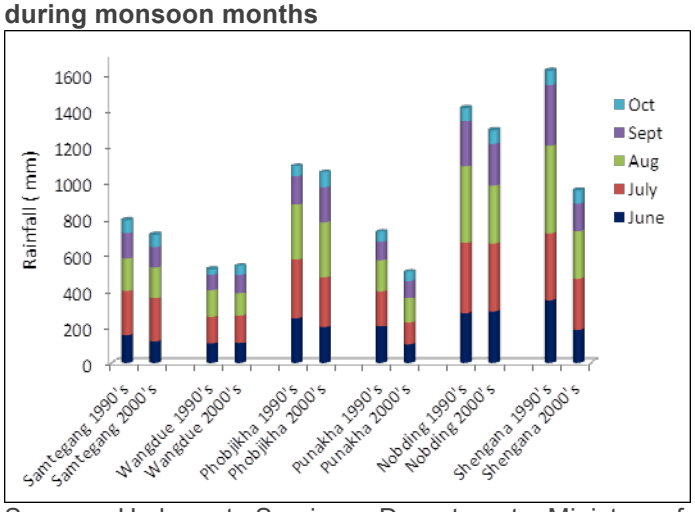
Source: Hydromet Services Department, Ministry of Economic Affairs, Thimphu, Bhutan.

Table 2-1 Temperature and rainfall in Punakha (2010)

	Temperature in Punakha district (°C)			Monthly rainfall (mm)	
	Max.	Min.	Average	Punakha *Dzong*	Shengana
January	18	5	12	0	0
February	14	1	8	2	3
March	16	6	11	10	13
April	19	9	14	30	41
May	26	14	20	62	76
June	31	21	26	143	125
July	33	22	27	251	372
August	31	22	27	98	213
September	31	21	26	120	256
October	29	18	24	37	103
November	25	14	20	8	19
December	23	6	15	4	0
Annual	25	14	19	764	1221

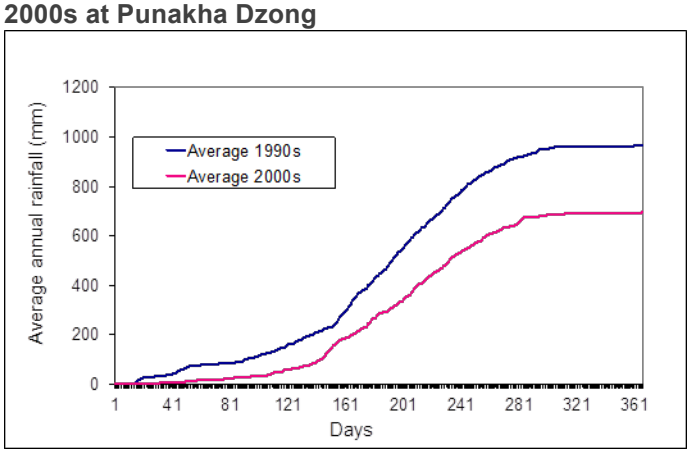
Source: NSB, 2011

Figure 2-5 Average rainfall in the 1990's and 2000's during monsoon months



Source: Hydromet Services Department, Ministry of Economic Affairs, Thimphu, Bhutan.

Figure 2-6 Cumulative rainfall averages of 1990s and 2000s at Punakha Dzong



Source: Hydromet Services Department, Ministry of Economic Affairs, Thimphu, Bhutan (analysis by Kees van der Geest, UN University, 2012).

3. Research methods

3.1 A mixed method approach

A research team of ten people spent two weeks in Punakha district to gather data in the field. The team consisted of a principal investigator, an international researcher, five enumerators, a note-taker, a practical assistant, a driver and a cook. One of the objectives of the study was to research loss and damage from the 1994 GLOF, which, according to government officials at the Punakha district administration, had particularly affected households in Dzomi and Toewang sub-districts, located on the east bank of the Pho-chhu River in Punakha district. The west bank was said to be much less affected, due to its steep slopes. In an effort to capture a sufficient number of households affected by the flood, we interviewed 100% of the households located within 300 meters from the main river in these two sub-districts – a total of 28 settlements (Table 3-1). In addition, we surveyed 100% of the households living within 300 meters from the river in several neighbouring settlements: seven on the west bank of the river (Chhubu sub-district), two upstream of Toewang (Lingmukha sub-district), and two downstream of Dzomi (Thedtsho sub-district).

Enumerators interviewed the heads of households, using a questionnaire that contained both open ended and closed questions, divided in four sections: (i) respondent and household characteristics, sources of livelihood and vulnerability; (ii) impact of and adapting to changes in river and stream flows; (iii) impact of and coping with weather-related extreme events; (iv) vulnerability, gender and policy (see Annex 1 for the full questionnaire). On average, interviews took between 40 minutes and one hour.

In addition to the survey, we conducted 31 in-depth interviews with key informants, namely village representatives, extension workers, sub-district representatives, and government officials at the district level (see Appendix 2 for list of key informants). The key informants were selected for their specific knowledge and/or experience.

We also organised focus group discussions with a total of 20 men and women of different ages in three settlements in Lingmukha, Dzomi and Toewang sub-districts (Appendix 3). The focus group discussions were meant to generate an open conversation with and among villagers about the themes under study, in order to obtain a more profound understanding of people's perceptions, attitudes, and internal discussions. During two group interviews we asked the participants to identify the adopted coping strategies in response to the 1994 GLOF and to rank them in order of importance. We organised one focus group discussion with just women, focussing explicitly on gender roles in the household economy and the differences in vulnerability to (climate-induced) changes between men and women.

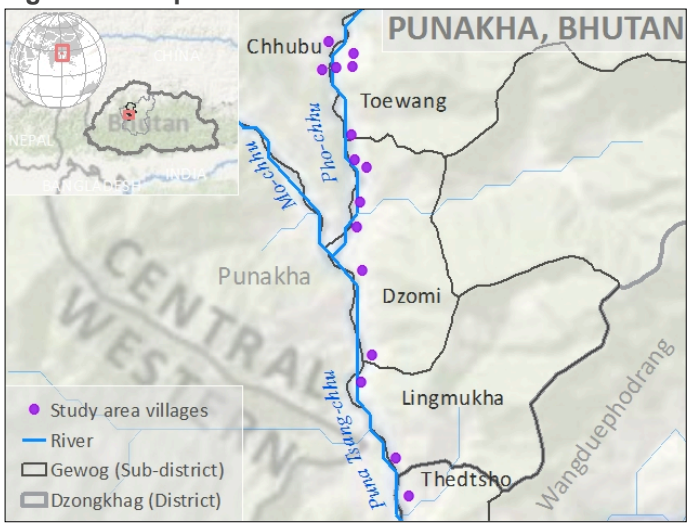
In the field, every evening all the questionnaires were checked and discussed with the enumerators. This allowed us to learn from the experiences of the enumerators and the stories from the field. Information from the survey was followed up in interviews with key informants and we occasionally re-visited survey respondents who seemed to have an interesting story for complementary in-depth interviews in order to gather extra information, particularly on people's life histories. At the same time information from in-depth interviews was used to instruct the enumerators.

The simultaneous use of quantitative and qualitative methods reinforced each other, not only during the field research, but also during the analysis of the data. The qualitative information provided the necessary insight for a meaningful analysis of the quantitative data, while we used the survey results to crosscheck statements by key informants.

Table 3 – 1 Research Sample

Sub-district	Nr of settlements	Nr of hh heads interviewed
Thedtsho	2	23
Dzomi	17	111
Toewang	14	83
Chhubu	7	27
Lingmukha	2	29
Total	42	273

Figure 3-1 Map of the research area



Map by Dara Mendeloff, The Earth Institute, Columbia University.
Note: The dots indicate the administrative villages as recorded in the 2005 population census. The 42 settlements surveyed include the sub-villages.

3.2 Research limitations and lessons

A practical limitation we encountered in the field was people's time availability. Our research period coincided with the paddy-harvesting time, which meant that all people (men and women) were busy in the fields – from early in the morning to late in the evening. Individual farmers were generally willing to be interviewed, either in the field or at home during the evenings, but it appeared more difficult to arrange group interviews during this busy time of the year.

Interventions to address loss and damage should not be based on assumptions, but on community consultation.

Due to a tight deadline in combination with long travel times, the team had not been able to organize an exploratory visit to Punakha district to conduct a reconnaissance survey, before the actual survey would start. In the first days of the fieldwork we found out that our questionnaire was not catered well to the local situation. The original questionnaire focussed solely on (the impacts of) changes induced by the retreat of glaciers, assuming farmers would be using the glacial-fed river for agricultural production. In the field we soon found that farmers were using rain-fed streams rather than the main river for irrigation purposes, and that they were complaining about decreasing water availability in their irrigation channels. We then decided to add new questions to the questionnaire, concerning these changes in water availability. Without this last-minute shift of focus, our research would probably not have yielded useful insights. It shows the importance of reflecting upon and crosschecking information while in the field and to allow for flexibility during the research. As Campbell and Sayer (2003) argue: Good research, like jazz, requires improvisation.

The fact we found out that glacier melt was not perceived as an immediate threat, while changing monsoon patterns were, provides another important lesson. It underlines the importance of a grounded understanding of local realities in order to develop appropriate and effective policies: interventions to address loss and damage should not be based on assumptions, but on community consultation.

4. Livelihoods and vulnerability along the main river

We interviewed a total of 273 households heads, all located within 300 meters from the main river. The average age of the respondents was 49, and the average household consisted of six members. Education levels of the heads of households appeared extremely low, with most of them having enjoyed no formal education whatsoever. School enrolment among the younger generations is much higher. Table 4-1 summarizes some basic characteristics of the interviewed heads of households.

As Table 4-1 shows, there are many more female household heads. In the research area it is common for the women to be the head of the household. It is the local tradition that the man moves in with the family of the woman. In terms of decision making at the household and community levels there is not much differentiation between the sexes. Women and men do, however, have specific roles in the household economy. Men are said to do the tough work, like ploughing and preparing the fields. Women usually do the rest of the work in the fields, like preparing seedlings, planting and weeding. Women usually take care of household chores and cooking.

Table 4-1 Characteristics of respondents

Characteristic		Percentage of respondents
Sex	Male	37%
	Female	63%
Household type	Single headed	12%
	Married (or double-headed)	88%
Education	No education	83%
	Entered primary school	11%
	Entered secondary school or higher	6%
Religion	Buddhist	97%
	Hindu	3%

4.1 Main sources of livelihood

Travelling through the research area in the summer months it becomes clear why the area is referred to as the rice bowl of Bhutan, with rice terraces stretched out on the mountain slopes along the main river. The vast majority of the people in the area are small-scale, subsistence-oriented farmers, producing primarily rice and vegetables. In addition, they often own a small number of livestock and fruit trees. About 80% of the households indicated that they consume more than half of their agricultural production. In general, only agricultural surplus is sold for cash. The mean annual cash income per household is BTN85,664 (US$1,556)[6]. The mean annual cash income per capita is BTN18,154 (US$330). More than half of the households are involved in non-farm activities, often in the winter season. The non-farm sector is the main source of cash income in the area (Table 4-2 and Figure 4-1).

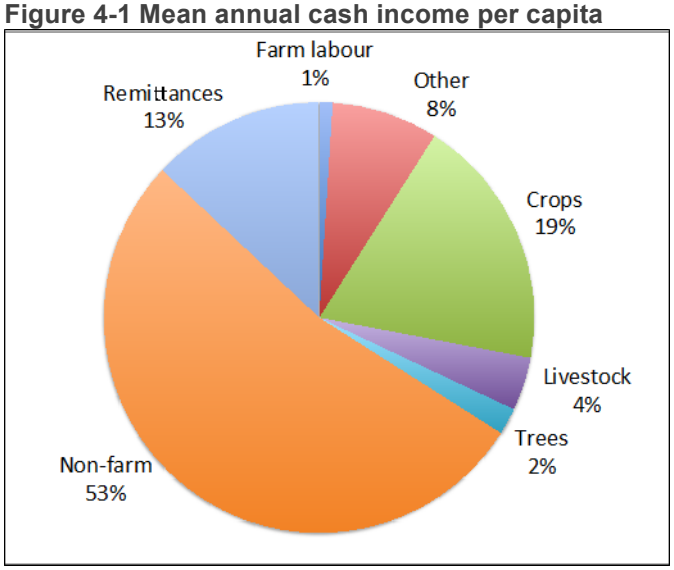
Table 4-2 Income-earning activities

Activity	N	% of hh	Mean annual hh cash income* (BTN)	(US$)
Crops	247	91%	16,593	301
Livestock	219	80%	3,019	55
Trees	181	66%	2,126	39
Non-farm	164	60%	45,175	820
Remittances	111	41%	11,225	204
Farm labour**	32	12%	667	12
Other***	18	7%	6,800	124

*Means calculated over the survey population (N=273)
**Households that earn cash income with farm labour. This does not include the households who are engaged in labour exchange.
***This category includes renting out houses and machinery (e.g. tractor, tiller, grinder, chainsaw, pump).

[6] Exchange rate BTN1.00 = US$0.0181591. The PPP (purchasing power parity) conversion factor in Bhutan was 0.39 in 2011 (Source: www.tradingeconomics.com).

Figure 4-1 Mean annual cash income per capita



Crop cultivation

More than 90% of the people are farmers – virtually all of whom practice irrigated rice cultivation on terraces and use either animal traction or a (hired) hand tractor to plough their fields.[7] The terraces are irrigated using rain-fed streams descending from the mountains. The rice is planted and harvested during the summer monsoon period, when there is enough water in the streams, and the water in the irrigation channels is shared among households and villages. In winter the main crops are maize, mustard and wheat, potato, pumpkin, radish, tomato, bean, barley, cabbage, eggplant, millet, union and spinach. Farmers produce for their own consumption first, and those who have surplus will sell it. Mean incomes from crop cultivation are relatively low (compared to non-farm income) but almost all households engage in subsistence-oriented farming.

Of the farming households, 94% own (part of) the land they cultivate, and 23% are involved in sharecropping arrangements. About 4% of the farming households do not own any land themselves and depend entirely on a sharecropping or rent arrangement. The average size cultivated per household is 2.1 acres. Table 4-3 presents the distribution in the size of lands owned.

[7] Eighteen households do not cultivate crops. Fourteen of them are specialised in non-farm activities (driver, teacher, extension officers), while the other four rely mostly on remittances.

Table 4-3 Land size and income

Land size category	N	% of hh	% subsistence-oriented hh within category*	Mean annual income from crop sales (BTN)	Mean annual income from crop sales (US$)
0-1 acres	75	30.9%	96%	12,011	218
1-2 acres	84	34.6%	90%	13,232	240
2-6 acres	73	30.0%	82%	24,007	436
6-14 acres	11	4.5%	73%	54,850	996

*At least half of the total agricultural production is consumed by the household.

Farming households take part in a labour exchange system within the community, which means that villagers work on each other's farms (reciprocal labour). Members of 32 households occasionally work as labourer on other people's fields for a daily wage, earning on average BTN5,693 (US$103) annually.

Crop trend

All respondents were asked to indicate whether their crop production changed over the last ten years (Table 4-4). If they noticed a change, they were also asked to mention the main reason why they think the production is changing (Table 4-5). According to just over one-third of the respondents, their crop production increased, while close to one-third indicated a decreasing crop production.

Of the respondents that indicated decreasing crop yields, 92% argued that this is primarily caused by changes in (timely) water availability. Other reasons mentioned are pests and decreasing fertility of the land. Of those with increased crop production, 87 per cent said that this has been because of access to improved technologies like chemical fertilizer and pesticides, and improved seeds. Some also explicitly mentioned the assistance of extension officers and improved traction (cow or tractor). This illustrates two simultaneous trends influencing agricultural production in the research area, but in opposing ways. Firstly, due to increased access to fertilizers, pesticides and improved seeds – made available in the 1990s through extension services by the government – people have been able to improve their production. Secondly, farmers seem to be dealing with unreliable water availability for their crops, hampering agricultural production. This is confirmed by Aum Sangay Om, a female farmer from Khawakha village, who said: "*In general, compared to before, there has been better yields due to use of fertilizers, better quality seeds and supported with some machineries. But when cultivation is delayed due to the lack of rainfall, the yields are much lower as they should be*" (interview on 03-07-2012).

Table 4-4 Trend in crop production (N=246)

Crop trend in last ten years	% of hh
Decrease a lot	2.0%
Decrease a little	28.0%
Remain the same	35.4%
Increase a little	32.1%
Increase a lot	2.4%

Table 4-5 Causes for changes in crop production (N=147)

	Decreased production		Increased production	
	Nr (N=76)	%	Nr (N=71)	%
Water	69	92%	0	0%
Pests	2	2%	0	0%
Technology	0	0%	62	87%
Extension services	0	0%	6	9%
Other	5	7%	3	4%
Total	76	100%	71	100%

Livestock and economic trees

About 75% of the surveyed households own one or more cows, with an average of six cows and a maximum of 18 cows per household. Twenty-nine per cent of the households have one or more pigs (any number up to four), and 44% own some fowls (five on average). Livestock is primarily used for own consumption. Cows are used for both traction and to produce milk and cheese, which are important ingredients in the Bhutanese kitchen. Surplus milk and cheese is sold, generating a mean annual income of BTN3,736 (US$68) for those households with cows.

Forty-three per cent of the households own a small number of economic trees, such as citrus, guavas, peaches and plums, mostly for own consumption. About half of them occasionally sell surplus tree products. For households that own trees, the mean annual cash income from selling tree products is BTN3,206 (US$58).

Non-farm activities

The non-farm sector is the most important source of cash income in the area (Table 4-6). Farmers often look for non-farm activities in the lay season, when there is less work on the farm. A large number of people work as craftsman in the construction and maintenance of houses, for which the demand is high, as the typical Bhutanese house demands a lot of subtle carpentry and painting work. Work in construction of roads is also common. A small number of households (5%) is fully specialised in non-farm activities, such as teachers, taxi drivers and extension officers. [8]

For the households with non-farm income, the mean annual income earned with non-farm activities is BTN73,926 (US$1,342), but the differences are large, ranging from BTN200 (US$4) for occasionally helping with painting houses, up to BTN600,000 (US$10,896) for the combination of a shop, a bar and a taxi business. The mean annual income earned in white-collar jobs (mostly civil servants and government officials) and the 'other' category (mostly taxi and truck drivers) is relatively high: US$2,888 and US$2,224, respectively.

Table 4-6 Most important non-farm activities

Activity	Examples	% of hh
Trade	Small shop, trade in vegetables	7%
White collar	Extension officer, village representative, teacher	8%
Blue collar	Construction work	18%
Crafts	Carpentry and painting	22%
Other	Truck and taxi drivers, religious services (rituals)	11%

Remittances

The relative importance of remittances in the research area (Table 4-2) is explained by the fact that many young people, especially those who have enjoyed some education, leave the area in search of non-farm jobs in the urban centres. About 41% of the interviewed household heads reported income from remittances, mostly from the Thimphu/Paro region (51%) and Bumthang (18%). For the households that receive remittances, the average amount of money received is BTN27,608 (US$501) per year. Next to that, people also receive goods from their relatives who work in other parts of the country. People try to return home at least once a year, and when they do, they generally bring goods for their family. The average estimated value of the goods brought in by relatives is BTN11,490 (US$209) per household per year.

Income diversification

As indicated above, most households farm and have one or two additional income sources – often temporary work in the non-farm sector and remittances. There is no significant relation between the number of sources of cash income and the mean cash income per capita (Table 4-7).

[8] Trade in the caterpillar fungus (*Cordyceps sinensis*) is a major source of income for farmers at a higher altitude (Gasa District), but does not exist in Punakha.

Table 4-7 Cash income diversification

Nr of cash sources	N	% of hh	Mean cash income per capita (BTN)	Mean cash income per capita (US$)
0	2	0.7	0	0
1	67	24.5	18,962	344
2	91	33.3	18,299	332
3	75	27.5	19,027	346
4	30	11.0	15,846	288
5	8	2.9	14,674	267

4.2 Housing and household property

Virtually all houses in the research area are built in traditional Bhutanese style. They are typically constructed with rammed earth and whitewashed with lime paint. Only six per cent of the houses are made of baked bricks. Houses are spacious with two or three storeys and with room for livestock and storage on the ground floor. The doors and windows are made of wood and richly decorated with animal, religious, or floral designs. The use of corrugated galvanised iron sheets for roofing is widespread (97%), and all houses, except for some temporary dwellings, are connected to the national electricity grid. Private latrines are common. Only six per cent of the households in the survey depend on surface water for drinking. All the other households have access to a water pipe.

4.3 Poverty

Two important characteristics that help to define the livelihood-status in the area are the land size per capita, determining how much food one can produce, and the cash income per capita, determining how much food and other consumer products one can buy and the productive investments one can make (e.g., purchasing fertilizers). The relation between land size and income is not straightforward. As could be expected, the poorest households have little or no land and little additional cash income, but wealthier households do not necessarily have much land. There are two types of households with a high per capita cash income: (1) those specialized in non-farm activities, such as teachers and extension officers, who have little land, and (2) farm households with large landholdings.

We defined three wealth categories, based on the ranking of land-size per capita and cash income per capita (Table 4-8). The dependency ratio is significantly smaller for the high wealth category (ANOVA, sig=0.019), which means that this group is characterized by a higher number of economically active household members compared to the other two groups.

There is no significant difference between the cash income of female-headed and male-headed households, but Table 4-9 suggests that the mean annual per capita cash income of single-headed households (generally widowed or divorced) is much lower than that of other households (ANOVA, sig.=0.095). Of the single-headed households, 85% are female-headed.

Table 4-8 Wealth categories (N=270)

	% of hh	Mean land-size per capita (acre)	Mean annual cash income per capita (BTN)	Dependency ratio*
Low	33%	0.24	3,399	1.4082
Medium	34%	0.34	11,390	1.5043
High	33%	0.62	40,002	1.1037

* No. of economically non-active hh members divided by the no. of economically active hh members.

Table 4-9 Per capita income differences and marital status

	% of hh	Dependency ratio	Mean annual cash income per capita (BTN)	Mean annual cash income per capita (US$)
Single	88	1.3	10,257	186
Married	12	1.65	19,221	349

4.4 Food security

Despite being the rice bowl of Bhutan, some households in the research have occasional problems with food security. Nineteen per cent of the research population indicated they have had years with food shortage in the past decade. According to most of these respondents this is related to labour shortage when children are still young, demanding both care and food. The lowest wealth rank is the most vulnerable (Table 4-10).

Table 4-10 Wealth rank and food security

Wealth rank	% of hh that experienced food shortage in past ten years
Low	30%
Middle	12%
High	14%

5. Loss and damage from changing monsoon patterns

5.1 Changing water availability and its impact on agriculture

Main River

As we were interested in the potential effects of glacial melt on local agricultural activities, we asked all respondents whether they noticed any changes in the flow of the main river, and, if so, how this affected agricultural production. According to 49% of the respondents the flow of the river has been changing over the last two decades, with the peaks becoming more pronounced. The effects of the mentioned changes on people's livelihoods, however, appeared minimal. The geography of the valley, with its sharp inclines on either side, implies that farmers cannot use the river for irrigation – at least not without using a pump, which very few farmers in the area have. Only one per cent of all respondents noted that they are negatively affected by changes in the main river. They claimed the river submerges the fields located on the side of the river during summer, which gradually washes away their lands.

Streams and irrigation channels

We initially set out to explore the possible effects of gradual changes in the flow of the glacial-fed river, and while doing so, we discovered that the perceived local impact of another climate variable – rainfall – was much more prominent. As part of the questionnaire we asked farmers whether their crop yields had changed over the last 20 years and if so, why. We soon noticed that many of the respondents pointed to the changes of water availability in the small (rain-fed) streams and channels as one of the main factors negatively affecting their production. This led us to modify the questionnaire by adding new questions about these streams and channels.

We found that according to 91% of all respondents the availability of water in streams and irrigation channels has changed over the last two decades. According to them, the monsoon rains are decreasing in quantity, and are increasingly unreliable and delayed. Water availability may be influenced by other factors as well, such as population growth and deforestation, but analysis of secondary data from weather stations in the area (which have been presented chapter 2) confirm that rainfall patterns have indeed been changing.

Eighty-nine per cent of the respondents who reported a change in water availability, indicated that this negatively affects their household economy. Among those who are affected (N=215) the most significant negative impact of changing water availability is on the irrigation of crops (Table 5-1). Some also express worries concerning the availability of water for tree crops (23%) and livestock (12%). According to 9% of the respondents who are affected, lower yields cause the local market prices of agricultural products to increase in years with insufficient irrigation water.

Aum Namgay, a woman from Dzomisa village, said: "Most of our income comes from the cultivation of paddy, but now, due to unsystematic rainfall and water getting scarce, our paddy is unhealthy and easily infected by pests.[9] As a result, the yield has been decreasing. We are changing to other crops like beans, potatoes and so on, but even those yields are disappointing" (interview on 01-07-2012).

Eighty-nine per cent of the respondents who reported a change in water availability, indicated that this negatively affects their household economy.

Table 5-1 Impact of changing water availability (% of impacted households - N=215)

	Crops	Tree crops	Livestock	Food prices
Moderate negative effect	57%	20%	10%	7%
Severe negative effect	40%	4%	2%	1%

[9] Pests could be symptomatic of climate change, as rising temperatures may lead to the migration and survival of species beyond their historical range or periodicity. They are another facet of climate change to which farmers will have to adapt and could be another source of loss and damage (Ken Bauer, pers. comm.)

5.2 Vulnerability

Some households are more vulnerable to gradual changes in availability of irrigation water than others. The main sources of irrigation water for the villagers are the government-constructed concrete irrigation channels, which are coming down from the mountains. Water arrangements exist to make sure that 'the last in line' get their share. For villages located further away from the main channels, the main factor determining the security of water availability therefore is the existence of water sharing arrangements. Related to this, we found that those farmers who have migrated into Punakha – usually originating from rural areas in Central Bhutan – are more vulnerable than native inhabitants of the region, as traditional water rights are seldom shared with newcomers. This usually means that they will have to pay to get a share of the water.

People's vulnerability to changes in water availability is also related to their geographical location. Generally, farmers located far from the larger government-constructed irrigation channels are more vulnerable to fluctuations in water availability, particularly when there are no water-sharing arrangement with other villages in place, or when water sharing arrangements are violated by villagers who live closer to the main channels (see section 5.4). Moreover, access to water is also related to the location vis-à-vis the smaller channels that are constructed within the villages themselves. The percentage of households that are negatively impacted by changes in water availability differs significantly between the different settlements that were part of the survey (Pearson Chi-Square, df39, sig: 0.002), which underlines the importance of geographical location.

Box 5-1 A vicious cycle – the story of Gyem

Compared to most other houses in Punakha district, Gyem Dorji's house is a poor man's hut. It is built of brown unplastered sundried bricks, located on a steep slope opposite of the Punakha *Dzong*. It consists of only one room, with an earthen floor and a roof of wooden planks. There is no furniture. Three old suitcases are piled up in one of the corners, and his young daughter is sleeping under a basket, as the room is filled with small mosquitoes.

Originally Gyem is from Thimphu. In 1981 he moved to Punakha to work for the Ministry of Agriculture. His wife started cultivating vegetables on their small plot of land, while he had a decent salary from working as an extension officer. Things took an unfortunate turn when his wife died and he had to resign from his job in order to be able to take care of their children and the fields. Since then he has been a full-time farmer, struggling to produce sufficient food to feed his children.

Gyem owns a modest piece of farmland right near his house, which he uses for non-irrigated vegetables. In addition he cultivates about one acre of someone else's paddy field in a sharecropping arrangement, from which he gets half of the annual paddy yield. In normal years this is just enough to feed his family – but in years when water is scarce it is not. He then has to look for people from whom he can borrow rice, as he does not have cash money to buy food in a store. This is seldom a good deal. Borrowing 100 kilograms of paddy grains generally means having to pay back 130 kilograms in the next year.

With declining yields over the last ten years, Gyem has built up a debt. Recently he sold a significant part of his land for a total of 100,000 Ngultrum (US$1,816). So far he received half of the amount – the rest will be paid in six months time. He used 20,000 (US$363) to buy a rice cooker and other household utensils, and with the remaining 30,000 (US$545) he paid off a part of his debt. Now he still has an outstanding loan of 2,672 kilograms of paddy grains. He hopes to settle this as soon as he gets the rest of the money.

Selling his land was the last option. It hurt, because he used the land to cultivate vegetables for their own consumption. Now they will not eat as much vegetables anymore. A rich family from Thimphu has already started the construction of a big house on the land where his vegetable garden used to be. Luckily they were willing to pay a good price, because it is close to Punakha town and has a magnificent view on the *Dzong*.

Gyem Dorji, (1955), Zomesa village, Dzomi sub-district (09-07-2012)

5.3 Measures in response to changing water availability

Of all the respondents who indicated to be affected by the changes in water availability, 88% said that they took specific action to deal with these changes. The most mentioned measures were: (i) performing religious rituals to request for rain; (ii) developing new, or modifying existing water-sharing arrangements between households and villages; (ii) maintenance of irrigation channels, to compensate for decreased availability of water; (iii) shifting from irrigated to rain-fed crops; (iv) buying irrigation water from upstream villages; and (v) purchasing or hiring a gasoline water pump (Table 5-2).

Table 5-2 Most popular measures to deal with changes in water availability (N=266*)

	N	% of the hh that indicated to take measures (N=192)
Perform Rituals	135	71%
Install water-sharing arrangements	92	48%
Maintain irrigation channels	70	37%
Shift crop mix	58	31%
Buy water	13	7%
Use water pump	9	5%

*Seven of the 273 respondents did not answer the question about changes in water availability.

Rituals

Asked about the actions taken to deal with changes in water availability, most farmers would first mention the performance of dedicated Buddhist ritual. At the level of sub-district and district administrations as well, religious rituals were regarded as one of the most important measures in response to changing water availability.

An average Buddhist household arranges a ritual once a year to pray for general prosperity, called *Lo-chhoe.* In addition to the 'general' annual ritual at the household level, there are special rituals to request for rain. Household members will go to a monastery or a village temple to make offerings. They can also do this in the altar-room of their own house.

When water is scarce and threatening the (timing of the) paddy cultivation, a community will arrange additional rituals to appease the local deities (called *Yu-lha*), especially dedicated to requesting rain. This ceremony consists of offering fumigation and libation (*sang* and *serkem)* to the deities and usually lasts for a day. Local priests perform the prayers and all members of the community are required to participate. In some cases, community members failing to attend the ceremony have to pay a fine.

In addition to the community-level rituals, sub-district authorities may arrange large-scale rituals to request for rain. Villagers can approach the head of the sub-district to express their worries about the lack of rain. The sub-district head then goes to the *Dzong* to make arrangements with the Lama's of the central monastic body to organise a collective ritual at the sub-district or district level. Such an event usually involves a large group of monks and civil servants (100+). Together they walk along the main river, passing all the villages and then back to the *Dzong*, carrying volumes of Buddhist scriptures. This ritual is known as the *Kanjur linkor*. At the start of the paddy season in 2012, this special prayer was performed for the sixth consecutive year (Source: Tenzin Tshewang, government official, Toewang).

Asked about the actions taken to deal with changes in water availability, most farmers would first mention the performance of Buddhist rituals.

Religious ritual (Kanjur linkor) to request for rain

Water-sharing arrangements

Forty-eight per cent of the respondents who indicated to take measures in response to changing water availability mentioned the introduction or altering of water-sharing arrangements. Water-sharing arrangements exist both between villages and between households within one village. When several villages depend on one source of water, they may for example agree that each village is allowed to use the water for 24 hours alternately. The arrangements between villages have a certain degree of flexibility. In years when water is scarce, village representatives may start negotiations to alter an existing arrangement. They can for example decide to change the number of consecutive irrigation hours from 24 to 48 hours per village.

Within one village, the households with traditional water rights will each be entitled to the water for a certain number of hours. The arrangements are usually based on the size of the land holding and the contributions made for ceremonies and the maintenance of irrigation canals. Arrangements within villages are decided upon at the start of the paddy-planting season. This usually happens at a village-level meeting. Here the time per household is determined, as well as the order of households, for example using *lucky draw*. During the season changes can still be made upon negotiations between the individual households.

In some villages, water-sharing arrangements have been introduced only recently in response to population growth and water scarcity. In other villages, the arrangements have been in place for ages, but are increasingly adjusted, in order to deal with the changes in water availability. An adjustment may for example mean that the arrangement is modified from 24 hours of water per village to 48 hours per village.

Maintenance of irrigation channels

Thirty-seven per cent of the respondents who indicated to take measures in response to changing water availability mentioned the maintenance of irrigation channels. This is to make sure water is used more efficiently.

Each year, each village elects a *Yu-pen.* This person gets the task to manage irrigation in the village for that year, and he or she will get an extra 24 hours water (in addition to the usual share) in return. When two or more villages share one water source, the irrigation-managers of these villages will consult each other on a regular basis. This is not only related to water sharing, but also to irrigation channel maintenance. The irrigation-managers will, for example, decide together upon the number of days each household in each village will need to contribute to the maintenance of the channel, which depends on the water availability. Maintenance of the government-constructed channels includes both major and minor repairs.

Every year, right before the paddy cultivation season, the *Yu-pen*, together with the sub-district head and representatives of all households of the community, will walk along the main irrigation channel and clean wherever needed. This includes removing sand deposits and constructing stonewalls. When larger repairs are needed, and the community has adequate allocated funds from the government, community members will carry out the works themselves, including reparations of the walls using cement. In addition to maintaining the government-constructed channels, villagers are expected to maintain the smaller irrigation channels within the village boundaries. They usually do this while working in the paddy fields.

Change of crops

In response to water scarcity, farmers are adapting their cultivation practices. If the water is not enough to irrigate paddy rice on all of the terraces, a farmer may, for example, decide to plant crops that need less water, like maize, on part of the fields.

Thirty-one per cent of the adapting households indicated to make such shifts in their crop mix, in response to the changes in water availability.[10] Aap

[10] The choice of crop may also be influenced by labour availability, as rice cultivation is more labour intensive.

Leki, farmer in Dzomisa village explained: "*The people here mostly depend on agriculture and most of the lands are used for paddy cultivation. Usually paddy is cultivated in the 4th month of the Bhutanese calendar, but due to the shortage of monsoon rain and water supply they delay it to the 6th month. Many farmers are now switching to other crop such as maize, cabbage, wheat, millet, etcetera, which consume less water*" (Aap Leki during focus group discussion in Dzomisa village, 01-07-2012).

If the water is not enough to irrigate paddy rice on all of the terraces, a farmer may decide to plant crops that need less water on a part of the fields.

Some farmers mentioned that they have shifted from two harvests of paddy per year to one harvest. In the 1990s the government introduced improved seeds in part of the research area, which allowed for harvesting twice a year. About a decade later, however, most farmers who were part of this experiment shifted back to one harvest per year. As one of the reasons for this shift they mentioned decreasing water availability. When the monsoon is delayed, the first paddy harvest is postponed, which leaves too little time for a second harvest. Farmers also mentioned the lack of labour and the fact that pests often affected the second harvest. At the same time, the demand for agricultural products from urban areas has been growing. For this reason, the cultivation of certain rain-fed crops, like potatoes, wheat, beans and radish, became more attractive, as they can easily be sold at the local market.

Buying irrigation water

When a downstream settlement is located far from one of the government-constructed irrigation channels, and does not have an agreement with an upstream village to ensure their access to water from these channels, farmers depend entirely on local rainfall for the irrigation of their paddy. Whenever there is rainfall, the small irrigation channels fill up, and the farmer will use this to irrigate the terraces one by one. Often there is not enough rain to fill all the terraces. If there is insufficient rainfall, these farmers have no option but to pay the upstream village in order to be allowed to use part of their water. The upstream village will then open its own irrigation system for an agreed number of hours, allowing the water to flow into a channel going to the downstream households. Seven per cent of the respondents reported this as important measure.

Pumping water from the Main River

The main river contains plenty of water throughout the year, but the geography of the valley complicates its use for irrigation purposes. The only way to actually draw water from the river is by using gasoline pumps, but this is not common practice. To the surprise of the Bhutanese team members, we discovered that some households have recently started pioneering with the use of water pumps. In response to increased difficulties getting enough water from the irrigation channels, they purchased a pump to carry water from the main river to the fields using long plastic hoses. The neighbours, in turn, could hire the pumps. In total, we found that 5% of all respondents in the research area are now making use of gasoline pumps, of which four households owned the pump. There is one major limitation. The pumps cannot carry the water very far up the slope and it is therefore only an option for households who have low-lying fields. We observed farmers pumping water to fields located as far as 200 meters from the river, and up to an estimated 15 meters above the water level.

Are measures sufficient?

Only 13% of the respondents who adopted measures to deal with decreasing availability of irrigation water indicated that their adaptation measures had been sufficient. This small group said that they no longer experienced negative effects from the changes in water availability, and in a few cases – those who live close to the main river and who managed to purchase a gasoline pump – the measures even improved their situation. Eighty-seven per cent of the affected farmers, however, indicated that their measures were not enough, as water supplies remain scanty. What's more, the measures come with significant extra costs, as we will describe below.

Box 5-2 From two to one paddy harvest

Ap Gala lives in Tsekha village. Most of the villagers are out in the fields, to plant rice on the terraces. They are working long days. From 6:30 am to 7:30 pm. The monsoon has started late this year, so everyone has to work extra hard to get things done before the summer ends. They are exchanging labour on each other's farms. Spread over the terraced landscape you can see clusters of men and women working together in one paddy field.

Gala is not out in the fields today, as he needs to take care of his baby. When we ask him about the availability of water he explains that he no longer produces enough rice for his own consumption. More than ten years ago he had started planting a new variety, which enabled him to harvest twice a year. In 2009, however, he was forced to shift back to one harvest, primarily because of the lack of water.

Since he discontinued the second harvest it has become more important for him to find temporary unskilled work during the winter months, for example in the construction of houses, paying US$3.50 per day. He needs the money to buy rice and other food items for his young family. "Food used to be more secure," he says. "Now we sometimes do not have enough to eat."

Ap Gala (1977), Tsekha village, Dzomi sub-district (05-07-2012)

5.4 The costs of measures

The price of rituals

Rituals are performed to please the deities both at the household and at the community level. A common annual household-level ritual may cost between US$700 and US$900, including the payment for the monks and all items for offering, such as food and drinks. For a household-level ritual that is dedicated to requesting rain, a household would pay around US$100, although rich households will generally pay more for offerings. In case of a community ritual to request for rain, each household member has to make a contribution both in kind and in cash. Usually this is about 1.5 kg of rice and between US$3 and US$6 per household member per ritual.

Water sharing and conflicts

Water sharing arrangements are associated with tensions between households and villages. This is because some farmers break existing water sharing agreements by secretively diverting an irrigation stream to their own fields during the night, even though it is not their turn yet to use the water. Essentially, such behaviour is a form of adaptation as well, be it an illegal one. Although these types of behaviour and the resulting tensions are not new, sixty per cent of the respondents who mentioned water sharing as an important measure to deal with water scarcity, indicated that conflicts are on the rise. Aum Yuden, farmer from Thamji village, stressed that the conflicts are getting ever more serious: *"There is rise of conflicts about sharing water, because some people put sand or stones to divert the stream. If it continues like this then there are chances that people will kill each other* (interview on 05-07-2012). Conflicts also occur when upstream communities use cement to improve their channels in order to increase the volume of water in their fields. This is because downstream users traditionally have the right to all seepages from the main upstream canals and any upstream effort to decrease seepages may therefore lead to tensions between downstream and upstream water users.

When a conflict occurs, the involved villages send their representatives (e.g. the village representative, or *Tshogpa,* and irrigation manager*, or Yu-pen)* to solve the problem. If that does not work, and the conflict is about to get out of hand, the village representatives will approach the sub-district head and request for conflict resolution. The sub-district officials we interviewed all noted a drastic increase in conflicts and tensions in recent years.

Conflicts do not only occur between villages, but within villages as well. Often only the original inhabitants of the village are entitled to use the water from the main irrigation channel. Water rights are 'distributed' at the time a main channel is constructed. All 'original' households will then

automatically receive a right. Migrants will only receive such an entitlement under certain conditions, for example when they contribute labour during the construction of the channel.

Several respondents stressed that conflicts are rising between relatives in particular. When the children of one of the entitled households establish their own households in the village, they will not get their own share, but will depend on the water source of their parents. Hence, households with traditional rights have to share their water with a range of related households, and during dry years this leads to tensions within extended families. This illustrates that access to water is not only a function of available water but also of population growth.

Maintenance is a time investment

The maintenance of irrigation channels takes time. When water is scarce, each household is expected to work on the (shared) main channels for a set number of days, depending on the size of their paddy fields. We asked several farmers and a *Yu-pen* from Gumkamo village (Limukha sub-district) to estimate the number of days needed for irrigation maintenance. When water is sufficient, a household with one acre of rice fields may spend one or two days for maintenance during the paddy season, while in water-scarce years the same household may have to spend up to 15 days. Those who cannot contribute physical labour need to pay BTN200 (US$3.63) per assigned working day. For comparison: the daily wage for agricultural work in Punakha district is usually between BTN250 (US$4.54) and BTN300 (US$5.45). In addition to the maintenance of the main channels, farmers need to maintain their own small channels. This too, is a lot of work, especially in dry years. These are significant time investments, considering labour is scarce during the paddy cultivation season.

Changing crops

Faced with a lack of irrigation water, a farmer may decide to cultivate a part of the lands with a non-irrigated crop such as maize instead of paddy rice.
Although the cultivation of irrigated rice is more labour-intensive compared to the cultivation of non-irrigated crops, changing from irrigated to non-irrigated crops is seldom the preferred option for farmers. This is not just related to the fact that rice is the staple food in the area; respondents also argued that the yields of non-irrigated crops as less secure. Moreover, the income per acre from rain-fed crops tends to be lower. Data on prices and production of maize and paddy rice between 2000 and 2010 in Bhutan from FAO (http://faostat3.fao.org) suggests that the gross income per acre of paddy is on average about 2.5 times higher than that of maize. Analysis of production and price data from 2010 in Punakha district showed even much larger differences between the income from maize and paddy. In 2010 the average yield of maize was 1.126 kg per acre, which equalled US$315 in market prices, while the average rice yield in that same year was 1,905 kg per acre, equalling US$2.477. Hence, income from paddy rice can be up to eight times higher compared to income from maize (based on data from Agriculture Statistics (2010) of the Ministry of Agriculture and www.agrimarket.gov.bt).

Changing from irrigated to non-irrigated crops is seldom the preferred option for farmers.

Paid access to water

As mentioned above, some farmers are paying upstream villages in dry years, in order to be allowed to access their irrigation water. To use water from an upstream village, a household pays a little more than US$7 per 24 hours. Besides being expensive, this option is unreliable, as the upstream village may decide not to share its water, whenever they are faced with water scarcity themselves. In such cases, households downstream have no water (see Box 5-4).

For people with fields at a level not much higher than the main river, it is possible to use a gasoline pump to get water from the main river. A strong-enough pump costs somewhere between US$1,000 and US$1,500, which means that purchasing such a pump is only possible for wealthy households. Several of the people who managed to purchase a pump had saved money with non-farm activities elsewhere. In addition, there are the costs of gasoline and maintenance. For those who can afford it, it is a profitable investment, as it secures the access to water, while also opening opportunities to rent the pump to neighbours at an average rate of US$5.50 per hour. For a farmer with one acre of paddy fields, the rental of a water pump may costs around US$163 per season (Table 5-3).

Table 5-3 Costs of accessing water per one acre*

		BTN	US$
Buying water (+/- 10 days per season per acre)	Price per 24 hours	400	7,26
	Price per season	4,000	72,72
Renting pump (+/- 30 hours per season per acre)	Price per hour	300	5,45
	Price per season	9,000	163,43

*Based on estimations by key informants

Box 5-3 Inter-village conflicts

"In the middle of the night all the men from my village went to the neighbouring village and destroyed the bunds bordering their rice terraces. The neighbours were smart: they didn't react. Why should they? By that time they had already stolen our water. Moreover, our village is much bigger, so they wouldn't dare to start a fight.

I guess we are used to conflicts. Especially during the summer, when everyone needs water for paddy cultivation. The tensions, however, are rising, and conflicts are getting more severe. Our village is located at the very end of the irrigation channel that carries water from the high mountains into Punakha valley. As we are last in line, our village is depending on water sharing agreements that have been developed by our forefathers with the village upstream. They agreed upon the division of water from the main channel. Our village is much bigger, so we got two thirds of the water, while they got one third. What happens in dry years is that people from the neighbouring village secretly divert extra water into their fields, more than they are entitled to. And when we find out, they will act like nothing happened.

In response to the growing number of conflicts the water sharing arrangement was modified three years ago. The people from both villages gathered in a big meeting and came to a new agreement. From then onwards, the stream would no longer be diverted into two parts, but we would take turns instead. During the paddy season, they would get 24 hours of water, after which we would get 48 hours, and so on and so forth. Unfortunately this was no success. As they are located upstream from our village, they could still tap water from the channel during our 48 hours. The number of conflicts only seemed to increase, so this year the village leaders decided to shift back to the old system. The water from the main irrigation channel is again diverted into two continuously flowing streams – ours slightly bigger than theirs. In essence it does not make a huge difference. Neither one of the arrangements seems to be able to prevent conflicts. It's like choosing between two evils."

Phub Lham (1959), Gumkamo village, Limukha sub-district (10-07-2012)

Box 5-4 The costs of water

"It must have been six years ago. That's when I hired a water pump for the first time. Although we live only 100 meters from the main river with plenty of water, we had never been able to use the river to irrigate our paddy fields because of the steep slopes. Unfortunately, we do not live close to any small stream.

There used to be an arrangement with a neighbouring village from whom we could buy irrigation water, costing me about 3,500 Ngultrums (US$63.56) per rice harvest. But, because the monsoon has been delaying and all the water streams seem to be drying up, the neighbouring village started having problems getting sufficient water for their own fields. For this reason they were no longer willing to sell us their water during dry times, leaving me in a difficult situation. No water, no paddy.

I guess we were lucky that a rich family had just moved to Samdingkha village. The husband worked for the army. He bought a water pump to irrigate his paddy fields and suggested we could make use of his pump when he was not using it. Not for nothing of course. He charges 300 Ngultrums (US$5.45) per hour, which comes down to about 9,000 (US$163.43) per rice harvest. It is much more expensive than what I used to pay for the water from the neighbouring village, but what can I do? I cannot buy a pump myself. Someone told me it costs 60,000 Ngultrums (US$1089.55) – I could never afford that.

Leaving the village to look for other work is no option, as I am divorced and live here with four small children and my sixty-year-old mother who all fully depend on me. I cannot leave them. I have no other option but to hire the pump, even though it costs me money."

Passang Lhamo (1978), Samdingkha village, Toewang sub-district (05-07-2012)

Box 5-5 From loss to gain, for some

Although he is 78 years old, *Ap Dophu* is still hale and hearty. He is covered with mud, coming straight from his paddy field. It's planting time, which means hard work, but he is in good spirits. This year is an exceptionally dry year. The monsoon rains only started in the sixth month of the Bhutanese calendar (July), while they used to start as early as the fourth month. Still, he is able to plant all of his fields on time, because he does not depend on the rain. Dophu uses the main river coming from the high Himalayan Mountains, carrying melting water from the glaciers. At this time, in summer, the river is swollen and flowing furiously through the valley. With a kerosene pump he taps water from the river, directing it to his paddy fields using long plastic hoses. Without his pump he would have a serious problem.

As a young man, Dophu joined the Royal Bodyguards, to protect the third King of Bhutan. At a later age he moved to Punakha, where he opened a shop in hardware materials and started a small transport business. When he was 68 he met his second wife and with her he moved to the small village of Samdingkha, only a few kilometres away from the village where he was born. He inherited six acres of good quality land. The problem was the decreasing availability of water – there wasn't enough to irrigate all his lands. The first years he would harvest about 1,000 kilograms annually and after three years of disappointing harvests he decided to buy a small water pump, costing him a little more than 20,000 Ngultrums (US$363.18) at that time. A significant investment, but nothing he couldn't bear. He had saved plenty of money during his time in Punakha.

As soon as the neighbouring villagers got to know about his purchase, he was overloaded with their requests to make use of his pump. The demand was so high that he even found himself operating the pump in the middle of the night. Back then he usually charged 200 Ngultrum (US$3.63), but would occasionally decrease his price, particularly for those of whom he thought could not afford it. Dophu quickly realised this was good business and within two years he had recovered the investment costs. In 2009 he bought a second pump – stronger than the previous one, enabling him to irrigate his lands faster. He kept his first pump, just for renting it to his neighbours.

These days he is able to harvest 4,700 kilograms per year. Purchasing his pump not only was a successful adaptation to water scarcity, but also a profitable investment. And his example has been followed. Three other villagers now own a pump. The rest of the villagers do not earn enough to make such an investment and either rely on the increasingly unpredictable rainfall or rent a pump from one of the owners. They lose. But, without the possibility of renting the pumps they would even be worse off. The real losers are the farmers living further away from the river, up the slopes, as no pump could get the water there.

Recently the owners in Samdingkha village have increased their price to 300 Ngultrums (US$5.45) per hour. Dophu himself, however, stopped renting out his pump. Due to high blood pressure the doctor advised him to take it a bit easy.

Ap Dophu (1934), Samdingkha village, Toewang sub-district (07-07-2012)

6. Loss and damage from the 1994 GLOF

"That morning, like every morning, I was crossing the bridge towards the Dzong, when suddenly people started shouting that I should turn around and run back to the riverbank. At first I thought they were teasing me, but then I looked to the right and saw that the river no longer looked like water – it was dark and solid. The river was completely filled with logs, which were heading into my direction. After reaching the side of the riverbank I saw the prisoners camp, located right in front of the Dzong. There must have been more than ten people there. They all got washed away" (Ap Betu, Changjokha village, 09-07-2012).

On the 7th of October 1994, the dam containing the Luggye Tsho glacial lake failed, causing a Glacial Lake Outburst Flood (GLOF) in the Punakha-Wangduphodrang valley. Right after the flood, on 20–23 October, the Department of Geology and Mines conducted a survey in the affected areas of Punakha and Wangduphodrang districts. According to this survey: 17 lives were lost; 12 houses and 5 water mills were damaged; 816 acres of crops and 965 acres of pasture land were either washed away or covered with sand and silt; 16 yaks were killed; 36 cowsheds with manure were washed away; 6 tonnes of stored food grains were lost; 4 bridges were destroyed; 2 stupas were destroyed; a part of the *Dzongchung* of the Punakha *Dzong* was destroyed; and the temple at Tsojug was badly damaged (DGM, 1994). Most of the casualties belonged to a group of prisoners who had been working on the renovation of the *Dzong* and who had been staying in a temporary camp located near the riverbank.

Although there is no evidence that the 1994 GLOF was caused by anthropogenic climate change, it is well established that global warming is increasing the risk of GLOFs in the future (see, e.g., IPCC, 2007). We explored, in retrospect, people's experiences with the 1994 GLOF, in order to understand how such extreme events may result in loss and damage at the household level. We therefore asked people about the GLOF's impact, their short-term responses to the deal with this impact, and the extent to which they experienced negative effects on the long-term.

6.1 Impact, coping and permanent loss

Impact

Of the 273 household-heads interviewed during our field research, 15% said that their household was in one way or another negatively affected by the 1994 flood.[11] Most of the affected households indicated that part of their lands were flooded. It had just been harvesting time, and paddy bunches piled up on the fields located near the river were all washed away. Two households in the sample lost livestock, and household property of three households was destroyed. The flood also destroyed several bridges in the research area, because of which people could not cross the river for several months. This implied, for example, that children could not go to school, or had to look for a boarding arrangement near the school.

> *Twelve per cent of the respondents lost (part of) their fields for good, because they were either washed away, or covered with stones and a layer of silt, making them unsuitable for further cultivation.*

The average size of lands lost to the flood per household was about 0,4 acres. Fifty per cent of the affected household indicated to have received a compensation payment from the government for the lands they lost. One of the people who lost part of her land was Aum Namgay from Samdhikha village. She explained: "*I lost about 0,75 acre of land during*

[11] Considering we took a sample of all households within 300 meters from the river, the number of households affected seems relatively small. This is because few lands are located at river level. Also, many of the lower lying lands are owned and managed by the monastic body, of which the caretakers do not necessarily live in the research area and were thus not included in the survey. Also, several respondents had no recollection of the event, either because they were too young, or did not live in the area at the time of the flood.

the flood. Government officials came to the village and told me that I would be compensated, but after few years there was no sign of getting back anything. I didn't take further action… There is only one government, while there were many in queue for being compensated… The lands that got flooded are still covered with sand and cannot be used further for cultivation. I can neither sell it nor reclaim it. So I just leave it like that" (Interview on 2-7-2012).

Coping strategies

Losing (part of) the annual paddy harvest had immediate consequences for people's short-term access to food. Of the affected households, 34% said they took action to deal with the immediate negative consequences. Aum Sangay Dema of Bajo Thangu village told us about the way her family dealt with the flood: "*The flood happened during the harvest time. Half an acre of our lands had been washed over by the river and we lost about 600 kg of paddy grains. After the flood we borrowed 300 kg of grains from our neighbour, which we had to pay back later with 30% interest. My husband started doing temporary work as a contract labourer in construction, to generate extra income. We worked together to take out small pieces of wood from the lands that had been flooded, and we started irrigating the field again, but the yields have never been as good as before* (interview on 11-07-2012).

Table 6-1 presents the most common responses as reported in the survey. Of the 14 respondents who indicated to have taken specific coping measures, 11 said these were not enough to overcome the negative effects of the event. This is mostly due to the permanent loss of good agricultural lands, which were not, or only partly compensated.

Table 6-1 Coping strategies (N=14)

Coping measure	Percentage of households
Asked food or money from other people	50%
Tried to earn extra income	57%
Migrated	29%
Sold property	7%
Reduced expenses	64%

During a focus group discussion in Samdingkha village, participants ranked the various coping strategies in order of importance. According to them, the first option would always be to look for friends and neighbours who might be willing to provide some food or other necessities. The second most important 'coping strategy', according to the participants, would be to ask the government for assistance and compensation. Reduction of the number of meals and general expenses was mentioned as the third most important strategy and the same importance was attributed to finding temporary work on others people's farms or outside of agriculture. The last resort option would be the selling of lands (Focus group discussion in Samdingkha village on 07-07-2012).

Loss and damage

People vividly recalled the 1994 flood – the sound, the size and even the colour of the river. Asked about the long-term impact of the event, they tended to emphasize that prisoners got killed and the damage that was caused to the Dzong. Respondents from Dzomisa village also resented the fact that the bridge that got washed away due to flood was rebuild at another location, much further from their village. Although 12% of the respondents reported the permanent loss of good agricultural lands, they tended to trivialize the long-term impact on their household economy. This is partly explained by the response of the government, who compensated about half of the people who had lost their lands. Although the quality and location of the compensation lands were not always comparable to the lands that were lost (see, e.g., Box 6-1), the government's response obviously mitigated the long-term negative impact.

6.2 Responses to increased GLOF risks

After the 1994 GLOF, the government took several measures to decrease the risk of future GLOFs, and to prepare people for future extreme events. One of the most outstanding decisions was to attempt to lower the water level of the Thorthormi Lake in Lunana artificially, as this lake was identified as an immediate risk – expected to cause a major GLOF, if no action was taken. In addition, a permanent monitoring system of the glacial lakes in Lunana was set up, including Early Warning Systems along the main river downstream. The government launched the Community Based Disaster Risk Management (CBDRM) program. As part of this program, villagers along the *Pho-chhu* and *Mo-chhu* rivers were encouraged to plant bamboo and tree plantations on the riverbanks and Disaster

Management Committees in all the districts (chaired by the district governors) were established, including a district-level focal person for reporting during disasters. To prepare people for possible future floods, the department launched a national GLOF awareness campaign and distributed posters with general do's and don'ts to prevent damage in the occasion of floods. Finally, maps of disaster-prone areas were created, indicating red zone areas near the major rivers, where people are discouraged to build and farm. A government official at Dzomi sub-district says about this last measure: "*The sub-district officials have made clear that people should not build in the red zone. If you do, you will not get any government support in case of floods. But people are not listening. Even after the government's warning some people still construct new houses near the river*" (Yonten Jamtsho, Administration Officer, Dzomi Gewog, 03-07-2012). In line with this, we found that people were not very preoccupied with future floods. Aum Phub Dem, who runs a general shop right next to the main river in Woolathang village, said, laughingly: "*If there is a flood, I would simply run away, and happily bear the loss. I would rather lose my shop than lose my life*" (interview on 06-07-12).

Box 6-1 Loss of land

"My family's fields, three acres in total, used to be located right near the river. I still dream about those lands and my father working on them. Ploughing the fields, planting and harvesting the paddy. I was 25 years old when we lost the lands to the flood. I remember it was almost harvest time. A few hours after the flood we found out that we had lost six months worth of food. Half of our land was completely gone – taken by the river. The part that had not been washed away no longer seemed usable for cultivation, as it was largely covered with a layer of white sand, left behind by the water. After the flood my father started working on other people's lands in sharecropping arrangements. He ended up working for three different landowners, on about 12 acres in total. It was hard work, but he managed to earn enough rice for our family.

Within one year after the flood, the government started building an embankment to protect the Dzong from future floods. For this they needed earth, so they requested my father to give away his remaining land. They told him he would be compensated for both the area lost to the flood as well as the land provided for the construction activities. After several months he still hadn't received any new fields, so eventually my father and three other people who were in the same situation went to the King's palace in Thimphu to prostrate and ask for his help. Apparently this worked. Soon afterwards we were compensated with three acres of land. Unfortunately, however, the new lands were located in Samdingkha village, very far from our house. My father had to look for people to work on the new lands in a sharecropping arrangement, while he himself started working in all kinds of small jobs, like going to the forest to gather fodder for community cattle and running the water mill of the central monastic body. He didn't earn much, but he managed to sustain our family. At the end of his life he sold the lands in Samdingkha. My father passed away in 2004.

I built my house 10 meters from where my parent's house used to be. I have no land left, except for some square meters with maize and flowers. I earn my money with painting ornaments in houses and monasteries. Every morning when I step outside I see the river flowing where once our lands were and it always reminds me of my father."

Ap Betu (1953), Changjokha village, Dzomi sub-district (09-07-2012)

7. Reflections and policy options

Water availability for agriculture

Farmers in Punakha district find it increasingly difficult to access sufficient water for irrigation. According to 91% of the respondents in our survey, the availability of water for irrigation in the paddy cultivation season has been decreasing over the last two decades. According to most respondents the changes in water availability are the result of an overall decrease in rainfall, a more erratic nature of the rains, and a delayed onset of the monsoon. This is in line with the findings of some recent studies on changing monsoon patterns, and rainfall data from the research area (1990-2010) as presented in Chapter 2. Virtually all farmers claim that these changes negatively influence their household economy, especially their crop production. Changing water availability did not necessarily imply that overall crop production declined, as the negative effects of changes in water availability seem largely outbalanced by general improvements in agricultural practices, including the use of better seeds, fertilizers and mechanized traction. Despite these improvements in productivity, farmers were worried about the negative effects of changes in water availability, and were looking for ways to deal with the changes.

Of the farmers who mentioned to be negatively affected by changing water availability in rain-fed streams, 88% take specific measures in response. Eighty-seven per cent of these respondents argued that the measures are insufficient to neutralize the negative effects (Figure 7-1). Moreover, the measures come with significant extra costs, which can be expressed in terms of money, social cohesion, time and security. Some of the most important adaptation measures and their associated costs are presented in Table 7-1.

Asking people for their adaptation strategies, they generally mentioned the performance of religious rituals first. In the realm of climate change science, the performance of religious rituals would generally not be considered an adaptation measure. Still we decided to include it in this report, as it became clear that the people in Punakha themselves perceive it as the most important measure to deal with changes. It highlights that adaptation measures are context- and culture-specific and not necessarily in line with common scientific thinking. The Bhutanese themselves see the performance of rituals as a worthwhile adaptation practice.

The measures come with extra costs, which can be expressed in terms of money, social cohesion, time and security.

Although we argue that adaptation measures often imply extra costs, the difference between 'costs' and 'investments' is not always clear-cut. This is true for rituals, which are considered investments in wellbeing. It may also be true for the purchase of a water pump, which can turn out to be a profitable investment, when the pump is rented out to other villagers. The problem: making such an investment requires sufficient financial savings, which many households do not have. With an increasing number of young people going to cities looking for non-farm labour, the flow of remittances into rural areas is increasing rapidly. We therefore expect that a growing number of households will have the possibility to purchase a pump in the near future. From this perspective it is an important advantage to have fields near the river, but at the same time these are the fields that are most at risk in the event of a GLOF.

Figure 7-1 Summary of the findings

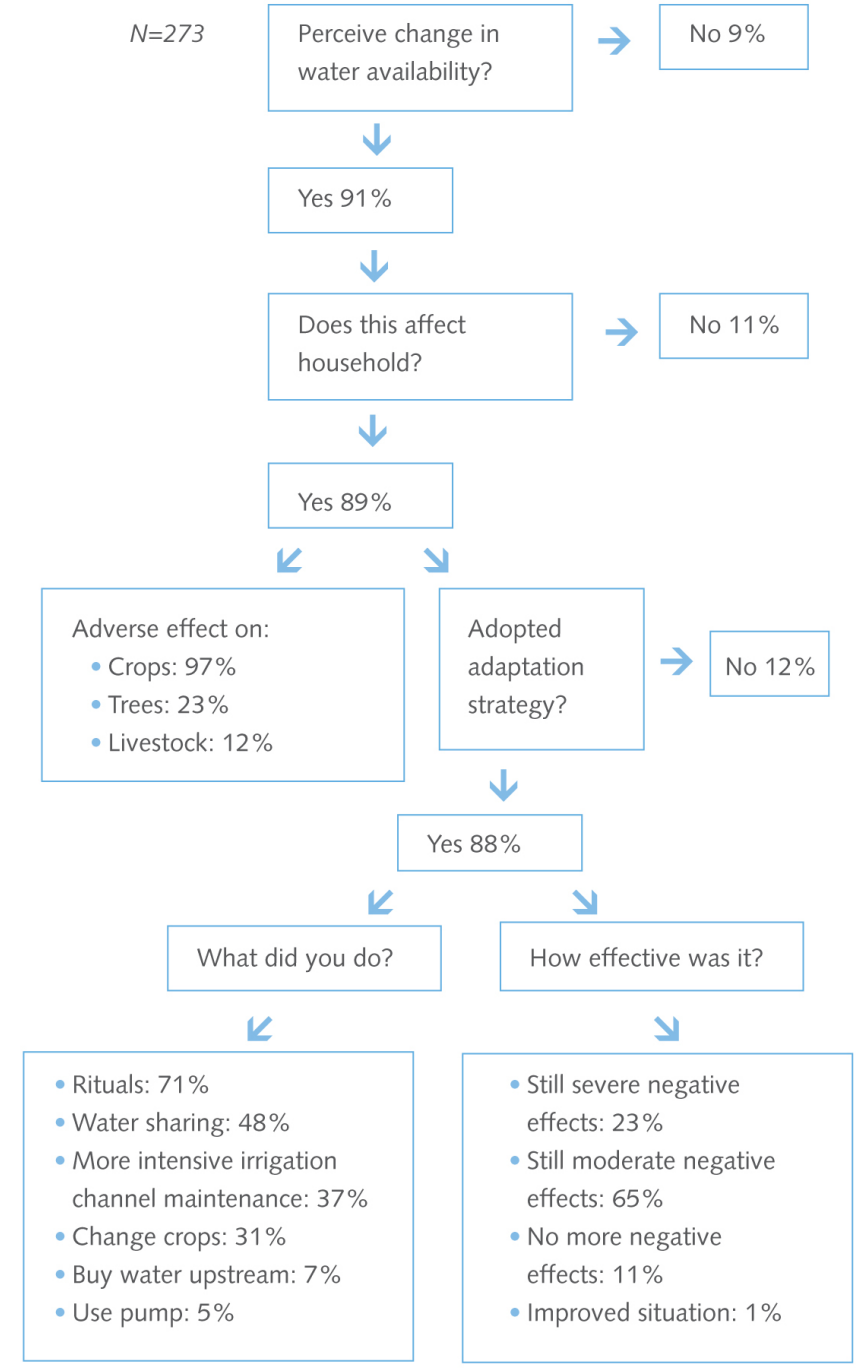


Table 7-1 The costs of adaptation

Adaptation measure	Costs
Changing from irrigated rice cultivation to the cultivation of rain-fed crops.	Rice is preferred as food crop. Moreover, the harvest of rain-fed crops is less reliable, and the income per acre can be up to eight times lower compared to paddy rice.
Using gasoline pump to extract water from the main river.	For a household with one acre of paddy fields, hiring a water pump costs around US$160 per cultivation season. Purchasing a pump costs around US$1,000.
Buying the right to access part of the irrigation water from an upstream village.	For a household with one acre of paddy fields, this costs around US$70 per cultivation season.
Water-sharing arrangements between households and villages.	Violation of arrangements leads to (violent) conflicts, negatively affecting social cohesion within and between villages.
Intensifying maintenance of irrigation channels.	In water scarce years, the amount of time a farmer has to spend on the maintenance of irrigation channels can be up to 15 times higher compared to wet years.

1994 Glacial Lake Outburst Flood

The 1994 Glacial Lake Outburst Flood directly affected 15% of the households living within 300 meters of the river. The most severe effect of the flood was the loss of a part of the annual paddy harvest, and the permanent loss of good agricultural lands. In response, affected farmers asked for food or money from neighbours and friends and reduced expenses. Many also indicated they had to look for additional income, for example through sharecropping arrangements. The government played an important role in reducing permanent loss through the compensation of lands to those households who lost part of their fields. The geography of Punakha valley, with sharply inclined slopes on both sides of the river, helps to explain the relatively small number of affected households, as only few farmers have lands or property at the river-level. The flood may have impacted many more people in the flatter areas further downstream.

The 1994 GLOF was dramatic, had a collective impact (damage to the Punakha *Dzong*) and warranted a strong and visible government response. It caused a sudden boost in the awareness of the danger of future GLOFs. While the Royal Government of Bhutan initiated a range of measures to prevent loss and damage from possible future GLOFs, farmers in 2012 seemed hardly preoccupied with future flood risks. At the household level, people were not taking measures anticipating future extreme events, and those living close to the main river seemed to take that risk consciously. Generally, people indicated to fully rely upon – and trust – the government to deal with the risk of GLOFs.

Box 7-1 Respondents' suggestions for interventions
We asked respondents and key informants what they thought the government should do to deal with gradual changes and extreme events. This yielded many suggestions to prevent loss and damage from future GLOFs. The most often heard were: (i) building protection walls along the river side; (ii) planting trees and bamboo on river banks; (iii) developing mechanisms to warn people whenever a flood is coming; (iv) resettlement of people who live close to the river; (v) building higher and stronger bridges, which could withstand another flood; and (vi) more education on GLOF risks. Most respondents, however, acknowledged that the government is already taking these measures. One man said: *"The government already did many things, like a flood warning system, red zones, training people, and planting bamboo and trees. So now I think there is nothing more we should expect from the government."*
Regarding government interventions to deal with the more gradual changes in water availability, the suggestions were: (i) planting of trees upstream; (ii) building water tanks; (iii) repairing irrigation channels; (iv) providing budget, cement and machinery to communities so they can build irrigation channels; (v) providing communities with strong gasoline pumps, to get water from the main river; and vi) explore the possibility of installing bore/tube wells.

Policy options
There is a difference between the ways in which the government and individual farmers respond to gradual and abrupt changes. While the Bhutanese government has been active to prevent future GLOFs and to minimize loss and damage of such events, farmers' attitude towards future GLOF risks appeared rather phlegmatic. Farmers seem more concerned with the gradual changes, as they are dealing with issues of water availability on a day-to-day basis.

For the government, the impact of gradual changes in water availability is less visible and less dramatic compared to the impact of a flood, which makes it an easily overlooked area for interventions. We therefore underline the importance of efforts to secure access to water by small-scale farmers, in addition to agricultural extension services aimed at adopting new technologies and better seeds. There is a need for research on, and development of collective and private water-services, like water-storages (so water available for irrigation can be spread more evenly over the paddy season) and water pumps (enabling people to use the water from the glacial-fed river to irrigate their fields). Not only the technical possibilities should be explored, but also the opportunities and constraints from a socio-economic point of view. Possibilities to improve farmers' access to water services could involve private investors as well as farmers' associations and cooperatives.

For the government, the impact of gradual changes in water availability is less visible and less dramatic compared to the impact of a flood, which makes it an easily overlooked area for interventions.

In addition to efforts aimed at improving water availability for irrigation, farmers' resilience may be improved through agricultural diversification, i.e., including crops in the crop-mix that can grow under erratic rainfall and extreme water conditions, such as certain perennials and fruit trees. Although the shift from irrigated to non-irrigated crops is generally not the preferred option, the trend towards the cultivation of non-irrigated crops to complement paddy rice is likely to continue, due to a combination of unreliable access to water, a growing demand for certain cash crops in urban areas, and decreasing labour availability in rural areas. This trend demands specific attention from agricultural extension services to identify and promote economically feasible diversification options. Based on existing experience and expertise, local institutions (like extension centres, forest/park range offices, education centres and water user associations) could be strengthened strategically, to provide the farmers with adequate technical and marketing support.

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Appendix 1: Questionnaire

1. Questionnaire number:
2. Date of interview: _ _ / _ _ / _ _
3. Name of village or town:
4. Name of interviewer:
5. Date of data entry: _ _ / _ _ / _ _
6. Name of data entry officer:

Section 1: Respondent, household, livelihood and vulnerability

1.1 Respondent and household information

7. Name:
8. Birth year [YYYY] [write age (YY) if easier]:
9. Sex: 1=Male | 2=Female
10. Relation to household head: 1=Household head | 2=Spouse | 3=Other, specify _____
11. Marital status: 1=Single | 2=Monogamous marriage | 3=Polygamous marriage | 4='Consensual union' | 5=Widowed | 6=Separated/divorced | 7=Other, specify _____
12. Number of children: Sons _____ Daughters _____
13. Place of birth: 1=This village or town | 2=Elsewhere in Punakha district | 3=Elsewhere in the country, specify district _____ | 4=Abroad, specify country _____
14. Education level:
15. Ethnicity/mother tongue:
16. Religion: 1=Christian | 2=Muslim | 3=Buddhist | 4=Hindu | 5=Other, specify _____
17. Occupation [NOTE: OF THE HEAD OF THE HOUSEHOLD] (multiple options): 1=Farming | 2=Livestock raising | 3=Fishing | 4=Trading | 5=Salary work ('white collar'), specify _____ | 6=Other non-farm income, specify _____ | 7=Farm labour | 8=Other labour, specify _____ | 9=Housework | 10=Student | 11=Unemployed | 12=Other, specify _____
18. Household size:
19. Household composition: Adult men (aged 18-65) ___ | Adult women (aged 18-65) ___ | Boys (<18) ___ | Girls (<18) ___ | Elderly men (>65) ___ | Elderly women (>65) ___
20. How many members of your household are involved in activities that provide food or income? __

1.2 Land and farm

21. Do you (or does your household) 'own' land? 1=Yes | 2=No
    a. If yes, for what do you use your land (multiple options)? 1=Housing | 2=Crop cultivation | 3=Livestock raising | 4=Renting out | 5=Fallowing | 6=Nothing | 7=Other, specify _____
    b. If yes, please estimate the total land size? Number _____ Unit _____
22. Do you farm? 1=Yes | 2=No (if no, go to next section)
23. What is the land size you cultivated last year? Number _____ Unit _____
24. Do you own the land you farm? 1=Yes, all | 2=No, none | 3=Partly
    a. If 2 or 3, how do you get access to this land (multiple options)? 1=Renting | 2=Sharecropping | 3=Borrow | 4=Community land | 5=Other, specify _____
25. Is some of the land you farm irrigated? 1=Yes | 2=No
    a. If yes, how much? Number _____ Unit _____
26. Which crops did you cultivate last year? [in order of importance] (1) _____ (2) _____ (3) _____ (4) _____ (5) _____ (6) _____
27. Do you use animal traction or a tractor to cultivate your land? 1=Yes | 2=No
    a. If yes, do you own, hire or borrow these implements (multiple options)? 1=Own | 2=Hire | 3=Borrow | 4=Other, specify _____
28. Do you employ people to work on your land? 1=Yes | 2=No
    a. If yes, how many people per year? For how many days per year? _____
29. What is the main purpose of your crop production (choose one)? 1=Household consumption | 2=Sale | 3=Other, specify _____

30. How much of your crop production do you usually sell? 1=Everything | 2=More than half | 3=Approximately half | 4=Less than half | 5=Hardly anything | 6=Nothing
31. How much income did your household derive from crop sales in the last 12 months? _____
32. In the last 10 years, did your crop production 1=Decrease a lot | 2=Decrease a little | 3=Remain the same | 4=Increase a little | 5=Increase a lot
    a. If decreased or increased, please indicate the cause(s):

1.3. Livestock, fishing and economic trees

33. Do you or other household members own livestock? Please indicate the number of (1) Cows/buffalos ___ | (2) Donkeys ___ | (3) Goats and sheep ___ | (4) Pigs ___ | (5) Fowls ___ (5) Others, specify ___
    a. If yes, what is the main purpose of your livestock (choose one)? 1=Household consumption | 2=Sale | 3=Traction | 4=Other, specify _____
    b. Please estimate the income you derived from livestock raising in the last 12 months? _____
34. Do you or any other household members engage in fishing or fish raising? 1=Yes | 2=No
    a. If yes, please specify: 1=Fishing | 2=Fish raising | 3=Both
    b. What is the main purpose of your fishing / fish raising (choose one)? 1=Household consumption | 2=Sale | 3=Other, specify _____
    c. Please estimate the income you derived from fishing / fish raising in the last 12 months? _____
35. Does your household own economic trees (fruit, timber, etc)? 1=Yes | 2=No
    a. If yes, what is the main purpose of your economic trees (choose one)? 1=Household consumption | 2=Sale | 3=Other, specify _____
    b. Please indicate the number of economic trees: (1) <10 | (2) 10-50 | (3) 50-100 | (4) >100
    c. Please estimate the income you derived from your economic trees in the last 12 months? ____

1.4 Other income generating activities

36. Do you or any household members derive income from non-farm activities? 1=Yes | 2=No
    a. If yes, how many household members engage in such activities? _____
    b. In which activities do they engage (multiple options)? 1=Petty trading | 2=Larger business | 3='White collar' salary work, specify _____ | 4='Blue collar' salary work, specify_____ | 5=Crafts, specify _____6=Processing natural resources, specify_____ 7=Other non-farm income, specify _____
    c. Please estimate the total income derived from non-farm activities in last 12 months? _____
37. Does your household receive remittances from migrant relatives or friends? 1=Yes | 2=No
    a. If yes, from whom [relation to HH-H] (multiple options)? 1=Daughter | 2=Son | 3=Brother | 4=Sister | 5=Parents | 6=Other, specify _____
    b. Where do they live (multiple options)? 1=Within Punakha district | 2=Other district, specify _____ | 3=Abroad, specify _____
    c. Please estimate the total amount of money you received in the last 12 months _____
    d. And the value of other things (food, goods) you received in the last 12 months _____
38. Do you or household members sometimes labour on other people's farms? 1=Yes | 2=No
    a. If yes, how many household members? _____
    b. Please estimate: the total number of 'person days' in the last 12 months _____
    c. Please estimate the total annual income derived in the last 12 months _____
39. Do you have any other sources of income besides the ones you mentioned? 1=Yes | 2=No

a. If yes, please specify source _____
b. Please specify the total annual income derived in the last 12 months ____
40. Please estimate the total income of your household per year _____
41. Compared to other households in your village/town, would you say that your monthly income is (1) Less than most others | (2) Average | (3) More than most others

1.5 Housing and other assets

42. Do you 'own' the house you live in? 1=Yes | 2=No
43. Do you own any other houses? 1=Yes, specify how many _____ 2=No
44. Please indicate the building materials of the house you live in:
    a. Roof (multiple options): 1=Roofing tiles | 2=Iron sheets | 3=Concrete | 4=Natural materials, e.g. thatch or earth | 5=Other, specify_____
    b. Walls (multiple options): 1=Cement blocks/concrete| 2=Baked bricks | 3=Sun-dried bricks | 4=Wood | 5= Iron sheets | 6=Other natural materials, specify_____ 6=Other, specify ___
    c. Floor (multiple options): 1=Cement | 2=Earth | 3=Wood | 4=Other, specify _____
45. How many bedrooms does the house you live in have? _____
46. Compared to the other houses in your village/town, would you say that the house you live in is (1) Of better quality | (2) Average or | (3) Worse quality?
47. Does your house have electricity? 1=Yes | 2=No
48. What is the source of your drinking water (multiple options)? 1=Surface water | 2=Well | 3=Borehole/Pump | 4=Pipe | 5=Other, specify _____
49. Does your house have a private latrine or WC? 1=Yes | 2=No
50. Please indicate whether your household owns the following assets [and how many]: (a) TV __ (b) (Mobile) phone __ (c) Bicycle __ (d) Motorbike __ (e) Car __ (f) Fridge __ (g) Computer __

1.6 Food security

51. How many meals a day do adults in your household eat on a 'regular day'? _____
52. How many meals a day do children in your household eat on a 'regular day'? _____
53. In last year (2011), have there been months that you had to eat less? 1=Yes | 2=No
    a. If yes, in which months did this happen (multiple options)? 1=Jan | 2=Feb | 3=Mar | 4=Apr | 5=May | 6=Jun | 7= Jul | 8=Aug | 9=Sep | 10=Oct | 11=Nov | 12=Dec
    b. What was/were the cause(s) of this food shortage?
54. In the past ten years, has your household experienced any food shortages? 1=Yes | 2=No
    a. If yes, in how many out of ten years?
    b. What was/were usually the cause(s) of such shortages?
55. How much of the food your household consumes is bought (i.e. not produced by household itself)? 1=Everything | 2=More than half | 3=Approximately half | 4=Less than half | 5=Hardly anything | 6=Nothing

Section 2. Gradual changes [GLACIAL-FED RIVER AS WELL AS RAIN-FED STREAMS]
56. In the past twenty years, how many years have you lived in this [district, area or province]? ____

2.1 Open questions
57. What changes have you experienced in river/stream flows in your village/town over the last twenty years?
58. How do changes/fluctuations in river/stream flows affect your crop production? [NOTE: if no clear trend over the last decade(s) please focus on fluctuations BETWEEN various years]
59. Do these changes/fluctuations have any other negative effects on your household? Please explain.
60. Has your household done anything to deal with the changes/fluctuations in river/stream flows? 1=Yes | 2=No (if no, skip next two questions)

IF MEASURES ARE TAKEN:
61. What did you do?
62. Are you still experiencing negative consequences, despite the measures? Please explain:

AFTER THE RESPONDENT HAS ANWSERED, TICK ONE OF FOLLOWING OPTIONS
1=No | 2=Yes, measures are not enough |3=Yes, measures have costs/negative effects | 4=Yes, other reason, specify _____

IF NO MEASURES TAKEN:
63. Why did your household not take any measures? Please explain:

BASED ON THE ANSWER, PLEASE TICK ON OF THE FOLLOWING OPTIONS
1=Don't know what to do | 2=Lack of financial resources (to do what?) | 3=Lack of skills/knowledge (to do what?) | 4=Lack of other resources (to do what?) | 5=It's not a priority/not very important to us | 6=Not my task/responsibility | 7=Other, specify: _____
64. Does the fact that you have not taken any measures has negative effects (loss, damage, costs) on your household? 1=yes | 2=no. Please explain

2.2 Closed questions: Gradual changes
65. Have you experienced changes in river/stream flows over the past twenty years? 1=Yes, a lot | 2=Yes, but only a little | 3=About the same
66. If 1 or 2, does this adversely affect (the economic situation of) your household? 1=Yes, a lot | 2=Yes, but only a little | 3=No, it doesn't affect us at all
67. If yes, how does it affect your household?
    a. Negative effect on crops: 1=None | 2=Moderate | 3=Severe | 4=Not applicable (NA)
       If 2 or 3, explain: _____
    b. Negative effect on livestock: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____
    c. Negative effect on fishing: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____
    d. Negative effect on tree crops: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____
    e. Negative effect on trade/business: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____
    f. Effect on food prices: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____
    g. Damage to house/properties: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____
    h. Other negative effects, specify _____1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____

Questions about what households do/did to adapt to changing/fluctuating flows:
68. Did you modify agricultural production/fishing to deal with fluctuating flows? 1=No | 2=Yes, shift to other crops/livestock/fish, specify_____ | 3=Shift from rain-fed to irrigated agriculture | 4=Modify production techniques/inputs, specify _____ 5=Other, specify_____

69. Did you engage (more) in non-farm activities to deal with fluctuating flows? 1=No | 2=Yes, switch to new economic activities, specify _____ | 3=More household members engaged in economic activities | 4=Expand existing non-farm activities | 5=Other, specify _____
70. Did you or household members migrate (more) to deal with fluctuating flows? 1=No | 2=Yes, I migrated | 3=Yes, other household member(s) migrated | 4=Yes, whole household migrated
    a. If yes, for what periods? 1=Short-term (<6 months) | 2=Longer-term (>6 months)
    b. If yes, where to? 1=In Punakha | 2=Other district, specify _____ | 3=Abroad, specify ____
    c. Was migration destination rural or urban? 1=Rural | 2=Urban
71. Did you do anything else to deal with fluctuating flows? 1=No | 2=Yes, specify _____
72. (Only ask if measures were taken): Are these things you did to deal with fluctuating river/stream flows enough to avoid negative effects on the living standard and well-being of your household? 1=No, still severe negative effects | 2=No, still moderate negative effects | 3=Yes, it allows us to carry on | 4=Yes, it has even improved our situation

Section 3. Impact of and coping with weather-related extreme events

3.1 Open Questions

73. Do you remember the 1994 GLOF? If yes, please reconstruct what happened:
74. How did the GLOF affect your agricultural fields and household properties (including cattle)?
75. Did GLOF have any other negative effects on your household? Please explain:
76. Did your household do anything to deal with the impact of the GLOF? 1=Yes | 2=No (if no, skip next two questions)

IF MEASURES ARE TAKEN:

77. What did you do? [NOTE FOR ENUMERATORS: Focus on the measures taken in the days/weeks/months immediately AFTER the flood. In case the respondent took action right BEFORE the flood to prevent impact (e.g. the family left the house and took their belongings) you can write this down here, but this is not considered a 'measure' in the following questions.
78. Are you still experiencing negative consequences, despite the measures? Please explain
    BASED ON THE ANSWER, PLEASE TICK ON OF THE FOLLOWING OPTIONS

1=No | 2=Yes, measures are not enough |3=Yes, measures have costs/negative effects |

IF NO MEASURES TAKEN:

79. Why did your household not take any measures? Please explain

BASED ON THE ANSWER, PLEASE TICK ON OF THE FOLLOWING OPTIONS

1=Don't know what to do | 2=Lack of financial resources (to do what?) | 3=Lack of skills/knowledge (to do what?) | 4=Lack of other resources (to do what?) | 5=It's not a priority/not very important to us | 6=Not my task/responsibility | 7=Other, specify: _____

80. Does the fact that you have not taken any measures has negative effects (loss, damage, costs) on your household? 1=yes | 2=no Please explain

3.2 Closed questions: extreme events (impact and coping)

81. Has your household been affected by the 1994 [GLOF]?
    1=No | 2=Yes, but not severely | 3=Yes, severely
82. If yes, how does it affect your household (multiple options)?
    a. Negative effect on crops: 1=No | 2=Moderate | 3=Severe | 4=Not applicable (NA)
       If 2 or 3, explain/estimate costs: _____
    b. Negative effect on livestock: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain/estimate costs: _____
    c. Negative effect on fishing: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain/estimate costs: _____
    d. Negative effect on tree crops: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain/estimate costs: _____
    e. Negative effect on trade/business: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain/estimate costs: _____
    f. Effect on food prices: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain/estimate costs: _____

g. Damage to house/properties: 1=None | 2=Moderate | 3=Severe | 4=NA
   If 2 or 3, explain/estimate costs: _____
h. Other negative effects, specify _____1=None | 2=Moderate | 3=Severe | 4=NA
   If 2 or 3, explain/estimate costs: _____

Questions about what people did to cope with (impacts of) the 1994 GLOF:

83. Did you ask for food or money from other people to deal with the GLOF? 1=No | 2=Yes, from a relative | 3=Neighbour | 4=Friend | 5=Other, specify _____
84. Did you receive support from an organization to deal with the GLOF?
    1=No
    2=Yes, government agency, specify _____
    3=NGO, specify_____
    4=Religious organization, specify _____
    5=Other, specify_____
85. Did you or household members try to earn extra income to deal with the GLOF? 1=No | 2=Yes, intensified existing activities, specify_____ | 3=Engaged in new activities, specify_____
86. Did you or household members migrate (more) to deal with the GLOF? 1=No | 2=Yes, I migrated | 3=Yes, other household member(s) migrated | 4=Yes, whole household migrated
    a. If yes, for what periods? 1=Short-term (<6 months) | 2=Longer-term (>6 months)
    b. If yes, where to? 1=In Punakha | 2=Other district, specify _____ | 3=Abroad, specify ____
    c. Was migration destination rural or urban? 1=Rural | 2=Urban
87. Did you sell properties to deal with the GLOF? 1=No | 2=Yes, land | 3=Livestock | 4=House | 5=Productive assets, specify _____ 6=Means of transport, specify _____ | 7=Luxury items, specify _____ 8| Other, specify _____
88. Did you try to spend less money to deal with the GLOF? 1=No | 2=Yes, spent less on food items | 2=On school fees | 3=On healthcare | 4=On productive investments, specify_____ | 5=On house maintenance | 6=Other, specify_____
89. Did you modify food consumption to deal with the GLOF? 1=No | 2=Yes, bought less expensive foods | 3=Limit portion sizes | 4=Reduce number of meals per day |5=Adults ate less so children could eat | 6=Less people eating at home | 7=Other, specify_____
90. Did you do anything else to deal with the GLOF? 1=No | 2=Yes, specify _____
91. If measures were taken, were these things you did to deal with the GLOF enough to avoid negative effects on the living standard and well-being of your household? 1=No, still severe negative effects | 2=No, still moderate negative effects | 3=Yes, it allows us to carry on | 4=Yes, it has even improved our situation
    a. Please explain:

Section 4. Vulnerability, gender and policy

92. Do you feel that your household is more or less likely to suffer from the impacts of glacier melt (changing river flows and GLOFs) than other households in your community? 1=More | 2=Average | 3=Less
    a. Why?
93. Do you think that the impacts of glacier melt (changing river flows and GLOFs) affect men and women differently? Please explain.
94. Do you think men and women play different roles in dealing with these threats? Please explain.

What do you think the government or other organizations could do to reduce the impacts of these threats?

APPENDIX 2: LIST OF KEY INFORMANTS

	Name	Age & Sex	Function/ Designation	Village	Gewog	District
1	Namgay	54 F	Farmer	Jangsabu	Dzomi	Punakha
2	Om	75 F	Farmer	Mendhagang	Dzomi	Punakha
3	Namgay	80 F	Farmer	Gubji	Dzomi	Punakha
4	Rinchen Penjor	32 M	District Environment Officer			Punakha
5	Tandin Tshewang	40 M	Offtg. DAO			Punakha
6	Tshering Norbu	30 M	Focal Officer for Disaster Management			Punakha
7	Dorji	61 M	Machey Zimpon			Punakha
8	Penjor	52 M	Asst . Census Officer			Punakha
9	Dorji Wangda	48 M	Clerk			Punakha
10	Sangay Om	35 F	Farmer	Khawakha	Dzomi	Punakha
11	Namgay Tshering	60 M	Farmer	Jobakha	Dzomi	Punakha
12	Phuntsho namgay	62 M	Head of sub-district		Dzomi	Punakha
13	Yonten Jamtsho	27 M	ADM Officer, Dzomi Gewog			Punakha
14	Bidha	66 F	Farmer	Jara	Dzomi	Punakha
15	Phurba	66 M	Farmer	Jara	Dzomi	Punakha
16	Gala*	35 M	Farmer	Tsekha	Dzomi	
17	Tauchu	51 M	Head of sub-district	Samdingkha	Toewang	Punakha
18	Euden	30 F	Farmer	Dawakha	Toewang	Punakha
19	Namgay Om	42 F	Farmer	Samdingkha	Toewang	Punakha
20	Pasang Lham*	34 F	Farmer	Samdingkha	Toewang	Punakha
21	Zati	57 M	Farmer	Kewana	Toewang	Punakha
22	Namgay	75 F	Farmer	Samdingkha	Toewang	Punakha
23	Dophu*	78 M	Farmer	Samdingkha	Toewang	Punakha
24	Nim Tshering	49 M	Farmer	Changjokha	Dzomi	Punakha
25	Dakpa	51 M	Farmer	Dzomeysa	Dzomi	Punakha
26	Betu*	59 m	Farmer	Changjokha	Dzomi	Punakha
27	Gem Dorji*	57 M	Farmer	Dzomeysa	Dzomi	Punakha
28	Phub Lham	53 F	Farmer	Gumkamo	Lingmukha	Punakha
29	Tsencho	45 M	Farmer	Bajothangu	Thedtsho	Wangduephodrang
30	Sacha Om	50 F	Farmer	Bajothangu	Thedtsho	Wangduephodrang
31	Sangay Dema	50 F	Farmer	Bajothangu	Thedtsho	Wangduephodrang

*Follow-up interviews with survey respondents

APPENDIX 3: LIST OF FOCUS GROUP DISCUSSIONS

Group 1	Name	Age/Sex	Village
1	Thinley	68 M	Dzomeysa
2	Leki Dorji	59 M	Dzomeysa
3	Namgay	67 F	Dzomeysa
Group 2			
1	Namgay	64 F	Thamji
2	Phub Dem	32 F	Thamji
3	Lhaden	41 F	Thamji
4	Dema	44 F	Tshachuphu
Group 3			
1	Tauchu	37 M	Samdingkha
2	Dophu	78 M	Samdingkha
3	Singye Norbu	39 M	Samdingkha
4	Thuje Dem	67 M	Samdingkha
5	Yankey Pem	60 M	Samdingkha
Group 4			
1	Phuntsho Namgay	62 M	Tsekha
2	Chenga Om	49 F	Tsekha
3	Kezang Dem	39 F	Tsekha
4	Sonam Tshering	25 M	Tsekha
5	Ratu Dendup	24 F	Tsekha
6	Kinley	23 M	Tsekha
7	Haap Tshering	19 M	Tsekha
8	Kinley Dorji	19 M	Tsekha

The Loss and Damage in Vulnerable Countries Initiative

Accepting the reality of unmitigated climate change, the UNFCCC negotiations have raised the profile of the issue of loss & damage to adverse climate impacts. At COP-16, Parties created a Work Programme on Loss and Damage under the Subsidiary Body on Implementation (SBI). The goal of this work programme is to increase awareness among delegates, assess the exposure of countries to loss and damage, explore a range of activities that may be appropriate to address loss and damage in vulnerable countries, and identify ways that the UNFCCC process might play in helping countries avoid and reduce loss and damage associated with climate change. COP-18, in December 2012, will mark the next milestone in furthering the international response to this issue.

The “Loss and Damage in Vulnerable Countries Initiative” supports the Government of Bangladesh and the Least Developed Countries to call for action of the international community.

The Initiative is supplied by a consortium of organisations including:

Germanwatch

Munich Climate Insurance Initiative

United Nations University – Institute for Human and Environment Security

International Centre for Climate Change and Development

Kindly supported by the Climate Development and Knowledge Network (CDKN)

For further information: **www.loss-and-damage.net**

Germanwatch

Following the motto "Observing, Analysing, Acting", Germanwatch has been actively promoting North-South equity and the preservation of livelihoods since 1991. In doing so, we focus on the politics and economics of the North with their worldwide consequences. The situation of marginalised people in the South is the starting point of our work. Together with our members and supporters as well as with other actors in civil society we intend to represent a strong lobby for sustainable development. We endeavour to approach our aims by advocating fair trade relations, responsible financial markets, compliance with human rights, and the prevention of dangerous climate change.

Germanwatch is funded by membership fees, donations, grants from the "Stiftung Zukunftsfähigkeit" (Foundation for Sustainability), and by grants from a number of other public and private donors.

You can also help to achieve the goals of Germanwatch and become a member or support our work with your donation:

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