SAGARMATHA

Snow and Glacier aspects of Water Resources Management in the Himalayas

Final Technical Report: Volume 3

An assessment of the potential impacts of climate change induced deglaciation on communities and their livelihoods in the Hindu Kush Himalaya

by

Caroline A. Sullivan[1], Shiba Prasad Rijal[2], Mandira Shrestha[3], Narendra Raj Khanal[2] and Dermot P. O'Regan[1]

[1.] Centre for Ecology and Hydrology, Wallingford, UK

[2.] Tribhuvan University, Kathmandu, Nepal

[3.] International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal

June 2004

SAGARMATHA

Snow and Glacier aspects of Water Resources Management in the Himalayas

DFID KAR Project No. R7980

Final Technical Report: Volume 3

An assessment of the potential impacts of climate change induced deglaciation on communities and their livelihoods in the Hindu Kush Himalaya

by

Caroline A. Sullivan[1], Shiba Prasad Rijal[2], Mandira Shrestha[3], Narendra Raj Khanal[2] and Dermot P. O'Regan[1]

[1.] Centre for Ecology and Hydrology, Wallingford, UK
[2.] Tribhuvan University, Kathmandu, Nepal
[3.] International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal

June 2004

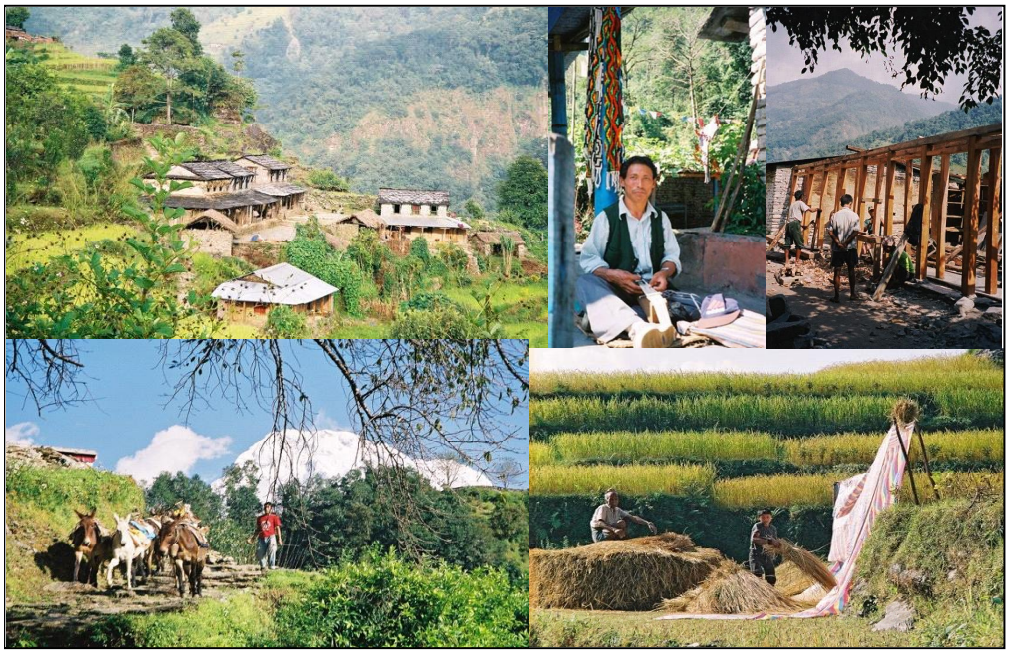
Centre for Ecology and Hydrology
Crowmarsh Gifford
Wallingford
Oxfordshire, OX10 8BB

Tel: +44 (0)1491 838800
Fax: +44 (0)1491 692424

SAGARMATHA

Snow and Glacier Aspects of Water Resources Management in the Himalayas

Livelihoods Report



Contents

	Page
1. Executive Summary	1
2. Background	2
3. Project Purpose	5
4. Research Activities	6
5. Research Findings	21
6. Conclusions	52
7. References	56

Appendices

Appendix 1: Survey Methodology & Instruments

A1.1 Water and Livelihoods in Mountain Areas: Conceptual Framework
A1.2 Household Survey Questionnaire
A1.3 Participatory Rural Appraisal (PRA) Procedure
A1.4 Check list for group discussion/PRA and recording schedule for water use survey
A1.5 Table of group participants by survey settlement
A1.6 Photographs: Community Survey/Water Use Inventory

Appendix 2: GIS Mapping

A2.1 Background to GIS Approach: Application of Geographic Information Systems to Water Resources and Livelihoods in the Himalayas

A2.2 Modi Khola Scale Mapping
A2.2.1 Modi Khola: Study Area
A2.2.2 Modi Khola: Study Zones and Study Settlements
A2.2.3 Modi Khola: Water Use: Irrigated Agriculture & Micro-Hydro Generation
A2.2.4 Modi Khola: Water Use: Domestic and Drinking Supply
A2.2.5 Modi Khola: Services and Markets

A2.3 Modi-Kaligandaki Corridor Scale Mapping
A2.3.1 Modi-Kaligandaki: rivers, major hydraulic schemes, cultivated land and major towns
A2.3.2 Modi-Kaligandaki: close-up of area around major hydropower scheme with distribution of settlements and cultivated land

A2.4 Nepal Scale Mapping
A2.4.1 Nepal: Existing & Planned Hydropower Development
A2.4.2 Nepal: Number of Watermills Running by Snow Fed Rivers (Traditional & Improved)
A2.4.3 Nepal: Irrigated and Irrigable Land from Snow Fed Rivers
A2.4.4 Nepal: Rafting Rivers and Number of Tourists

Appendix 3: Stakeholder Consultation Workshops

A3.1 Community Workshops, Kusma & Ghandruk, Nepal, March 2004
A3.1.1 Participant List
A3.1.2 Participant Feedback Sheet: Adaptation Strategies
A3.1.3 Photographs
A3.1.4 Background Document 1 (Mountain Livelihoods and Climate Change leaflet)

A3.1.5 Background Document 2 (project objectives, methodology and major findings of the survey - (Nepali)
A3.2 Corridor Workshop, Pokhara, Nepal
(Snow and Glacier Aspects of Water Resources Management in the Himalayas (SAGARMATHA): Kaligandaki Stakeholder Consultation Workshop, Pokhara, Nepal, April 21, 2004)
A3.2.1 Agenda (English & Nepali)
A3.2.2 Participant List
A3.2.3 Minutes
A3.2.4 Photographs
A3.2.5 Background Document (English & Nepali)
A3.2.6 Participant/Breakout Group Feedback Sheet: Adaptation Strategies (English & Nepali)
A3.2.7 Participant/Breakout Group Feedback: Draft policy briefing note (also used at Delhi workshop) (English & Nepali)

A3.3 International Workshop, New Delhi, India
(Deglaciation: Impacts and Adaptations for Water Resources and Livelihoods in the Himalayas: Stakeholder Consultation Workshop, India International Centre, New Delhi, India, April 27-28, 2004)
A3.3.1 Agenda
A3.3.2 Participant List
A3.3.3 Minutes
A3.3.4 Photographs
A3.3.5 Breakout group guidelines
A3.3.6 Participant/Breakout Group Feedback Sheet: Sectoral Impacts and Adaptation Strategies
A3.3.7 Participant/Breakout Group Feedback: Draft policy briefing note (same as Appendix 3.2.7)
A3.3.8 Results from Corridor Workshop (presented to Delhi participants after breakout discussions)

Appendix 4: Dissemination Outputs

A4.1 Project Leaflet: 'Mountain Livelihoods and Climate Change'
A4.2 Posters (presented and distributed at India and Nepal Workshops 2004)
A4.2.1 'Climate Change, Water Resources and Livelihoods in the Himalaya: case studies from across the region'
A4.2.2 'Climate Change and Water Resources in Nepal'
A4.2.3 'Mountain Livelihoods and Climate Change: a case study from Nepal'
A4.3 Press Coverage: Nepal Workshop
A4.4 Press Coverage: India Workshop
A4.5 Policy Briefing Note 1
A4.6 Policy Briefing Note 2
A4.7 Conference Presentation: '*Mountain livelihoods and climate change: A case study from central Nepal'* (presented at The University of Bergen Workshop: 'Fragile Mountains – Fragile People? Understanding "fragility" in the Himalayas'), Bergen, Norway, November 2003.

Acknowledgements

This publication is an output from a research project funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID.

The authors are grateful to the whole SAGARMATHA project team and the many people who assisted during the course of the project. We are especially thankful to the hundreds of participants who contributed to the community surveys conducted in Nepal and to those who attended the stakeholder workshops in Nepal and India. We would also like to acknowledge the contributions of Dr Binayak Bhadra, Prof Chandra Bahadur Shrestha, Mr Kamal Man Gurung, Mr Adarsha Prasad Pokhrel, Mr Bodh Raj Adhikari, Dr Kishore Shakya, Prof R. K. Saxena, Dr S. K. Das, Prof Syed I. Hasnain, Dr L. S. Rathore and Prof V. Subraminium

1. Executive Summary

Scientific evidence suggests that climate change is likely to impact on water resources, and the severity of this impact will vary with both spatial and temporal scales. Millions of very poor people throughout the world may be affected by future changes in water resource availability, and also by more extreme events in the medium and longer term. This component of the SAGARMATHA project has served to identify livelihood opportunities in mountain communities in the Hindu Kush Himalaya, and through a process of participatory consultation has investigated how scenarios of climate-induced deglaciation may impact on mountain communities and livelihoods. This report provides Volume 3 of the SAGARMATHA Final Technical Report, and full details of all aspects of the project as a whole can be found in the other volumes 1,2 and 4.

Local communities in mountain systems are often heavily dependent on open access resources and, as a result, often have a comprehensive ecological knowledge of how resources can change. In the case study carried out in Nepal for this project, it is clear that people are already aware of climate/weather-induced changes, and their inputs into future decision-making on resource use would be valuable. On the basis of the hydrological modelling carried out in the project, it is evident that communities living at higher altitudes will be more vulnerable to the impacts of climate change than those living lower down the catchments but, ranging from east to west across the region, there are significant differences in how these effects will be felt.

Linking information from different scales is clearly a challenging task. How small communities in isolated valleys in the mountains may be affected in the future is difficult to discern from large scale hydrological and climatic models. The potential variation in both impact and response to climate-induced deglaciation across the region cannot be overstressed, but nevertheless, this work has not only provided some insight into potential impacts, but has also has served as a consultative platform through which these issues have been discussed with key stakeholders, at the local, national and regional scales.

Suggestions which have been generated through this consultation process include more awareness raising, better monitoring of key indicators in high altitude zones, more community involvement in both monitoring and policy development, and the need for more emphasis on mechanisms to support and promote adaptation strategies. The major DFID goal associated with this project is W1 – *Improved assessment, development and management of water resources*. This project has contributed to this goal by developing a more integrated modelling approach by which more accurate and spatially distributed assessments can be made of water resources in snow-fed catchments. This will facilitate better future management of those resources, by raising awareness about the key issues, and by enabling stakeholders and communities to discuss possible future options for such management.

Three full size posters have been distributed to project beneficiaries in Nepal, India, Bhutan and Bangladesh. Workshop proceedings have been compiled, and sent to participants following the national and regional workshops. In addition, as a mechanism to provide maximum opportunity to deliver research findings in a succinct way to policy makers and other stakeholders, two ‘policy briefing notes’ have been generated for widespread distribution.

2. Background

Some 500 million inhabitants live in the Indus, Ganges, Mekong and Brahmaputra river basins and, in many areas, they rely heavily on a perennial supply of melt-water from the Himalayas. As population has continued to rise rapidly in these areas, water demand has risen dramatically, particularly from agriculture and industry, giving rise to problems of water stress in the region. As a result, any reduction in the availability of freshwater could have serious impacts on the day to day lives of many millions of people, not only within the effected basins, but in the wider economies of South Asia. Concern has been raised about the rate of glacial retreat in the Himalayas (IPCC, 1998; WGMS, 1998), and, given the fact that over half of human populations worldwide rely on freshwater which first accumulates in mountains (Mountain Agenda, 1998), this has now become a global concern (Down To Earth, 1999; Worldwatch News Brief, 2000; Frontline, 2001; Sharma, 2001). It has even been suggested that *"glaciers in the region will vanish within 40 years as a result of global warming"* and that the flow of Himalayan rivers will *"eventually diminish, resulting in widespread water shortages" (New Scientist, 1999; BBC, 1999).*

As a result of this concern, scientists and water managers with an interest in the region highlighted the need for more integration between hydrological modellers, glaciologists and climate scientists. It is hoped that this collaboration has enabled better understanding of potential climate impacts across the Hindu Kush Himalaya region, and possible impacts on its huge dependent human populations.

The Himalayas extend 3,500 kilometres from Myanmar in the east to Afghanistan in the west, and contain several of the world's highest peaks. Altitude varies dramatically from some 50m in the plains (Terai) to the south to over 8000m in the high mountains, only 150kms away. It has been estimated that between 10-20% of the total surface area of the Himalayas is covered by glaciers or permanent snow, with an additional 40% affected by seasonal snow cover. This represents a huge freshwater reservoir for the river systems that emerge from the mountains, and a complex system of micro-climates exist across the region, determined by variations in slope, aspect and relative altitude (Alford, 1992). The mountain ranges block the northward advancement of the moist monsoons, causing widespread and intense rainfall on southern slopes, whereas on the lee of the mountain ridges drier conditions prevail. As the winds move from east to west, rains come later and precipitation decreases. The variation in topography results in numerous local irregularities to this general trend of orographic precipitation and, often, extreme differences can be observed even between adjacent catchments.

Some of the highest annual rainfall totals on Earth are experienced on the southern slopes of the Eastern Himalayas, while other areas receive only 50mm a year. In Nepal, average annual rainfall ranges from 250mm to 4500mm (average 1600mm), with about 85% coming from the summer monsoon and 15% from winter rains. Evapotranspiration increases steadily from a minimum in December to a maximum in May. As a general rule, evaporation losses decrease with altitude, as available thermal energy decreases (Alford, 1992). Mean daily air temperatures generally decline during the post-monsoon period (October to January).

This significant climatic and topographic variation ensures that all rivers in the Himalayas are characterised by great variations in seasonal flow. Runoff is concentrated in the summer months, as the monsoon coincides with the optimal period for the melting of snow and glacial ice. Flow recession in rivers starts in

October/November and continues until the following spring. Rivers of catchments containing snow or ice generally recover from low flows earlier than rain-fed catchments, as melting recommences due to the temperature increases of early spring. This perennial occurrence of snow and ice-melt, ahead of the summer monsoon, is vital for the successful cultivation of crops, for the hydropower industry and for most other water resources projects (Sharma, 1993). It is felt that the disappearance of the region's glaciers would affect the timing and quantity of the melt contribution during this critical period and would, thus, threaten food production, industrial productivity and the economy of the region in general.

Changes in the timing and volume of the water available for irrigation will threaten agricultural productivity (IPCC, 2001). Some of the largest irrigation networks in the world are supported by Himalayan waters (Messerli and Ives, 1997), and changes in water availability in these major Asian rivers will impact heavily upon the economy of the region (Matthews et al., 1995), and on the food security of millions of people who are already described as undernourished (FAO, 1999; UNICEF 1999). While it may be possible to adapt to changing conditions using novel farming methods and more intensive land conversion, this could lead to problems of water pollution, soil erosion and degradation, and subsequent knock-on impacts on the ecology and bio-diversity of the region (IPCC, 2001).

Poverty is a major constraint to development in the region, affecting as it does well over half of the regional population (DFID, 2000). Rapid population growth continues to put a strain on resources, and a reduction in water supply from the mountains could further affect economic activity by limiting energy from hydropower plants and hampering industrial productivity. In India, power shortages are already at about 10% of total electrical energy and 20% of peak capacity requirements (World Bank, 2000), and in other countries of the region power cuts are a common event. Any possibility that the energy potential from hydropower may not be achieved (due to climate change) would have serious implications for the development plans of the whole region.

Furthermore, industries that require a reliable supply of water, both as an input to the manufacturing process and as a medium for the dilution of effluent, (e.g. food processing, mining, paper, chemical and steel production) would also be effected. At a time when the Government of India is actively promoting poverty reduction strategies, and the use of renewable energy sources as a clean and sustainable way of meeting the nation's growing energy requirements (MNES, 2001), this is a particularly worrying scenario.

While climate-induced deglaciation may hinder economic development nationally, the impacts are likely to be hardest felt at the local level by the most vulnerable in society, particularly the women and children of poor families. Already these are the members of society who bear the greatest burden of domestic water provision, and reduction in water resources will make their lives more difficult and more vulnerable to negative health impacts such as cholera, giardia and salmonella. Since some 25-40% of the urban population in developing countries already live with little or no access to water and sanitation (Word Bank, 1997; IPCC, 2001), any further increase would impose considerable stress on urban infrastructure, yet reductions in rural resources and livelihood opportunities may create rural out-migration, increasing pressure on systems already under stress. Numerous social, economic and cultural implications for both the rural and urban areas are well known (Pebley, 1998).

Much literature is available on the social and economic impacts of climate change in the region. Bartarya (1997) has highlighted the effect of diminishing water resources on village life, while Conway et al. (2000) have considered environmental pressures on the livelihoods of people at the frontier regions of Nepal. ICIMOD (2000) has examined poverty and social exclusion in the South Asian Highlands, and the specific impacts of climate change on crop production in Asia have been identified (Iglesias et al., 1996). The challenges of sustainable development in the Himalayas have been widely discussed (Ives and Messerli, 1989; Ramakrishnan et al., 1994), and the implications of climate change for human health have been identified (McMichael et al., 1996). From these studies it is clear that some efforts should be made to consider possible adaptation to the impacts of climate change in the region (Sharma, 2001) and, indeed, some work has been done to address this. Appropriate adaptation strategies will vary both between and within countries, according to the bio-physical characteristics of different regions (IPCC, 2001). Specific adaptation options for Bangladesh have been considered (Ali, 1999) but, in general, such strategies will involve improving the planning and management of water resources to ensure more efficient and sustainable use. Such strategies would necessarily be determined in consultation with local communities and should include measures that are applicable at local, regional and national level (IPCC, 2001). It is hoped that the outputs of the SAGARMATHA project will contribute to this process, by identifying stakeholder-driven adaptation strategies based on consultations at the local, national and regional levels.

3. Project Purpose

The overall purpose of the SAGARMATHA project is "*to assess the seasonal and long term water resources in snow and glacier fed rivers originating in the Himalayan region, and to determine strategies for coping with impacts of climate change induced deglaciation on the livelihood of people in the region*". It is hoped that this work will enable a better understanding of how water resources may be influenced by climate-induced deglaciation and, subsequently, how this may impact on people. The overall aim of this is to identify mitigation and adaptation measures which may be appropriate for communities in the Hindu Kush Himalaya.

This report is concerned with the activities and outputs associated with that part of the project that addresses the impact of climate-induced deglaciation on water resources and livelihoods in the Himalayan region. While the hydrological component of the project provides a regional model for the whole Hindu Kush Himalaya region, and on the water resources of the Indus, Ganges and Brahmaputra river basins, the livelihood impact study has been restricted to selected communities within Nepal. This is due to the limited resources available for the project, and the fact that within Nepal there is great diversity of both ecozone type and of livelihood strategies, both of which can serve as a proxy for communities across the region[1]. In addition, it was felt that the security situation within Nepal was likely to be most favourable for this type of research[2].

One of the main objectives of the livelihood component of the project was to investigate how downstream communities would be influenced by deglaciation, and what possible adaptation strategies could be developed in response to these impacts. The findings from this research are based on detailed household surveys in 12 communities across the range of ecozones in the study catchment, and on extensive stakeholder consultation at local, national and international levels. These findings have been analysed and disseminated to a wide selection of local stakeholders in Nepal, as well as to a range of international researchers and practitioners from the region. On the basis of inputs from a number of stakeholder consultation workshops carried out at different scales, 2 policy briefing notes have been produced to deliver the research results to policy makers and other relevant groups who represent the beneficiaries of this work. These can be seen in Appendix 4.5 and Appendix 4.6.

[1] It is important to stress that while this socio-economic and hydrological variation provides some insight into how different communities may be impacted by potential changes in water resources, the results of this specific study cannot be generalised to all types of communities and conditions across the whole HKH region. These results can only provide a preliminary assessment of how some types of communities may be impacted by the effects of deglaciation.

[2] Unfortunately, the security situation in Nepal deteriorated during the life of the project, coinciding as it did with the mass murder of the ruling royal family, and the rise of Maoist insurgency in rural areas (a State of Emergency was declared in Nepal on 23 November 2001). While this did impact on some of the research and consultation activities, it was possible to safely complete the work by taking care with the timing and location of surveys, workshops etc.

4. Research Activities

The research activities carried out in this project are summarised below. These included:

- Community assessment in the Modi Khola catchment;
- Development of a spatial database and GIS mapping of the catchment;
- Upscaling: Modi/Kaligandaki river corridor study;
- Inventory of water use in Nepalese rivers;
- Stakeholder consultation and workshops

All of these activities were carried out as a collaborative effort between the research team. Local level consultation was carried out by Shiva Rijal, assigned as the case study researcher for this part of the project. In spite of Maoist insurgency and other political turmoil in the country, all the work was carried out more or less on schedule, and the consultation exercise, with various key stakeholders at different scales, was completed successfully. More details on all the actual activities conducted during the research are found in the background documents provided with this Final Technical Report.

4.1 Community Assessment, Modi Khola

In order to establish a base line of understanding about how people live in mountainous catchments, household surveys were carried out in sample households in 12 communities. These communities were selected on the basis of their geographical location within the catchment, and provided a longitudinal section from the high mountain zone right down to the lower areas. Variations in aspect were also taken into account in the selection of the study villages. The distribution of these settlements within the catchment is shown in Figure 1, with the study zones and location of the area within Nepal.

Figure 1. *Study Settlements and Study Zones in the Modi Khola*

In addition to the household surveys, information was sought through group discussions with key informants, and these were further cross-checked by a number of informal discussions carried out with different individuals or groups during the fieldwork period. These activities provided community level information about resources, livelihood assets (natural, physical, human, social and financial capitals) distributional issues and current utilization patterns, and qualitative information about people's perceptions of climate change and its relation to local livelihoods. For this purpose, groups consisting of 5-10 persons representing different occupational groups were brought together, including elected persons, social workers and farmers were formed for group discussion. A photograph from one of these sessions is shown in Figure 2. Participants were mostly senior persons from the community. A total of 12 groups were organized for discussion, one per selected settlement.

Figure 2. *Group discussion in Landruk, Modi Khola*

Discussions were facilitated in Nepali by a Nepalese project team member, and responses were recorded by an assistant. During discussions, participants also made maps on the ground (with sticks, pebbles etc.) showing areas of snow cover, and changes in the area and density of forest and pasturelands. These maps were checked and compared with topographical maps of the area. Consensus and majority views were recorded. A checklist (see Appendix 1.4) was used to promote discussion. Details of group composition by community are given in Table 1. Results from the community surveys and group discussions are provided in Section 5.1.

Table 1. *Composition of community discussion groups*

Settlements	No. of participants	Group composition
Chhomrong	9	Ward chairman and chairperson of mother's group, businessman, farmers and electricity users committee members (Chairman and Secretary)
Melache	5	Teachers, and farmers (1 female)
Ghandruk	7	Ward chairman, female representatives (Chairperson and member of mother's group), teacher, and farmers
Landruk	9	Ward chairman, teacher, businessman, and farmers
Syaulibazar	5	Teacher, farmers and businessman
Moharia	6	Ward chairman and farmers
Rele/Halzure	6	Farmers (1 female)
Halhale	10	Social worker, VDC secretary, and farmers
Bajung	5	Vice chairman of VDC, teacher, farmers
Jhorbang	5	Teachers, social workers and farmer
Chuwa	5	VDC chairman, and farmers
Katuwa Chapari	7	Social worker, teacher, farmers

Source: Rijal 2002.

4.1.1 Development of a spatial database and use of GIS mapping

In addition to the qualitative, participatory mapping approach described above, a spatial database was developed with the use of Geographic Information Systems (GIS) technology and methods. A spatial database for the Modi Khola catchment was developed by digitizing existing hard-copy maps and from the georeferencing of primary data from the community survey and an inventory of water use in the area.

Existing topographical and political maps (at scales 1:25,000 and 1:50,000) were digitized and data extracted relating to elevation, major rivers, land use and land cover, administrative boundaries, roads, services and settlements.

An inventory of different water uses was made for the whole catchment through observation by team members and in consultation with local people and spatially referenced with the aid of GPS (Global Positioning System) receivers. The water uses recorded include water mills, irrigation canals, power plants, woodcarving workshops, sources of piped water supply and religious and culturally important places. The inventory included the taking of a number of photographs of related locations, infrastructure and people. Figure 3 shows the Modi Khola catchment and some features including the location of domestic water sources, micro-hydro generation sites and the study settlements. Figure 4 shows a local water mill and its operator.

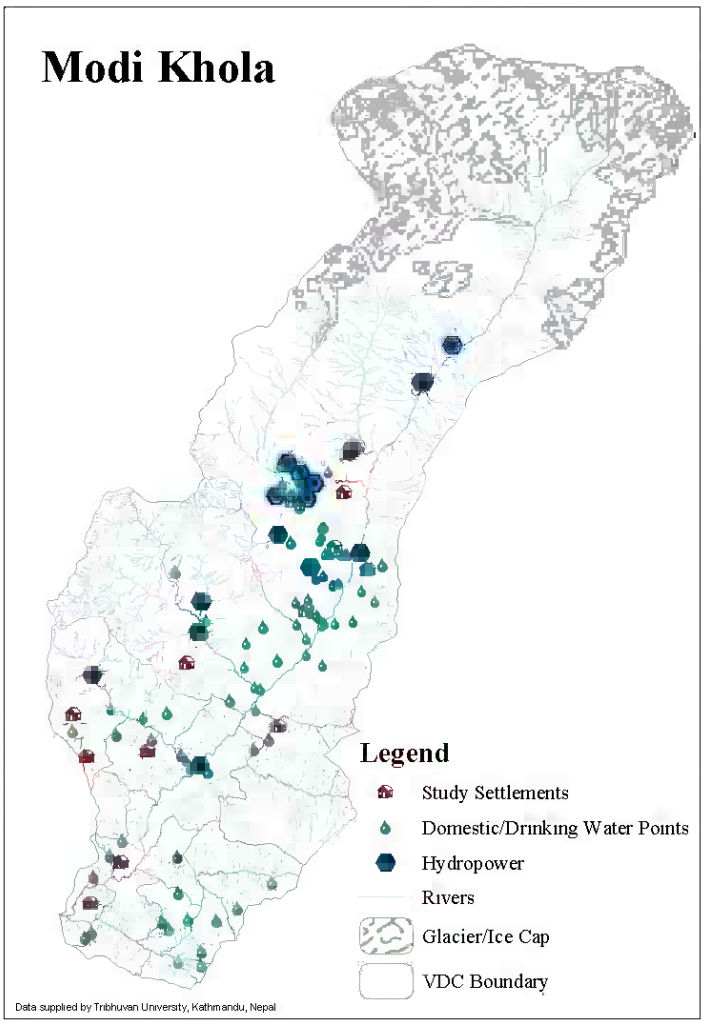


Figure 3. *Water use in the Modi Khola*

Figure 4. *Water use in the Modi Khola: local water mill and operator*

The creation of this integrated digital database provides a useful set of baseline information from which future work in the area can draw. The database itself is currently held in the University of Tribhuvan, Katmandu. See Appendix 2 for a background to the GIS approach, and additional examples of mapping from the spatial database.

4.2 The Modi/Kaligandaki river corridor study

To investigate the potential impacts of deglaciation at a wider scale, a study of the whole *Modi/Kaligandaki* river corridor was initiated during this study. This was designed to examine which large scale riparian activities may be impacted by climate change, and the extent to which such activities could be influenced by possible changes in river flows. On the basis of model outputs, a hypothetical scenario of 50% deglaciation for Himalayan glaciers indicates that runoff in snow and ice-fed rivers is likely to be affected for a distance of up to about 100km downstream from the glaciers. In higher precipitation areas, these impacts are likely to be less significant than in areas where precipitation is lower. Modeling also indicates that this trend is consistent for any level of deglaciation, and there is a clear difference between eastern and western areas of the region in terms of the degree of impacts likely to be felt. This is mostly due to the fact that in the western part of the Hindu Kush Himalaya, precipitation is much lower than in the east, particularly in the upper Indus region. In addition to this east-west variation, there is also considerable variation in potential climate induced impacts as a result of altitude and aspect in different locations.

As a way of linking to the studies carried out at the community level, a 'basin scale' assessment was made using data collected along the whole length of the river, from the headwater areas of the Modi Khola, to its confluence with the Kaligandaki, and along the Kaligandaki river down to the Nepal-India border. The study area was divided into four sections from upstream to downstream:

i) The Modi river from Ghandruk to Kusma,

ii) The Kaligandaki river from Kusma to Rampur,

iii) The Kaligandaki river from Rampur to Devghat, and

iv) The Gandaki river from Devghat to the Nepal-India border.

The hypothesis tested by this survey was determined on the basis of hydrological modelling, which suggested that as the distance increases from the glacial source of the Modi Khola, changes in the hydrological regime as a result of deglaciation becomes less significant.

Along the river corridors of the Modi/Kaligandaki rivers there are nine districts namely Kaski, Parbat, Baglung, Gulmi, Syangja, Palpa, Tanahun, Nawarparasi and Chitawan, and the specific area studied within these districts is shown in Figure 5. These areas contain a total population of 617,368 persons, and these people live in communities located on either side of the river (Table 2). In Nepal, the smallest administrative unit is the Village Development Committee (VDC), and water from the Modi and Kaligandaki rivers are used directly or indirectly by the people in more than 116 VDCs, as well as some of those living outside those areas.

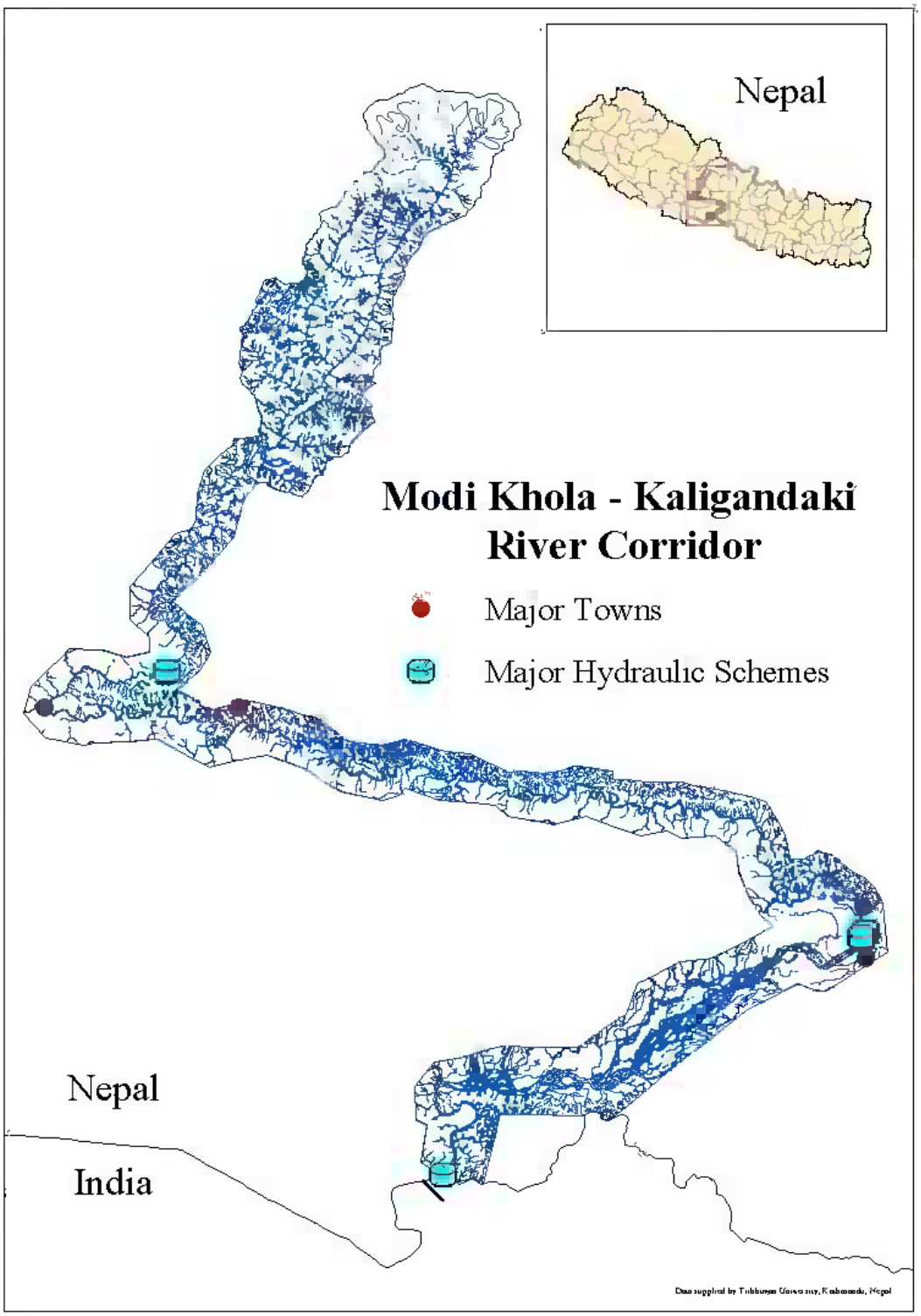


Figure 5. *The Modi/Kaligandaki river corridor*

Table 2. *Number of adjoining Village Development Committees and population by district*

Name of district	Number of VDCs	Population (2001)*	Remarks
Kaski	4	17,853	Headwaters
Parbat	22	63,745	Upper/middle
Baglung	7	27,485	Middle
Gulmi	9	31,026	Middle
Syangja	15	81,340	Middle
Palpa	17	77,524	Middle/lower
Tanahun	8	48,556	Lower
Nawalparasi	28	204,381	Lower/lowest in Nepal
Chitwan	6	65,458	Lowest in Nepal
Total	**116**	**617,368**	

Source: CBS, Population census, 2001

To collect information on water use patterns along the Modi and Kaligandaki rivers, group discussions and key informant interviews were carried out on any installation or community within 2.5km either side of the river. To examine livelihood impacts, these discussions were focused on energy (the supply of hydro-electricity and operation of water mills), production (irrigation, industrial use, fishing etc.) and household consumption of river water (drinking, washing and livestock feeding), as well as other religious and recreational activities. Results of this investigation are shown in Section 5.2 and some pictures of water use impacts are shown in Figures 6 and 7.

Figure 6. *The intake of the Modi Khola Hydroelectric Project, March 04*

Figure 7. *The Modi Khola downstream of the hydropower intake, March 04. This highlights the problem of downstream low flows observed after the plant construction.*

4.3 Inventory of water use in the rivers of Nepal

In addition to the detailed water use inventory carried out in the study catchment of Modi Khola, a water use inventory of all other rivers of Nepal was prepared through the collection and rigorous review of published secondary statistical data and information from several national and international organizations in Nepal. The inventory of water use in the rivers of Nepal includes information on irrigation, hydropower, industrial use, household water supply, fishing, and water transportation. The major sources of information were the Water and Energy Commission Secretariat, Department of Irrigation, Nepal Electricity Authority, Center for Rural Technology and the Nepal Association of Rafting Agents. The full report *Inventory of Water Use in the Rivers of Nepal* is included as one of the background documents attached to the SAGARMATHA Final Technical Report.

Many of the datasets collected have been spatially referenced and integrated for display and analysis using GIS software. Figure 8 shows the status of hydropower development across the country and highlights snow-fed river locations.

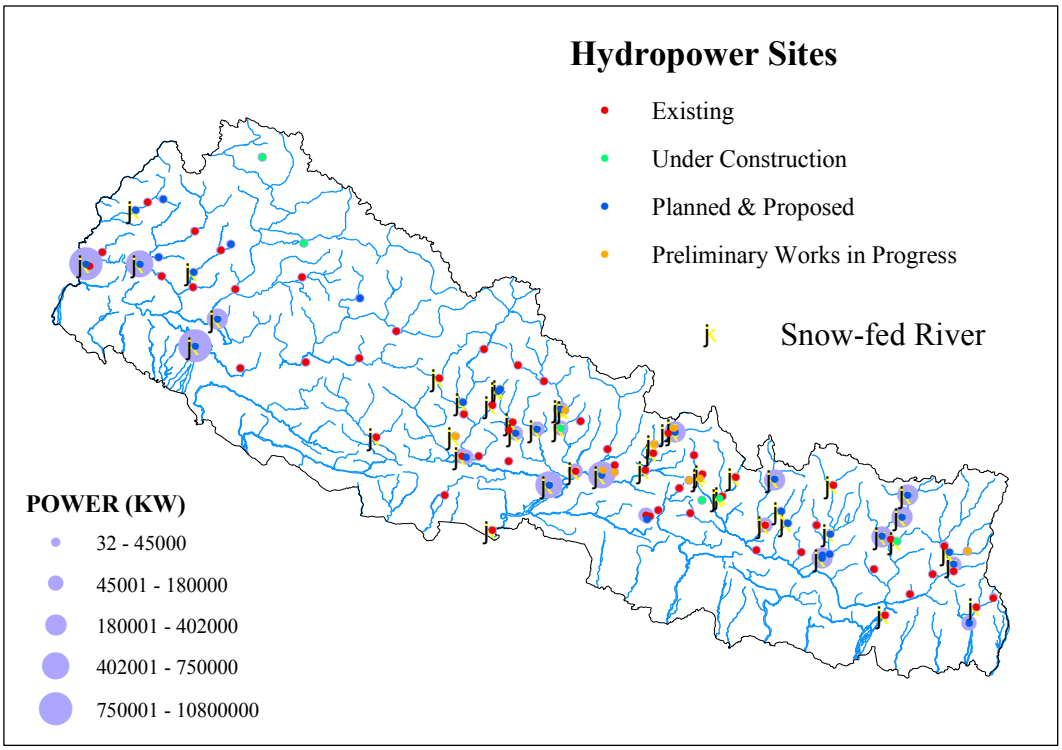


Figure 8. *Hydropower development across Nepal*

See Appendix 2 for background and additional examples of mapping from the water use inventory.

4.4 Stakeholder consultation and workshops

One of the most effective ways to evaluate conditions and behaviour in any location is through the process of participatory appraisal and consultation (Pretty et al., 1995). During the course of the SAGARMATHA project this was seen to be an important part of the research process, and consultation with communities and stakeholders took place at local, national and regional levels. To produce effective outputs from this research, the information generated from this multi-sectoral consultation has been combined with other findings from the project and used as the basis for the development of a policy briefing note. This is shown in section 5.4.6 and it is hoped that this will be seen as a useful way of delivering the project findings to target institutions and project beneficiaries. Posters consolidating these findings and a comprehensive CD of workshop proceedings have also been distributed to key stakeholders.

4.4.1 Objectives of stakeholder consultation

Any changes in water availability in the river resulting from deglaciation will have direct and indirect impacts on people's livelihoods. Floods, landslides, bank cutting and changes in river course as well as destruction of water delivery infrastructures are possible hazards of the increase river flows, whereas decreases in river flows will cause major water shortages, and infrastructure failure, influencing industry, hydropower, irrigation, drinking water projects, and water transportation.

The major objective of stakeholder consultations carried out as part of this project was to gather information, ideas and knowledge from local people, experts, water scientists, and other concerned authorities about how water resource impacts may be felt by different sectors of the economy and different social groups. This was then used to provide the basis for the development of adaptation strategies to cope with the impacts of climate-induced deglaciation. These consultation activities were carried out during the second part of the project period, and key local, regional and international workshops were held over a period of four months at the beginning of 2004. In these workshops, information from the project was disseminated (including model results where relevant) and structured consultation was carried out (see Appendix 3 for the consultation documents used in the various workshops).

4.4.2 Modi Khola workshops: consultation at the local scale

Two stakeholder meetings were organized in the Modi Khola catchment, one at Kusma and another at Ghandruk, representing downstream and upstream sub-regions respectively. People from all the villages selected for the household survey were invited to participate in these meetings. There was participation by representatives of all villages except Halhale, Mohoria and Landruk. Participants represented many different groups, including farmers, social workers, technicians, businessmen and representatives of hotel keeping and tourism activities. Official representatives from district irrigation, drinking water, electricity authority, and alternative energy development also participated in the meeting. Participant lists for these meetings are provided in Appendix 3.1.1. A leaflet was prepared prior to these meetings and distributed to all participants along with a background document in Nepali. A community workshop feedback sheet was also used to collect potential responses of the groups regarding adaptation strategies. Documents used in the meetings are provided in Appendix 3.1.

The local consultation meetings were divided into two sessions. In the first session, a brief account of the project, its objectives etc. were provided. In the second session, the major findings of the socio-economic survey carried out in the Modi Khola were presented, with requests for comments. Participants were encouraged to express their views, feelings and their experiences on different aspects of climate change and possible impacts on livelihoods. The views and experiences shared by participants were listed and recorded.

During the second session, detailed discussions on adaptation strategies took place. A round-table discussion was organized to facilitate interaction and group deliberation on possible adaptation strategies and a community workshop feedback sheet was used. Each participant had a chance to express his or her views and at the end of the meetings preliminary conclusions were drawn. Participants in local stakeholder workshops in the Modi Khola are shown in Figures 9 and 10.

Figure 9. *Local Stakeholder Workshop in Parbat, March, 2004*

Figure 10. *Participants of the Local Stakeholder Workshop in Kusma, March 2004*

4.4.3 The Kaligandaki corridor workshop – consultation at the basin scale

This one-day workshop took place on April 21st 2004 in Pokhara, Nepal. The objective of this workshop was twofold. Firstly, it was to provide feedback to relevant stakeholders about the work and findings of the project and secondly, it was used for the purpose of consultation on potential adaptation strategies. Outputs from these discussions were also used to generate the content of a policy briefing note for later delivery to relevant policy makers and others.

Participants from all relevant groups in the region attended the workshop. These included government officials from a number of relevant offices, academics from the local science community, water resource managers, hydro-power engineers, NGOs, farmers, tourism officials and local political representatives. A total of 38 local stakeholders attended including 5 women. Presentations were given in both Nepali and English, with translations provided by members of the project team. Participants at the meeting are shown in Figures 11 and 12 and materials used in the workshop are shown in Appendix 3.2.

Figure 11. *Pokhara workshop delegates*

Figure 12. *Groups in discussion at the Pokhara workshop*

In the opening session of the workshop the nominated chairperson Mr. Kamal Man Gurung, chairman of the Kaski District Development Committee, highlighted the importance of work to investigate climate change impacts on Nepalese glaciers, citing the recent problems of glacial lake outbursts and flooding in the Madi River, and dry landslides in the Kimrung river, a tributary of the Modi Khola. This was followed by a presentation by the chief guest, Mr. Bodh Raj Adhikari, Regional Administrator for the Western Development Region of Nepal. These presentations were followed by scientific presentations by various project team members to deliver the results of the study to the participants.

The second part of the workshop provided the opportunity to investigate group perceptions of various adaptation options, and to generate inputs to the policy briefing note, a useful output from the project. These were separately addressed in two discussion sessions. In the 'adaptation options' session, participants were allocated to groups on the basis of their professional backgrounds to provide a good cross section in each group. They then spent the first part of the breakout period discussing possible adaptation strategies which were distributed on feedback sheets. After discussion, they developed a group response to the listed issues and recorded these on the feedback sheets (one for each group). These were also supported by flip chart sheets which were used to enable feedback to all participants by a rapporteur from each

group. The results of these group discussions are shown in Section 5.4.2.2, in Tables 17, 18 and 19.

In the 'policy briefing note' consultation session, all participants were given a consultation document relating to the proposed policy briefing note (see Appendix 3.2.7). These were first completed on an individual basis to enable more detailed information to be collected, and to ensure full representation of all issues raised. The same issues were then discussed by each group and a summary consensus group version was produced. At the end of lengthy and enthusiastic discussion, each group reported back to the plenary session. Preliminary analysis of individual feedback sheets was also made to provide information to the plenary group about what had been said by individuals. This was analysed more comprehensively after the workshop. The suggestions made by both individuals and the groups on issues to be included in the policy briefing note are provided in Section 5.4, and Appendix 3.2.3, which also includes other details of the workshop.

At the end of the workshop, concluding remarks were provided by Dr. Binyak Bhadra, Deputy Director General at ICIMOD. This provided the opportunity to present a summary of the issues raised during the breakout and feedback sessions. He congratulated the participants on their diligence and interest in the topic and the variety of suggestions and comments received. He pointed out that it was important to consider the effect of the rain-shadow in certain places in the catchments in the high mountain areas. Mr Rees pointed out that this had been taken account of in the model developed during the project. The meeting concluded at 7pm with full participation for the whole day. A heavy hailstorm event occurred during the meeting providing a perfect example of the problems which can be faced as a result of extreme events. Much damage to vegetation (including crops) in the area was observed. After the workshop, all participants were sent a CD of the presentations, the posters, other relevant information, and a draft version of the completed policy briefing note.

4.4.4 The International stakeholder consultation workshop, New Delhi, India

This workshop was held over two days at the end of April 2004 and designed to provide feedback from the project to relevant stakeholders from different countries of the Hindu Kush Himalaya region, and also to the international scientific community. In addition, it was an important opportunity to examine the views of stakeholders concerned with larger scale issues on the potential impacts of climate change on water resources and possible adaptation strategies which could be developed.

This workshop was attended primarily by senior government officials from a number of different departments and from a number of countries, along with several representatives of the international research community in the region. The inaugural address was provided by the Chief Guest, Mr Shri S.K. Das from the Central Water Commission, Government of India. In his address, he highlighted the vast numbers of people who were dependent on glacial meltwater and pointed out the huge significance of both irrigation and hydropower to the continued development of the Indian economy and its efforts towards poverty alleviation. Presentations were given both by the project team and by representatives from other countries in the region where different types of climate induced impacts may be seen. The situation faced in India, Nepal, Bangladesh and Bhutan was described in these sessions, and this provided the opportunity to highlight significant regional variations in potential

impacts. Many of the speakers highlighted the importance of including site specific issues in model design and interpretation, and on potential adaptation strategies. Participants at the workshop are shown in Figures 13 and 14.

Figure 13. *Delegates at the Delhi workshop*

Figure 14. *Group discussions*

As with the Pokhara basin-scale workshop, this meeting provided an important opportunity for stakeholder consultation to be carried out. Once again, the focus of this consultation was on adaptation strategies and on the generation of a policy briefing note as an important form of dissemination of project results. The whole of the second day of the workshop was devoted to discussions of impacts and adaptation strategies and, in this case, attention was focussed on 3 areas – hydropower, food security, and commerce and tourism. Again, participants were divided into three groups and both individual and group responses were collected to obtain maximum information from the consultation exercise. Documentation used at the workshop is provided in Appendix 3.3 and the final draft of the policy briefing note generated from the workshop is shown in Section 5.4.6. Once again, participants were sent a CD of information from the project and the workshop after its completion.

5. Research Findings

The various forms of investigation used in this project have facilitated the development of a more comprehensive understanding of livelihood issues in the Hindu Kush Himalaya region. Local knowledge and views have been instrumental in characterizing these livelihoods and their relative importance. In terms of the identification of adaptation strategies, this has meant that potential actions have already been considered by local people and other stakeholder representatives. This paves the way for further awareness raising and policy implementation at some future date.

This section provides an overview of key issues which arose as a result of these investigations. For more detail refer to the project report *Water and Livelihoods in Mountain Areas: A Case Study of Modi Khola Watershed, Nepal,* included in the background documents attached to the SAGARMATHA Final Technical Report.

5.1 Findings from the household surveys.

Some 75,000 people live in the Modi Khola, with the majority living at altitudes between 1000 and 2000 metres. A total of 360 households were surveyed during the study, representing 2,331 people. Table 3 shows how this population is distributed in the different altitude zones.

Table 3. *Total and sample population of Modi Khola by altitude zone*

Altitude zone	Altitude	Estimated population (Census 2001)	Sample HHs	Sample population	Avg. HH size
Lower zone	<1000 m	12,500	60	443	7.4
Middle zone	1000-2000m	56,200	150	995	6.6
Upper zone	>2000m	6,300	150	893	6.0
Modi Khola		**75,000**	**360**	**2331**	**6.5**

Source: CBS, Population census, 2001

5.1.1 Primary occupations in the Modi Khola

Taking the Modi Khola as a whole, most people (48.8%) consider agriculture as their primary occupation, although 28.9% say they spend most of their time studying, reflecting the high proportion of the population who are below 25. For some 13%, 'Service' is the third major occupation. How occupations vary according to altitude zone is shown in Table 4.

Table 4. *Occupations in the Modi Khola, 2002 (Age 10 years and above)*

	% in occupation in each altitude zone			
Occupation	**Lower**	**Middle**	**Upper**	**Total number**
No occupation	26.7	42.2	31.1	45
Agriculture	15.7	44.6	39.7	906
Business	36.1	30.6	33.3	36
Service	22.4	42.3	35.3	241
Sikarmi/Dakarmi	0.0	85.7	14.3	7
Tailoring	100.0	0.0	0.0	3
Labour	0.0	57.1	42.9	14
Study	24.1	39.6	36.4	536
Other	18.8	18.8	62.3	69
Total	19.7	41.7	38.6	1857

Source: CBS, Population census, 2001

5.1.2 Land use and agriculture in the Modi Khola

The Modi Khola catchment is primarily forested, although over 28% of the area is covered by snow and ice or rocky cliffs. On the sunny aspects the sun heats up the soil and there is significant diurnal and spatial variation in temperatures and crop yields. Almost 20% is cultivated, with paddy rice being the most important in terms of production followed by maize and millet. Figure 15 shows some typical scenes of agricultural activities in the Modi Khola and emphasise the labour-intensive nature of this type of farming. Land cover and crop production data are shown in Tables 5 and 6 and they show how production of certain crops is influenced by altitude zone. It may be noted that this indicates which crop types may be more vulnerable to climate change impacts.

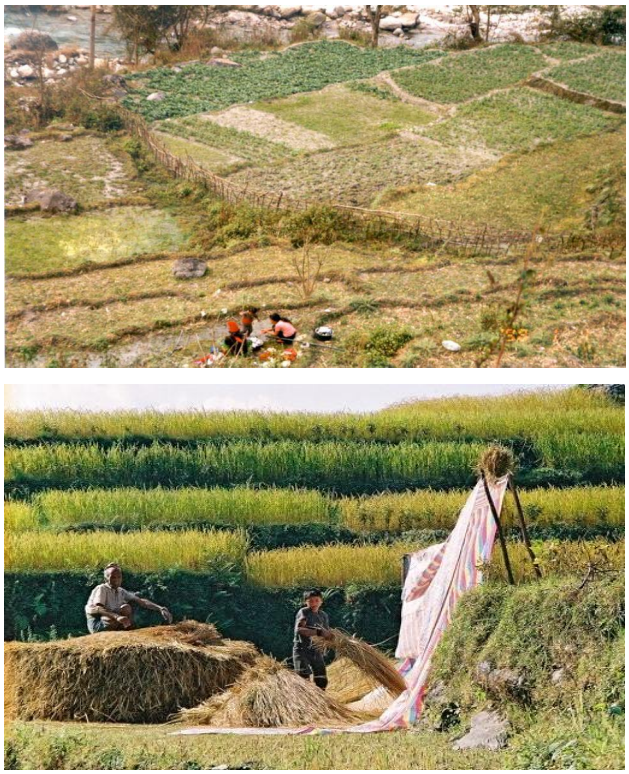


Figure 15. *Agriculture in the Modi Khola*

Table 5. *General land use, Modi Khola, 2002.*

Land use	Area (km^2)	%
Cultivated land	133.3	19.7
Forest	256.7	37.9
Grass	64.6	9.5
Bushes	17.1	2.5
Glacier/Ice	105.9	15.7
Rock/cliff	91.7	13.6
Sand/Gravel	6.3	0.9
Water bodies	1.0	0.1
Other	0.2	0.0
Total	**676.8**	**100.0**

Source: *Topographical maps of Nepal*

Table 6. *Area, production and yield of different crops*

Crops		Lower zone	Middle zone	Upper zone	Total
	Area	26.3	89.6	13.3	129.2
	Production	61,850	100,800	12,588	175,238
Paddy	Yield	2,350	1,125	946	1,356
	Area	19.5	56.8	44.7	120.9
	Production	31,886	56,880	34,833	123,599
Maize	Yield	1,633	1,001	779	1,022
	Area	6.2	43.3	35.5	85.1
	Production	8,359	48,453	33,495	90,307
Millet	Yield	1,341	1,119	944	1,061
	Area	7.7	15.2	3.7	26.5
	Production	13,739	11,576	3,149	28,465
Wheat	Yield	1,773	761.5	851	1,075
	Area	0.8	2.2	8.3	11.4
	Production	2,145	1,753	7,729	11,628
Barley	Yield	2,570	797	931	1,020
	Area	2.4	5.5	20.8	28.6
	Production	11,420	15,615	47,835	74,870
Potato	Yield	4,804	2,839	2,300	2,615

Source: *Rijal, S. Household Survey, 2002*

5.1.3 Vulnerability in the Modi Khola

As in many countries, subsistence households often have difficulty with the cash flows needed for participation in a modern economy. School fees, health costs, footwear etc. usually require cash payments. An indicator of the vulnerability to cash crises, the percentage of people in a society who are in receipt of a loan of any type represent households whose consumption patterns are likely to outweigh their income streams.

This is clearly an unsustainable situation, likely to increase household vulnerability and food insecurity.

On this basis, we can see that households in the lower zone are much less likely to be in receipt of loans than those in the upper zones. More detailed investigation would be needed to explain why these differences exist, but they do indicate the increased levels of vulnerability felt in communities living at higher altitudes. Sources and receipts of loans in the different altitude zones are shown in Table 7 and 8. Banks are the major provider of loans in the lower zone, but elsewhere they are much less important. In the middle and upper zones, local merchants and relatives provide the majority of loans. This reflects that there is less social capital available to local communities in these upper areas.

Table 7. *Percentage of households receiving loan*

Loan status	**Lower zone**	**Middle zone**	**Upper zone**
Yes	25.0	41.7	56.1
No	75.0	58.3	43.9
Total	100.0	100.0	100.0

Source: *Rijal, S. Household Survey, 2002*

Table 8. *Sources of loans*

Sources	**Lower zone**		**Middle**		**Upper**		**Total**	
	No	%[1]	No	%	No	%	No	%
Bank	27	45.0	28	18.7	9	6.0	64	17.8
Community fund	3	5.0	9	6.0	2	1.3	14	3.9
Local merchants	17	28.3	37	24.7	29	19.3	83	23.1
Relatives	14	23.3	31	20.7	26	17.3	71	19.7

Source: *Rijal, S. Household Survey, 2002*

[1]percentage of all surveyed households in each altitude zone

Another factor that will influence a household's vulnerability to the hydrological impacts of climate change is the availability of more than one source of water. In these communities we found that, in general, people use the rivers for domestic use when boreholes and wells run dry. As can be seen in Table 9, in some areas it was stated that there was no alternative source and of course, in this case, these households are particularly vulnerable.

Table 9. *Alternative water sources if present source of water not functioning*

Alternative sources	Lower zone		Middle zone		Upper zone		Total	
	No	%	No	%	No	%	No	%
Modi	31	51.7	65	43.3	10	6.7	106	29.4
Malyangdi	16	26.7	0	0.0	1	0.7	17	4.7
No alternative (Modi)	7	11.7	11	7.3	6	4.0	24	6.7
Jhari khola	0	0	11	7.3	0	0.0	11	3.1
Makes no difference	0	0	2	1.3	0	0.0	2	0.6
Other bigger river (nearby area)	6	10	61	40.7	133	88.7	200	55.6
Total	60	100	150	100	150	100	360	100

Source: *Rijal, S. Household Survey, 2002*

In all altitude zones, loss of crops from water related natural disasters was reported. There were marked differences, however, between the zones since the low altitude zones suffered mostly from drought, hailstones and floods and landslides, while in the high altitude zone hailstones were by far the most damaging impact, with 80% of households reporting that problem. Other damaging impacts on crops in the upper zone were landslides and drought. Hailstorms were also widely reported in the middle zone, with landslides being the second major cause of crop loss. Details of disaster impacts on crop loss are shown in Table 10.

Table 10. *Households reporting loss of property by water induced disasters*

	Lower zone		Middle zone		Upper zone		Total	
Land	HH	%	HH	%	HH	%	HH	%
Flood	7	11.7	16	10.7	5	3.3	28	7.8
Landslide	7	11.7	38	25.3	32	21.3	77	21.4
Crop		0.0		0.0		0.0		0.0
Flood	2	3.3	9	6.0	0	0.0	11	3.1
Draught	8	13.3	20	13.3	29	19.3	57	15.8
Landslide	2	3.3	13	8.7	7	4.7	22	6.1
Snow/avalanche	0	0.0	0	0.0	5	3.3	5	1.4
Hailstorm	9	15.0	95	63.3	120	80.0	224	62.2
Storm	1	1.7	8	5.3	4	2.7	13	3.6

Source: *Rijal, S. Household Survey, 2002*

5.1.4 Community perceptions of the impacts of climate change and extreme events

In all communities, widespread views on the impacts on various crops were expressed. These are summarised in Table 11, but it is clear that in the lower zone more people think that the overall crop area remains much the same over the last 10 years, but there is much more uncertainty about productivity and more views indicating change.

In the middle zone, many respondents suggested that there had been little change in crop area, although 40% did feel that there had been a decrease in the productivity of paddy rice production. Responses indicated significant variation in views about changes that had occurred in productivity, but it seemed that respondents' thoughts on crop productivity was more variable than in the lower zone.

In the upper zone, the majority of respondents indicated that they felt that crop area had not changed very much in the last 10 years but, in terms of productivity, respondents suggested most change would occur in relation to maize, millet and potato which were all seen to be declining.

Table 11. *Proportion (%) of households reporting changes in area and productivity of different crops (within 10 yrs)*

	Area				**Productivity**			
Lower zone	**No response**	**Increase**	**Decrease**	**Same**	**No response**	**Increase**	**Decrease**	**Same**
Paddy	6.7	16.7	15.0	61.7	10.0	26.7	35.0	28.3
Maize	0.0	13.3	11.7	75.0	5.0	23.3	25.0	46.7
Millet	28.3	8.3	6.7	56.7	31.7	16.7	16.7	35.0
Wheat	20.0	10.0	13.3	56.7	28.3	15.0	21.7	35.0
Barley	88.3	1.7	0.0	10.0	88.3	5.0	1.7	5.0
Potato	18.3	8.3	6.7	66.7	21.7	18.3	13.3	46.7
Other	76.7	1.7	5.0	16.7	81.7	3.3	1.7	13.3
Middle zone								
Paddy	12.7	12.7	20.7	54.0	12.7	9.3	40.0	38.0
Maize	5.3	12.7	17.3	64.7	5.3	11.3	38.0	45.3
Millet	8.0	13.3	14.7	64.0	7.3	10.7	30.7	51.3
Wheat	57.3	5.3	9.3	28.0	58.0	2.7	17.3	22.0
Barley	91.3	0.7	3.3	4.7	92.0	0.0	3.3	4.7
Potato	44.7	5.3	7.3	42.7	44.0	7.3	15.3	33.3
Other	73.3	0.7	1.3	24.7	74.7	1.3	8.7	15.3
Upper zone								
Paddy	70.0	1.3	4.7	24.0	72.7	1.3	15.3	10.7
Maize	17.3	2.7	9.3	70.7	18.0	9.3	38.0	34.7
Millet	26.7	1.3	9.3	62.7	26.0	6.0	29.3	38.7
Wheat	84.7	0.0	2.7	12.7	84.7	0.0	8.0	7.3
Barley	70.7	0.0	2.0	27.3	71.3	2.0	10.0	16.7
Potato	23.3	4.0	5.3	67.3	24.0	12.7	37.3	26.0
Other	86.7	0.0	1.3	12.0	86.0	0.0	8.0	6.0

Source: *Rijal, S. Household Survey, 2002*

Table 12 indicates people's views on the impact of changing weather patterns on farming. While very few respondents thought that food shortages would occur, it was clear that both the middle and upper zone inhabitants considered longer (colder) winters likely to reduce crop production. This could imply that shorter (hotter) winters may *increase* productivity, but this would have to be examined before conclusions could be drawn. Since the IPCC (2001) clearly shows the tendency of temperatures to

be rising, there could be a positive benefit in crop production, although the impact of increased yields on crop prices is uncertain.

Table 12. *Impacts on farming if cold weather continued until March*

	Lower zone		**Middle zone**		**Upper zone**		**Total**	
	No	%	No	%	No	%	No	%
Makes no difference	39	65.0	42	28.0	22	14.7	103	28.6
Production decreases	19	31.7	108	72.0	124	82.7	251	69.7
Creates food shortages due to decline in production	2	3.3	0	0.0	4	2.7	6	1.7
Total	60	100	150	100	150	100	360	100

Source: *Rijal, S. Household Survey, 2002*

During the household surveys, people were asked their views on a number of possible environmental changes observed over the last 20 years. These are summarised in Table 13. It is interesting to note that the majority of views expressed some positive indications relating to forestry, with most people (69.4%) observing that forest cover has increased. This was also reflected in the majority suggesting crown cover and tree species diversity also had increased. While fodder seemed to be more available, time and fuelwood were definitely thought to have decreased in the same period. This perhaps suggests that structural changes may be occurring in forest areas, possibly the result of both deforestation and of reforestation projects.

A decrease in land productivity was observed by 48% of respondents but, on the positive side, 67% felt that water collection distances had decreased, indicating water access had been improving over the period. The majority of respondents considered that there had been no change in rainfall, temperature or snowline (57.8%), and 68% felt that river flows were unchanged. Availability of forest foods, litter and herbs remained the same according to the majority of respondents, along with crop diversity (86%).

Land productivity is influenced by many factors but, if a declining trend is already observable, it is likely that additional climate-induced variability will strengthen that downward trend. While some 70% reported no change in the rate of flooding, drought periods were reported to have created crop losses. This suggests that more research should be initiated to investigate potentially robust crop types, or those which would improve under the expected conditions. This research should be a participatory investigation involving local communities and farmers groups.

Table 13. *Overall perception on environmental changes in local conditions (within 20 years)*

Perception on	%Increase		%Decrease		%Same
Total agricultural area	10.0		44.7		45.3
Area under cereal crop	8.3		36.7		55.0
Area under fruit	41.4		9.7		48.9
Area under vegetables	59.4		2.8		37.8
Crop diversity	11.7		2.2		86.1
Crop intensity	16.1		2.5		81.4
Productivity of land	19.7		49.2		31.1
Use of improved seeds	51.4		3.1		45.6
Use of fertilizer	39.4		5.8		54.7
Use of pesticides	24.4		2.8		72.8
Area of forest	69.4		8.1		22.5
Number of tree species	54.4		5.3		40.3
Crown cover	55.6		8.3		36.1
Availability of fuel wood	19.7		47.2		33.1
Availability of timber	17.8		46.7		35.6
Availability of fodder	51.4		9.2		39.4
Availability of litter	23.9		18.1		58.1
Availability of herbs	7.5		10.3		82.2
Wildlife	80.3		6.4		13.3
Availability of forest food	11.1		20.0		68.9
Area under pasture	6.9		47.5		45.6
Productivity of pasture	10.6		29.4		60.0
Area of wasteland	11.1		40.6		48.3
Use of wasteland	39.2		7.2		53.6
Surface runoff	23.3		16.4		60.3
Soil erosion	32.2		17.2		50.6
Landslide	29.7		13.9		56.4
Floods	15.6		5.3		79.2
Pesticides	34.7		8.6		56.7
Forest fire	3.3		49.2		47.5
Water quantity	15.8		11.7		72.5
Water quality	25.3		10.8		63.9
Water collection distance	3.6		67.8		28.6
Rainfall	40.3		8.1		51.7
Temperature	28.9		13.1		58.1
Snow line	18.1		24.2		57.8
Volume of river flow	21.7		9.7		68.6
Changes in season	11.1		1.9		86.9

Source: *Rijal, S. Household Survey, 2002*

In response to discussions on the impacts of increased rainfall, respondents from the higher altitude zone were much more conscious of potential negative effects, as shown in Table 14. Crops and infrastructure were considered the most vulnerable

sectors, with large numbers of people being affected particularly in the middle altitude zone.

Table 14. *Estimated number of people likely to be impacted adversely by more rainfall*

Impacts on	% People considering more rainfall as negative impact	Number of people likely to be impacted
Lower zone		
Crops	50.0	6,250
Animals	50.0	6,250
People	53.3	6,667
Forest	38.3	4,792
Infrastructure	68.3	8,542
Middle zone		
Crops	76.1	42,774
Animals	62.5	35,125
People	65.6	36,842
Forest	44.7	25,134
Infrastructure	73.6	41,369
Upper zone		
Crops	91.7	5,775
Animals	80.0	5,040
People	80.0	5,040
Forest	50.0	3,150
Infrastructure	83.1	5,233

Source: *Rijal, S. Household Survey, 2002*

Rising temperatures are a further likely characteristic of climate change over the next century (IPCC, 2001). In this case, communities in lower parts of the catchment are clearly concerned, while those in the upper and middle zones do not see that so much as a problem, although large numbers of people are likely to be impacted by this as shown in Table 15.

Table 15. *Estimated number of people likely to be impacted adversely by hot weather*

Impacts on	% People considering hot weather as a negative impact	Number of people likely to be impacted
Lower zone		
Crops	85.0	10,625
Animals	81.7	10,208
People	80.0	10,000
Forest	73.3	9,167
Infrastructure	85.0	10,625
Middle zone		
Crops	43.3	24,353
Animals	40.8	22,948
People	48.1	27,007
Forest	54.4	30,598
Infrastructure	46.9	26,383
Upper zone		
Crops	10.8	683
Animals	9.4	592
People	8.1	510
Forest	27.8	1,751
Infrastructure	19.2	1,210

Source: *Rijal, S. Household Survey, 2002*

5.1.5 Conclusions from the household surveys

On the basis of this and the rest of the information generated by this study (see Rijal 2002, Khanal et al. 2003 and other project background papers[3]), it can be concluded that the groups most likely to be vulnerable to climate-induced hydrological variation are those living at higher and middle altitudes. Large numbers of people live in the middle altitudes in the Modi Khola and if the change in climate is characterised by shorter warmer winters, it may be that increases in crop productivity will be observed. While this suggests an improvement in food security the impact on farm incomes is uncertain. If, on the other hand, winters are colder and longer, crop production is likely to fall. This highlights the uncertainty associated with climate impact research and emphasizes that great care must be taken when interpreting the results.

5.2 Findings from the Kaligandaki Corridor Survey

On the basis of the modelling results, it is likely that the Kaski and Parbat districts located in the upper part of the corridor will be considerably influenced by any change in runoff due to deglaciation. In the middle part of the corridor, the Baglung, Parbat, Gulmi and Syangja districts may experience high to moderate impacts, with Palpa and Tanahun in the in the lower part of the corridor are likely to be less effected. In the far downstream areas of southeastern Nawalparasi and western Chitawan, impacts will be least marked. In addition to the direct impacts of changes in flow rates of the

[3] Project background papers are provided in a separate volume.

Kaligandaki, the combined effects of other snow-fed rivers such as the Seti, Madi, Marsyangdi, Budhigandaki and Trisuli will also be felt downstream of Devghat where they influence the Kaligandaki flows.

Any changes in hydrological regimes can have serious consequences for infrastructure such as dams, hydropower and irrigation schemes. Currently, there are three hydroelectricity projects in the corridor. Another three have been proposed and planned. The Modi Khola hydroelectricity project is located at the Deupur VDC in Parbat district, and was completed in 2000 with an installed capacity of 14.8MW. The 29.1GWh of power generated is partially distributed locally with the remaining transmitted to the national electricity transmission grid through a 37 km long 132 kV transmission line to Pokhara substation.

In the middle part of the corridor, at Mirmi in Syangja district, is the Kaligandaki 'A' hydroelectricity project. It was completed in 2002 and is expected to generate about 868 gigawatt-hours (GWh) of electric energy per annum. The power is connected to the central grid to the Pokhara and Butwal substations. The Gandak hydroelectricity project is near the Nepal-India border and has an installed capacity of 15 MW. This was constructed by India after agreement between the governments of Nepal and India in 1959. Control of it was given to Nepal in 1981 and its output is shared between the India and Nepal national grids. A total of 527446.37 MWh power was generated in 2002/03 from these three hydropower projects, generating a revenue stream[4] of some Rs 353,389,067,900 for 2002/03 (NEA, 2003). This is a significant sum and would be at risk if these power stations were adversely influenced by changes in river flows.

Two of the three other proposed hydroelectric projects planned for construction in the headwaters of the Modi Khola area are likely to be affected by deglaciation. To take account of this, it will be important to consider the impact of changes in runoff, both on infrastructure and on power generation design. The Kaligandaki II has been proposed in the lower part of the corridor, so the impact of deglaciation will be less significant but the impact of increased extreme precipitation and floods is still to be assessed.

Another very important traditional use of water is to power water mills for grinding food grains particularly paddy, maize, millet and barley. In some areas, local people have been using water in this way for many centuries and they are an important part of the local social and physical capitals. There are altogether 55 water mills run by water from the Modi River in the upper part of the catchment. Some 3,320 households directly benefit from these mills, and they provide an important link in the food security chain. The average annual income earned by mill owners is estimated to be Rs 1500, so they contribute to financial capital as well. However, there are only a few water mills run on the Kaligandaki River. The Kaligandaki is large and flows in a confined gorge, providing limited water for water mills. About 50 percent of the water mills in the Modi Khola basin are seasonal but the rest operate throughout the year. In the event of climate change induced deglaciation, some of these mills may be effected, especially the seasonally operated ones.

There are a total of 11 formal irrigation schemes and a number of traditional irrigation *kulos* (canals) providing irrigation facilities in the Modi Khola. Water for irrigation is diverted from tributaries of the Modi Khola and natural springs. Water from the main

[4] Based on the average tariff rate fixed by Nepal Electricity authority of Rs 6.70 per unit.

channel of the Modi Khola and Kaligandaki rivers is only of limited use for irrigation due to the fact that rivers are very deep and cultivated land is located at higher altitudes on river terraces.

The Narayani Lift Irrigation Project was completed in 1985 in Chitwan District. Presently about 4700ha of land is irrigated from this project in five VDCs/municipalities. Around 37,000 families benefit from the irrigation water it brings. The Gandak Irrigation Project provides benefits for over 15,000 households in Nepal, as well as many more in India who also benefit from these waters.

In the Kaligandaki corridor water is being used for industrial use, especially in the lower part where the pulp and paper industry is using approximately 450 cubic meters per hour. This water is also used for drinking for workers and local people. There is, however, no other organised industry in the Modi basin but there are some cottage industries, which use water in their production.

Fishing is another important economic activity along the Kaligandaki river corridor. The economic activities of the Bote, Majhi, Darai and Kumal ethnic groups are traditionally based on river water, with ferrying and fishing as major sources of income. Income from ferrying has now disappeared in many places so these groups are solely dependent on fishing. Other communities such as the Darai and Kumal are also heavily dependent on fishing for their diet and for cash incomes.

Fishing is important not only for subsistence but also for commercial and sports fisheries. The annual catch from the river is estimated at between 80 to 150 tons, with the principal species being snow trout, mahasheer, carp, catfish, eel, murrel, loach and barbs. The Kaligandaki has a number of fish species specially adapted to the extreme gradient, and there is concern that the irrigation schemes are impacting on the aquatic habitat downstream from their intakes. The uppermost 13 km is particularly vulnerable as there are no tributaries to contribute flows and in recent years low flows in these and other stretches have resulted in no fish migration and reduced access to spawning or nursery grounds. Table 16 shows the population of these ethnic groups living in VDCs adjoining the river. There are in total 23,037 communities living in the corridor of the Modi/Kaligandaki River and, to some degree at least, most of them are likely to be affected by any change in runoff.

Table 16. *Population of ethnic groups engaged in fishing along Modi/Kaligandaki Corridor*

Districts	Bote	Majhi	Darai	Kumal
Kaski	0	8	0	1
Parbat	9	244	0	374
Baglung	0	82	0	16
Gulmi	0	44	0	23
Syangja	1	307	0	859
Palpa	344	495	106	2,165
Tanahun	477	0	546	1,979
Nawalparasi	1.702	430	1,548	6,729
Chitwan	68	75	867	3,538
Total	2.601	1.685	3,067	15,684

Source: CBS, *Population census, 2001*

The impact of a change in runoff on fishing and livelihoods of these ethnic groups is difficult to quantify, but it is likely that these ethnic groups will be further affected due to deglaciation.

Water in the region also has important religious and spiritual uses. There are altogether 22 traditional *ghats* (water mills) along the Modi/Kaligandaki river corridor used for bathing and cremating. Changes in runoff, either increases or decreases, may cause inconvenience and increased risks for local people. It is likely that these ghats would have to be relocated, reconstructed or renovated, at high cost to the community. This provides another example of how the social and physical capital available for a community can be changed as a result of changes in the natural resource base.

The Kaligandaki is a popular destination for tourism, particularly for white-water rafting starting from different locations such as Kusma, Riri and Ramdi. It is reported that every year about 1500 tourists are involved in rafting. The change in runoff may affect rafting activities. In turn, this will affect employment and marketing opportunities of local people living along the corridor, although it is difficult to quantify the impact accurately.

Runoff in the snow-fed rivers is likely to change due to global warming. In some areas, people and infrastructure along the corridor could be significantly affected. Efforts should be made to raise stakeholders' awareness of these potential changes, and planners, policy makers, development workers and local people should be encouraged to develop appropriate adaptation strategies to cope with these changing conditions.

5.3 Observations from studies across the HKH region

A review of case studies from river basins across the Hindu Kush Himalaya region highlighted how observed and predicted climate change and variability are impacting populations across the region in economic, social, cultural and environmental terms. The review focused on observed changes in temperature, precipitation and water resources, and the apparent impacts on livelihoods in each area, providing comparative assessments with the case study in Nepal. Figure 16 shows the region and the case study locations.

Figure 16. *Case study sites in the HKH region*

A study from the Siran River valley in the northwest region of Pakistan showed a decline in temperatures and increase in precipitation in areas below 2000 metres, an increase in both temperatures and precipitation in areas above 2000 metres, and an increase in the frequency and intensity of the monsoon with a shift in rainfall activity from northwest to northeast. River flow along the Siran showed an increase over a 32-year period to 1991 followed by a sharp decline in 2000. The study predicts negative impacts on livestock production in the area due a decrease in suitable pasture, although an increase in the forested area is expected. Being located in a humid mountain region, the valley is expected to receive increased precipitation in future with climate change. However, water for drinking and irrigation may decrease and the potential for damage to life and property increases as deforestation and inappropriate agricultural practices continue.

Studies from the Jhelum River basin in India revealed significant observed climate change, environmental degradation and cultural adaptations. Increasing temperatures have been observed in the Kashmir region over the last 20 years and for over a decade this region has not experienced the season of 'Tosh' - the 20-30 day snowy period between winter and spring. At the same time, rainfall during September has increased causing flash floods. A general decline in water quantity and quality has been observed in the Jhelum River and in nearby tributaries, springs and lakes. The area of Dal Lake has reduced by 50% during the last 50 years and the famous wetlands of Hokersar are suffering ecological degradation. The warming observed in the region is seen to have affected society in areas such as the dressing patterns of people and in building design. Traditional clothes have been replaced by much lighter woolens and the wearing of long rubber boots has been abandoned. The size of buildings is changing and the use of traditional construction and insulative materials has decreased.

The full report *Review of Case Studies on Climate Change and Livelihoods in the Himalaya* is included as a background document of the SAGARMATHA Final Technical Report.

5.4 Results and conclusions from stakeholder workshops

The workshops carried out during this project have enabled consultation to take place at a range of spatial scales. More detail on procedures etc. is provided in the project background documents to the SAGARMATHA Final Technical Report, but results are summarised here.

5.4.1 Local workshop results: Modi Khola Catchment

Following stakeholder consultation meetings carried out in early 2004 in the Modi Khola, the following issues were identified:

5.4.1.1 Perception of climate change

Participants of the stakeholder consultation exercises perceived that temperatures have been rising over the last 10 years, and they observed that the amount and intensity of rainfall has been increasing in the Modi Khola catchment. They also expressed the view that the snow-covered area of the glacier has been shrinking. The participants also expressed the view that over the last decade extreme events have been increasing. They have experienced more events of localized high intensity rainfall, causing heavy erosion and damage to life and property. The pattern of hailstorms and snowfall has also been seen to have changed. In the past, hailstorms usually occurred in the month of April, but now they seemed to be occurring in February, having clear implications for farming. The prevalence of mosquitoes in the higher altitudes was also noted, along with the upward shifting of paddy cultivation and early ripening of crops. Local people felt that these changing conditions served as proxy indicators of climate change. The majority considered that higher intensity and untimely rainfall events have a negative impact on livelihoods, especially farming. It was also considered that increases and decreases in river flow would adversely affect livelihoods.

5.4.1.2 Adaptation strategies

Members of the research team presented some generalised results from the hydrological modelling carried out in the project. These were presented carefully to avoid creating unnecessary concern in local communities. Responses to key issues were sought, and participants in these discussions believed that increases in temperatures greatly influence glacial retreat, and the amount, intensity and timing of rainfall. This is believed to have a major influence on water availability in the river. In the Modi Khola, people use river water for a number of purposes, and local stakeholders suggested the following strategies would be suitable to cope with changing water availability in the future:

- **Changes in cropping pattern, substitution of crop varieties and species**

  Agriculture in the Modi Khola is characterized by food crop production. Paddy (rice), maize, wheat, and millet are the major food crops grown in this area. Over the last decade, extreme events have been increasing and people experienced more events of

localized high intensity rainfall followed by droughts in adjoining areas. Changes in the periodic pattern of hailstorms and snowfalls were observed, and these badly affect winter crops such as wheat, barley and potato, particularly in the upstream sub-region. Also, untimely and variable rates of rainfall (both high and low) affect crop productivity. They expressed their concern that an introduction of new varieties of crops suited to the changing weather pattern should be explored. They viewed dry resistant varieties such as Ghaiya, Musuro, etc. as being suitable in dry areas.

- **Changes in animal husbandry techniques**

  The contribution of livestock to the local economy is significant. It has both direct and indirect benefits. The livestock population has declined in the Modi Khola area due to various reasons such as the expansion of forest land, and restriction of grazing in the forest area after the establishment of the Annapurna Conservation Area Project (ACAP), the development of local tourism activities, and out-migration of the working age population. Transhumance activity was formerly a major source of household income in the upper parts of the Modi Khola, but in recent years there has been a sharp decline. This decrease in livestock population has affected crop productivity due to a decline in manure availability. In spite of this, the demand for livestock products such as milk and meat is increasing in this area, and the introduction of community as well as commercial livestock farming of improved varieties would be considered beneficial. It was thought that this could meet local demand, as well as providing employment generation and extra income. Many thought that more livestock would help maintain productivity and soil fertility.

- **Promotion of social networks**

  People in the meeting felt that social networks greatly help local people in difficult situations. It was stated that the existing social networks are not adequate to cover environmental issues. They expressed the view that there is a need to increase awareness of local people regarding global climate change and its associated impacts. They felt that there would be much benefit from considering how these impacts may influence different livelihood sectors such as production of crops, forest, infrastructure, animal health, etc.

- **Development of early warning systems**

  As reported previously, extreme events are frequent in the area, and loss of life and property is increasing. The SAGARMATHA model has predicted that water flows in the Modi Khola are not likely to decrease for a number of decades. This causes some concern as there are many settlements situated close to the river, such as Himalkyu, Syaulibazar, Birethanti, and Dimuwa, and these may be at risk. Increased river flow coupled with high intensity rainfall may cause heavy floods, damaging life and property in these areas. There

was a call for the need to develop early warning systems in these areas to protect communities from these possible extreme flood events.

- **Development of fishponds and fish breeding**

  People in this discussion observed that the fish population in the Modi Khola has declined sharply. The main reasons for this decline are thought to be the construction of the Pokhara-Baglung highway, and the dam for the Modi hydroelectric project. While these impacts are not due to climate change, it was considered by the group that the development of fishponds and the introduction of new varieties of fish could greatly help in restoring fishing and related activities for the community. This was considered to be a potentially important adaptation strategy to be developed in the future.

- **Promotion of cultural tourism**

  The contribution of tourism to the household economy is significant in the upstream region of the Modi Khola catchment. A large proportion of the population of this region is engaged in tourism and related activities, such as hotels and restaurants, lodges, guides and portering. Some concern was expressed that the natural beauty of the Annapurna area is likely to decline due to shrinkage in snow cover area as caused by deglaciation, but in reality the scale of this change is not likely to be widely observed at the landscape scale. Deterioration in natural beauty may affect tourism activities and tourism business, and, according to local stakeholders, the establishment of a natural and cultural museum would be beneficial in promoting tourism activities in this region. A suitable area for such a museum is available in the upper parts. The construction of the road connecting Nayapul-Ghandruk-Chhomrung provides easy access for comfortable trekking, especially for older people.

- **Migration**

  Local stakeholders considered out-migration as an important source of family income in the region. The contribution of remittances to household income is significant, with some 31.2 % of household incomes accruing from them in 2001. It was considered important that such income transfers were a very important part of household livelihood strategies, and any disruption to these could cause severe income poverty in some households.

- **Changes in design specifications for water and other infrastructure, and modification of existing structures**

  The design specification of water use infrastructure such as water mills and micro-hydro plants should be modified. Most of the water mills in this area are of traditional (wooden chute with wooden blade) type and operated only in the rainy season, with a low processing capacity. Improvement in the design to increase

processing capacity would be beneficial. Suggestions included the introduction of a cascading system of water mill operations for the perennial rivers. Improvements in irrigation canals and construction of reservoirs for micro-hydro plants were considered necessary to overcome the adverse situation in the dry season. Rainwater harvesting and development of alternative energy systems would also be possible and should be encouraged.

- **Development of management strategies to cope with reduced water availability in an equitable way to prevent conflict**

  According to the model outputs, a reduction in river flows and water supplies is not a likely phenomenon in the area for decades. However, there are issues arising out of seasonal fluctuation of water flow and conflict between users. The majority of watermills in this region remain closed during the dry season due to low flows in the tributaries of the Modi Khola. Micro-hydro plants and irrigation systems are also facing similar problems, and this is likely to be restricting income generation potentials from this infrastructure. It was suggested that a priority list of water uses should be prepared, and legal provision for water use should strictly be followed to avoid conflicts on water use. As suggested by local stakeholders, mutual understanding and discussions could solve conflict among water users.

5.4.2 National Workshop Results: Kaligandaki Stakeholder Consultation Workshop, Pokhara, Nepal, April 21st, 2004

The first session of this workshop provided the opportunity to deliver feedback to the participants on outcomes from the research. In addition, responses to a series of stimulus material were sought from both individuals and groups, with a view to developing a more comprehensive understanding of the positions and opinions of different stakeholders.

5.4.2.1 Results from individual responses

During the course of the discussion sessions, individuals had the opportunity to express their personal views on a number of issues. Over 36% of them expressed the view that there was a need for more equitable water allocation, while 22% felt that more public awareness should be raised about the possible impacts of climate change on water resources. Almost 20% suggested that there was much need for better water and natural resource management.

5.4.2.2 Results from group discussions on possible adaptation strategies

These are summarised in Tables 17, 18 and 19.

Table 17. *Group 1 Results*

Topic	Positive advantages	negative disadvantages
Change in cropping patterns, new varieties etc	Traditional ways of agriculture should be continued along with the introduction of new technology	Introduction of new species would lead to the need for improvement in eating habits. New species should be identified on the basis on senstivitiy to climate change
Promotion of soc networks	Social mobilisation and networking across geographical boundaries should be promoted, including inter-caste marriage	There may be a negative effect on culture, may create conflict between different groups
Changes in location of activities,fishing etc	Local species of fish must be conserved and developed. Improved species should be cultivated and increased in production . Fish ponds should be developed	none
Changes in appropriate location of tourism	On the basis of feasibility studies, proper management of rivers for tourism use, rafting etc should be introduced	pollution could lead to ecological imbalance
Changes in animal husbandry techniques	Selection of local species of livestock for further improvement and development of the breed.	new diseases could be introduced
Migration	Migration from rural area should be discouraged	People may become more narrow minded
Changes in design of infrastructure	More equitable water allocation should be porsued and infrastructure developed accordingly	This could be costly and some existing infrastructure may no longer be of use
Development of management strategies to cope with changes in water	build awareness of the proper utilisation of water	changes in availablity may make management more difficult
Additional policies for local stakeholders	stakeholder consultation should be incorporated to reduce possible conflicts	existing policies may be inequitable
Important recommendations for policy	give priortiy to HEP based on small scale community involvement and investment, as well as in water supply and irrigation	conflicts must be minimised, some policies are conflicting, need integration of policies

Table 18. *Group 2 Results*

Topic	Positive advantages	Negative disadvantages
Change in cropping patterns, new varieties etc	Introduction of new high yielding varieties, especially for different ecological regions	Danger to biodiversity. Threat to indigenous vegetation
Promotion of soc networks	Informal education for awareness raising. Empowerment of local user groups	Group conflict. Resource constraints
Changes in location of activities,fishing etc	Introduction of improved species, taking account of local ecology. Encouragement of private fish production through the development of pond fishing	Marketing problems, ecosystem and biodiversity impacts
Changes in appropriate location of tourism	Identification of new tourism destinations, development of eco friendly tourism infrastructure, and heritage based tourism	cultural pollution and environmental degradation
Changes in animal husbandry techniques	introduction cross breeds and hybrids to build stock resilience, improvement in fodder production	new breeds may be more suceptible to diseases and worms
Migration	Development of detailed land use maps to identify good locations for human settlements	socio-cultural conflicts
Changes in design of infrastructure	Development of multipurpose dams, integrated basin wide water development plans and prioritisation of water uses	resource constraint
Development of management strategies to cope with changes in water	participatory water development plan needed	water rights problems may arise
Additional policies for local stakeholders	more social equity, employment generation policies and educational awareness promoted	none
Important recommendations for policy	More user empowerment, policy on water quality, demand driven water uses	beneficiary conflict, resource constraints, paradoxical stategies and policies

Table 19. *Group 3 Results*

Topic	Positive advantages	Negative disadvantages
Change in cropping patterns, new varieties etc	Increases in yield possible, taking advantage of new conditions (more rain, hotter weather etc) potential gain from new varieties if patents are put in place for new cultivars. Promotion of biodiversity conservation	lack of patent rights could cause the loss of all benefits
Promotion of soc networks	Public awareness raising on potential natural disasters and development of warning systems. Promotion of indigenous knowledge and skills.	could create social conflicts and worry
Changes in location of activities,fishing etc	ponds	none
Changes in appropriate location of tourism	could promote employments opportunities as an alternative to tourism	difficult to find markets and poor transport create limitations to this
Changes in animal husbandry techniques	Community based livestock management schemes	Marketing problems, erosion through over grazing
Migration	Encourage push back migration and discourage rural emigration	lack of jobs and adequate housing in situtations of growing population
Changes in design of infrastructure	Plans should be made so as to not disturb the environment	environmental and socio-economic disruption, degradation
Development of management strategies to cope with changes in water	Better implementation of existing laws with more participation in enforcement	If not done properly, could increase conflict
Additional policies for local stakeholders	Establishment of water user groups etc., promotion of water conservation techniques	conflicts could arise if shortages develop
Important recommendations for policy	Implement a poverty reduction programme through better water resources	underutilisation of water could be wasteful

5.4.2.3 Summary of group and individual inputs into policy briefing note

a. The nature of mountain livelihoods should include farming, tourism, external remittances, small scale industry and handicrafts. Key issues suggested by stakeholders were: livestock and dairy, the cultivation of medicinal plants and herbs, and the promotion of community forestry and non-timber forest products (NTFPs).

b. Current problems in mountain communities

Depopulation, unemployment, unpredictability of seasons and poverty were agreed as the main issues, with other problems including lack of

infrastructure being given significance, along with inappropriate farming policies.

c. Research findings to be included

- Modeled outputs suggesting changes in water availability
- Potential impacts on communities
- Potential adaptation strategies which would be suitable and acceptable
- Issues which are important for health and welfare of human populations
- Promotion of more equitable water management
- The need for more awareness raising re. climate change impacts

d. Policy recommendation suggestions

Participants were asked to rank a selection of issues as important to be included in policy recommendations. Those considered to be most important were:

1. Build awareness of the impacts of climate change
2. More participation in development of climate response policy
3. Better monitoring and data collection about conditions in upper mountain areas
4. Participatory survey on selected indicators of climate change implemented in key areas
5. Develop mechanisms to support and promote adaptation strategies
6. Investigate potential for water saving techniques
7. Encourage the development of experimental cropping (in conjunction with the Ministry of Agriculture)

e. Other issues which were also considered, but seen as less urgent were:

- Investigate scale of impacts on infrastructure in key basins
- Assess appropriate infrastructure responses
- Investigate potential for early warning
- Investigate potential need for water storage facilities

f. Other suggestions for inclusion made by individuals were:

- Research findings should be disseminated widely to people at all levels of society, not just policy makers
- Identification of geographical locations which might be safe from hydrological accidents and other natural disasters
- Introduction of a comprehensive (environmentally friendly, participatory, equitable) water use act by the government
- Development of a mountain database
- Restoration of forests in upper catchment areas (near glaciers)

- Need for more participation by women and marginalized people, including lower caste groups
- More integration and coordination between government departments, NGOs, etc.
- Implementation of participatory catchment conservation projects and afforestation programmes
- Promotion and fostering on existing social heritage in tourism development

5.4.2.4 Final Policy Briefing note generated by the Pokhara workshop

Mountain Livelihoods, Water Resources and Climate Change in Nepal

POLICY BRIEFING NOTE

The nature of mountain livelihoods

In Asia, 65% of the rural population live in upland areas, depending on farming, small scale industry, handicrafts, tourism and external remittances. While there is considerable cultural and social diversity in such regions, people often face the same kinds of threats and challenges. The topography and ecology of the region is also highly diverse, giving rise to many different microclimates and geographical conditions impacting on how people live, but in spite of adversity, people generally tend to be resilient and resourceful. In the upland areas of Nepal, livelihoods depend predominantly on animal husbandry, cultivation of medicinal plants, and the utilisation of non-timber forest products. Small scale hydropower and water mills are used to support communities within these mountain catchments, and domestic water supplies are almost always taken from springs, small tributaries or wells, rather than from the main rivers themselves, due to the fact that communities are usually located on steep valley slopes away from the river. Irrigation is important in some areas, and rivers originating in these upland zones provide water for people and the economy for hundreds of miles downstream.

Current problems in mountain communities

Poverty is a major problem for upland communities, and rural depopulation is a direct consequence of that, as young people leave the area in search of work. Because of the high levels of unemployment, non-cash income is important, and there is much dependence on the utilisation of open-access natural resources. Forests and water play an important role, but concern has been raised about environmental degradation, often characterised by landslides and floods. Unpredictability of seasons creates a problem for farmers, and people feel that outdated and inappropriate agricultural techniques currently in use should be revised. Lack of infrastructure such as irrigation schemes and transport, and poor educational facilities are considered a problem for these communities, along with lack of markets and political instability. In the mountain communities of Nepal, and other countries in the HKH region, people have considerable ecological knowledge, and from experience, have good understanding of how climate variation can influence local livelihoods. There is much scope for drawing on this local and indigenous knowledge, to support the development of more integrated and holistic resource management policies, in which communities are keen to be involved.

Research findings

1. Integrated hydrological modelling has suggested possible changes in water availability across the Himalayan region, as a result of climate change. Rising global temperatures are bringing about a process of deglaciation, directly impacting on river flows, initially causing an increase in flow rates in many areas, followed later by a reduction, as glacier melting rates decrease.

2. In the east of the region, increased volumes of water flowing out of mountain areas are likely to increase flows downstream, where precipitation is high during monsoon seasons. In western areas of the region, however, where rainfall contributes much less to local conditions, impacts of changes in snow melting rates will be more severe, resulting in significant reductions in water availability in the longer term.

3. Across Nepal, both immediate and longer term impacts may be felt, but not with the severity felt in other parts of the region. This is mainly due to the volume of snow and ice available at high elevations in Nepal.

4. These changes in water availability are likely to impact more on communities in upper parts of river basins, and this will have both regional and global implications. As a result, there is a need for the development of suitable and acceptable adaptation strategies, to address issues which may impact on the health and welfare of diverse human populations across the region.

5. Participatory consultation with a range of stakeholders highlighted the need for better, more equitable water allocation and management strategies, along with more public and professional awareness-raising campaigns.

POTENTIAL ADAPTATION STRATEGIES

Following extensive consultation at the local, national and regional levels, a number of adaptation strategies have been identified for further investigation:

- Develop management strategies to cope with changes in water availability
- Review approaches to techniques in the design of infrastructure, dams, irrigation schemes etc.
- Investigate change in cropping patterns, identify new, less climate-sensitive varieties
- Promote social networks of knowledge transfer and support
- Evaluate changes in location of fishing activities, development of community fish ponds
- Investigate appropriate alternative locations of tourism activities and options
- Review animal husbandry techniques, and development of new breeds
- Migration – need to prevent further rural depopulation

POLICY RECOMMENDATIONS[1]

- Build awareness of the impacts of climate change
- Encourage more participation in the development of climate response policy
- Promote better monitoring and data collection about conditions in upper mountain areas
- In key areas, introduce participatory surveys on selected indicators of climate change
- Develop mechanisms to support and promote adaptation strategies
- Investigate potential for water saving techniques
- Encourage the development of experimental cropping (in conjunction with the Ministry of Agriculture)
- Investigate potential for early warning
- Investigate scale of impacts on infrastructure in key basins
- Assess appropriate infrastructure responses
- Investigate potential need for water storage facilities
- Facilitate the introduction of a comprehensive (environmentally friendly, participatory, equitable) water use act by the government
- Support more integration and coordination between government departments, NGOs, etc., and development of a comprehensive mountain database
- Encourage the implement of participatory catchment conservation projects, and afforestation programmes near glaciers
- Promote and foster existing social heritage in tourism development
- Identification of risk levels associated with hydrological accidents and other natural disasters, in specific geographical locations
- Enable more participation by women and marginalized people, including lower caste groups, and encourage their empowerment and support
- Research findings should be disseminated widely to people at all levels of society, not just policy makers. Children are important recipients of knowledge about climate change impacts and adaptation strategies

[1] These are based on consultation outputs from local and national stakeholders. Full details can be found in Sullivan et al. (2004), *An assessment of the potential impacts of climate-induced deglaciation on communities in the Hindu Kush Himalaya*. CEH, Wallingford, UK.

This publication is an output from the SAGARMATHA research project (R7980), funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID.
Full details of this work can be found in the SAGARMATHA Final Technical Report, Rees et al, 2004, CEH. Wallingford, UK.

5.4.3 Results of the International consultation and dissemination workshop, New Delhi, India, April 27th-28th, 2004

During this workshop, an overview of the current situation relating to deglaciation in selected countries of the HKH region was given. These are summarised below and they provide some insight into how water resources may be impacted by climate change in different parts of the region.

- **India**

In India there are some 5000 glaciers, and about 50% of streamflow in the Himalayan foothills is said to come from snow and ice. 64% of the total water resources for India come from the three main river systems, Ganges, Brahmaputra and Indus. In all of these basins, the response to climate impacts will be greater near the glaciers, and there appears to be a likelihood of significant increases in runoff under higher temperature conditions. Current Landsat satellite data suggests that the retreat of the glaciers is likely to give rise to more flooding, but much more site specific information is needed for water resource planning. In contrast to this, in recent years low flows in major river systems have had the effect of reducing the output from hydropower plants by as much as 50% in some cases.

- **Nepal**

Nepal is characterised by very variable topography and a wide range of annual mean temperatures. There is some evidence of a rising trend in maximum temperatures, although minimums are little changed. These trends are most clearly seen in the post monsoon period and these impacts are exacerbated at higher altitudes. Overall the most significant issue for livelihoods is the much greater degree of seasonal variation which presents problems for farmers and water managers.

In Nepal, there are some 3252 glaciers (5323 sq kms) and many have been showing some evidence of retreat, in some cases almost 10m/yr. This suggests there is currently a decline in glacier mass balance, with implications for current and future water volumes in the catchment. In general, glacier lakes are growing in size and the observed hydro-meteorological and glaciological data in Nepal tends to support the model findings indicating a degree of glacial retreat with subsequent impacts on water resources. In some areas, glacier lakes have become very unstable, and in 26 cases these have been identified by the IUCN as 'very dangerous' since the risk of outbursts (*glofs*) is high. Several examples of 'glofs' were given, including the most severe in 1998. Some attempts to find a technical solution, including siphoning of water from the lakes and attempts to generate power from them, have been tried but with no real success. As a result, the development of early warning systems has begun with an investment of over 1M rupees to establish 19 sirens and 2 operational offices.

- **Bangladesh**

The whole of the country is subject to high level of water availability, including frequent flooding. In all river basins, precipitation is increasing in all rivers with corresponding increases in runoff. There are big impacts from seasonal variation and, as there has been an increase in total rainfall over the last 5 years, the 5yr discharge rate at the Ganges/Brahmaputra confluence is increasing. In spite of this, there has been in some areas a reduction in flow rates following the 1977 water sharing treaty which resulted in more upstream abstraction from the rivers. This is thought to have significant impacts on the Sunderbans wetland delta area. The actual impacts that

have been observed include bank erosion, loss of trees and crops, non-potable river water, saline intrusion, water logging of channels, dry season drought and persistent floods. In 1998, 73% of the country was flooded and, in an average year, some 22% of the country is flooded. Drought also affects some 25% of the country, and large areas are also subject to arsenic contamination. In 1999, salinity reached a record level, likely to increase in the event of sea level rise.

- **Bhutan**

Bhutan is an area where much study has been made of glaciers. There are 677 glaciers in the country of which 24 are potentially dangerous. Concern has grown over this issue since a large glacial lake outburst flood occurred in 1994. In 1974 and 1981, aerial surveys were carried out and glacier shrinkage has been estimated at an average of 8.1%. These studies have tried to identify triggers of outburst floods and better modelling may help to reduce risk and identify safe places for plant construction.

5.4.3.1 Climate risks and adaptation strategies – consultation results

Sectoral group discussions

Group discussions were held on hydropower, food security, and commerce and tourism, and the views expressed are summarised below:

5.4.3.2 Hydropower

Potential impacts

- Changes in water availability will influence the efficiency of hydropower projects
- Management strategies will be needed to cope with changes in water availability, but this is not likely to influence employment levels significantly
- Changing water levels may influence livelihoods and work activities, business profitability and migration levels
-

Potential adaptation strategies

- More accurate assessment of the links between deglaciation and climate change
- More testing of models needed
- Better understanding of the links between deglaciation and water availability
- More accurate meteorological data needs to be collected at high altitudes.
- Scope for participatory monitoring of ecosystem indicators
- Long term monitoring and database needed on discharge rates and suspended sediment

5.4.3.3 Food security

Potential impacts

- Risks perceived in terms of fluctuation in flows, span of seasons, extreme events – likelihood of reduction in efficiency of food production through crop loss and yield reduction.
- Flooding, crop damage, erosion and change in water quantity and quality may lead to the need to change location of farming activities
- Need for less climate sensitive varieties (mango, apple) as farm incomes will decline with loss of yield
- In both agriculture and fisheries these impacts may result in reduction in employment

Potential adaptation strategies

- Change in cropping pattern and introduction of new varieties
- Resettlement and employment opportunities
- Implementation of more integrated policies

5.4.3.4 Commerce and tourism

Potential impacts

- Disruption of infrastructure if more extreme events occur
- Transport, power and water systems impacted
- Production and revenue decline
- Employment levels down
- Tourism patterns changing

Potential adaptation strategies

- Construction of all weather roads and strengthened services
- Increasing capacity of water storage
- Shifting of business interests
- Technological advances

5.4.3.5 Individual responses

a. The nature of mountain livelihoods

Should include farming, tourism, external remittances, small scale industry and handicrafts. Key issues suggested by stakeholders were: livestock, fisheries, carpentry, portering, skilled and unskilled labour, and the need for more basic education services and an improved understanding of the impacts of climate change.

b. Current problems in mountain communities

Depopulation, unemployment, the unpredictability of seasons and poverty were agreed as the main issues. Other problems highlighted included low literacy rates, inequity in land distribution, the caste system, a lack of medical facilities, and poor communications and infrastructure development. Environmental problems such as deforestation, extreme events, soil erosion and lack of capacity in natural resource management were seen to be exacerbating the situation.

c. Research findings to be included

- Modelled outputs suggesting changes in water availability
- Potential impacts on communities
- Potential adaptation strategies which would be suitable and acceptable
- Issues which are important for health and welfare of human populations
- Importance of traditional knowledge
- The need for more awareness raising re. climate change impacts

d. Policy recommendation suggestions

There was seen to be a need to build public awareness of climate change impacts, and it was felt that mechanisms to support and promote adaptation strategies should be developed. More participation in development of climate response policy is recommended, along with more surveys of key indicators, especially in high altitude areas. Potential need for water storage facilities and water saving techniques need to be examined, along with the impacts of climate change on infrastructure.

e. Other suggestions for inclusion made by individuals were:

- Consider technological in addition to socio-economic alternatives
- Make domestic water supply available to all people
- Intensify adult education
- Create storage reservoirs
- Establish small-scale industries requiring less water
- Development of a mountain database with regular monitoring
- Increase/improve social networking
- Mitigation at the global level is required
- Needs long-term strategic planning
- Create a common framework for analysis and integration of data/information
- Assess the impact of land use changes on water resources in mountain regions
- Government should provide ‘disaster shelters’
- Improve the standard of living in mountain communities
- Promote tourism as an employer both seasonal and throughout the year
- Reduce pollution by reducing the influence of ‘outside communities’ such as tourists - ‘shift the interest of tourists’ - create new employment opportunities for local people

5.4.4 Conclusions and recommendations from the Delhi workshop

On the basis of the sectoral discussions held during the workshop, it seemed to be considered that all sectors of the economy are likely to be impacted by deglaciation. There was less certainty about commercial outcomes, and more risk associated with livelihoods. Key infrastructure will be at risk and measures should be taken to strengthen these. Disruption to economic activity may be expected as a result of more frequent extreme events. Measures should be taken to improve water management to take account of competing needs. Diversification of crops, increases in water storage and building stronger institutions were all considered to be worthwhile.

5.4.5 Summary of recommendations made on the basis of responses from the participants at the regional consultation workshop, Delhi

1 Build awareness of the impacts of climate change
2 Develop mechanisms to support and promote adaptation strategies
3 Participatory survey on selected indicators of climate change implemented in key areas
4 More participation in development of climate response policy
5 Better monitoring and data collection about conditions in upper mountain areas
6 Investigate potential for water saving techniques
7 Investigate potential need for water storage facilities
8 Encourage the development of experimental cropping (in conjunction with the Ministry of Agriculture)
9 Investigate scale of impacts on infrastructure in key basins
10 Investigate potential for early warning
11 Assess appropriate infrastructure responses

5.4.6 Policy briefing note from the Delhi workshop

Climate Change, Water Resources and Livelihoods in the Himalayas

POLICY BRIEFING NOTE

Water resources and mountain systems

There is compelling evidence that climate change is a widespread problem with serious consequences for water resources around the world, and more than half of humanity relies on the freshwater that accumulates in mountains. The Hindu Kush-Himalayan (HKH) mountain region stretches across eight countries, is home to more than 140 million people, and influences the lives of three times as many in the plains and river basins below. The snow and glaciers of the HKH provide up to 90% of the lowland dry-season flows of the Indus, Ganges and Brahmaputra rivers and their vast irrigation networks. Scientists are studying the retreat of Himalayan glaciers and, although uncertainty exists, the consequences of deglaciation on water resources in the region could have serious consequences for the environment, national and regional economies, and for the day to day lives of many millions of people. To cope with these predicted and potential changes, and in the face of the increasing demands on water resources from growing populations and economic development, the effective management of mountain water resources is essential. Policies and adaptation strategies need to be developed and achieved in consultation with different stakeholders, considering the ideas, experience and knowledge of local people and scientists, as well as government and non-government organisations.

Current issues in mountain communities

Communities in mountain regions face many problems such as poverty and inequity, depopulation, unemployment, a lack of healthcare and educational facilities, and poor infrastructure. People across the HKH region share these problems which are exacerbated by environmental issues such as the unpredictability of seasons, extreme events (e.g. floods, storms, droughts), deforestation, soil erosion, and a lack of capacity in natural resource management. Water is vital for all kinds of economic and livelihood activities and any changes in the quantity, availability and quality of water resources would add to the current social, economic, and environmental problems faced by populations across the region.

Research findings

The SAGARMATHA project[1] has made an assessment of the potential impacts of deglaciation on the water resources of the Himalaya and on the livelihoods of people in the region. This has been achieved through the development of hydrological modelling and livelihood assessment and with the involvement of many stakeholders across the region. The studies have found that:

1. Changes in water availability in Himalayan Rivers as caused by deglaciation can have direct and indirect impacts. An increase in river flows can affect human activities in many ways through flooding, landslides and the destruction of water delivery systems. Reduced water availability creates water shortages for water-dependant activities such as agriculture, fisheries, hydropower, industry, domestic water supply and water transportation.

2. For many areas, the catastrophic water shortages forecast by some experts are unlikely to happen for many decades, if at all. Rather, some areas may benefit from increased water availability in the medium-term. Areas where glacial meltwater contributes significantly to river flow, such as in the upper Indus, however, appear to be vulnerable to deglaciation and this could have serious consequences for water availability and use throughout the basin. Eastern Himalayan areas, benefiting from high summer monsoon rainfall, are less susceptible to droughts, but more likely to experience flooding.

3. In the longer term, a reduction in water supply from the mountains could affect the economy of the region by limiting the energy from hydropower plants and hampering industrial productivity. However, while deglaciation may hinder economic development nationally, the impacts are likely to be hardest felt at the local level by the most vulnerable in society, particularly the women and children of poor families, and the communities most vulnerable are those living at higher and middle altitudes and dependent on their crops, livestock, and small-scale industry.

4. The impacts of deglaciation, and other effects of climate change, will vary considerably with time and specific location across the HKH region. The research has also highlighted the uncertainty associated with climate research and emphasises that care must be taken when interpreting the results.

[1]Rees *et al*., *SAGARMATHA: Snow and Glacier Aspects of Water Resources Management in the Himalayas*, CEH Research Report 2004.

POTENTIAL ADAPTATION STRATEGIES

Following extensive consultation at the local, national and regional levels, a number of adaptation strategies have been identified for further investigation:

- Improve long-term monitoring, data collection, and modelling of the links between climate impacts and hydrological regimes
- Carry out research into alternative cropping patterns and crop varieties
- Increase water storage capacity
- Promote water saving techniques in all sectors
- Develop early warning systems to give longer warning of forthcoming events, hail storms etc.
- Diversify employment opportunities in upland areas
- Improve and expand planning of communications & infrastructure to take account of potential impacts of changes in river flows
- Develop integrated, equitable & sustainable water resource management strategies
- Promote institutional networking and development
- Empower women and marginalized communities to have more inputs into water policies

POLICY RECOMMENDATIONS[2]

It is considered that deglaciation could impact on all sectors of the regional economy and on many people's livelihoods and that mechanisms to support and promote appropriate adaptation strategies need to be developed to face these challenges. These strategies will need to be site-specific and aimed at creating sustainable livelihoods for all people across the HKH region, particularly the poorest.

- There is a need to improve systems of data collection and modelling to reduce uncertainty
- In key areas, introduce a survey on selected indicators of climate change, to improve monitoring of conditions in upper mountain areas
- Investigations should be carried out to assess the potential for the introduction of water saving techniques, and to identify the need for water storage facilities
- Assessments of the scale of impacts on infrastructure in key basins is needed
- Development of experimental cropping and new crop types are recommended
- General awareness-raising of climate change impacts is needed, and specific training about climate change mitigation should be given to key persons and institutions
- Alongside scientific and technical approaches, it is particularly important to take a more participatory approach in the development of climate response policy
- There is a need for an assessment of the potential benefits of early warning systems for extreme events, and providing better communication of forthcoming hailstorms etc.
- Long-term and appropriate strategies are required that will build stronger institutions and improve water management to take account of competing needs

[2] These are based on consultation outputs from local and national stakeholders. Full details can be found in Sullivan et al. (2004) *An assessment of the potential impacts of climate-induced deglaciation on communities in the Hindu Kush Himalaya*. CEH, Wallingford, UK.

This publication is an output from the SAGARMATHA research project (R7980), funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID.

6. Conclusions from the project

6.1 Summary

The main objective of this part of the overall project was to identify how people in mountain communities are likely to be impacted upon by changes in water resources resulting from climate-induced deglaciation. Budgetary and other limitations meant that specific study was restricted to Nepalese communities and larger scale stakeholders in Nepal, with inputs from other countries being made through desk studies, literature reviews, and workshop consultations. While the results from the Nepali study may provide some generic insight into how mountain communities may be influenced by deglaciation-induced changes, it must be noted that such impacts will vary considerably according to site specific variation across the region.

In general, the findings can be summarized as follows:

- Climate change is likely to impact on water resources, and the severity of this impact will vary with both spatial and temporal scales;
- Millions of very poor people may be affected by significant changes in water availability, and by more extreme events in the medium and longer terms;
- People in the higher altitudes are most likely to be effected by climate change, but there are significant differences in these effects ranging from east to west across the region;
- Local communities are already aware of climate/weather induced changes in an anecdotal way;
- Appropriate mitigation and adaptation strategies are needed, and community responses to these strategies may be influenced by social and economic factors;
- 'Appropriate' here means what is relevant and suitable for the very diverse communities dependent on the water resources flowing from the Himalayas. The variation in both impact and response to climate change across the region cannot be overstressed. Not only are water resources very site specific, but the cultural and ethnic diversity across the region are also very significant and will influence how people will respond to different situations.

While some attempt has been made to examine these impacts at different scales, much more work needs to be done if a more comprehensive understanding of these issues is to be achieved. It is suggested that the kinds of activities carried out in this study could be carried out in other parts of the region, and, in this way, greater account could be taken of local stakeholder considerations in other areas. The key issues expressed by participants in the consultation process have been considered and, in Table 20, examples are shown of how attitudes to these issues vary according to the scale of enquiry. While building awareness of the impacts of climate change was seen as the most important issue at both the national and regional (supra-national) scales, better monitoring in high altitude zones, and more participation in monitoring and policy development were seen as being more important at the local and national level than they were at the larger regional scale. At this larger scale, more emphasis was put on mechanisms to support and promote adaptation strategies, and to develop greater storage facilities to cope with increasing seasonal variation. This is an interesting reflection of the fact that local people want to be much more involved in water resources planning and management than they are at present, while at the same time,

there is a clear appreciation of the need for more strategic issues to be addressed at a larger scale.

Specific information on how the project contributes to DFID's development agenda, and how its outputs can be shared with beneficiaries and target institutions, are considered below. In addition, we make some recommendations for further work and we have crystallized the core of these findings in the policy briefing notes.

Table 20. *A comparison on how key issues have been ranked in importance by participants in the national and regional consultation workshops*

	NEPAL RESPONSES		INDIA RESPONSES
1	Build awareness of the impacts of climate change	1	Build awareness of the impacts of climate change
2	More participation in development of climate response policy	2	Develop mechanisms to support and promote adaptation strategies
3	Better monitoring and data collection about conditions in upper mountain areas	3	Participatory survey on selected indicators of climate change implemented in key areas
4	Participatory survey on selected indicators of climate change implemented in key areas	4	More participation in development of climate response policy
5	Develop mechanisms to support and promote adaptation strategies	5	Better monitoring and data collection about conditions in upper mountain areas
6	Investigate potential for water saving techniques	6	Investigate potential for water saving techniques
7	Encourage the development of experimental cropping (in conjunction with the Ministry of Agriculture)	7	Investigate potential need for water storage facilities
8	Investigate potential for early warning	8	Encourage the development of experimental cropping (in conjunction
9	Investigate scale of impacts on infrastructure in key basins	9	Investigate scale of impacts on infrastructure in key basins
10	Assess appropriate infrastructure responses	10	Investigate potential for early warning
11	Investigate potential need for water storage facilities	11	Assess appropriate infrastructure responses

6.2 Contribution to DFID's developmental goals

The major DFID goal associated with this project is W1 – *Improved assessment, development and management of water resources*. This project has contributed to this goal by developing a more integrated modelling approach by which more accurate and spatially distributed assessments can be made of water resources in snow-fed catchments.

It has also contributed to this goal in so far as it facilitates better future management of those resources by raising awareness about the key issues, and by enabling key stakeholders and communities to discuss possible future options for such management.

6.3 Promotion of outputs to client institutions and beneficiaries

The major beneficiaries of this project are the millions of people living in the Indo-Gangetic plain who depend on water resources which originate in the Himalayas. By improving our understanding of the impacts of changes in the level of meltwater runoff, it becomes more possible to anticipate and cope with potential difficulties in the future. The more reliable estimates of water availability which result from the project outputs will help water authorities, hydropower companies, and farmers to make more informed decisions about water allocation and use. Hopefully, this will also result in a more informed stakeholder body and more effective water resource management at both the local and basin scale. By ensuring future water resource decisions are made in the light of better information about climate change, it is likely that the needs of the most vulnerable groups (women, children and the poorest of the poor) will be addressed.

As a result of the stakeholder consultation and dissemination workshops held at the local, national and regional scales, it is hoped that the project results and conclusions will be incorporated into the long-term strategic plans of appropriate authorities. In addition to the participation of staff from these institutions, the findings have also been distributed in the form of a workshop CD distributed to all participants, and in the form of more formal 'policy briefing notes' which have been explicitly drawn up in a participatory manner for widespread dissemination to all relevant institutions and beneficiary groups.

Other beneficiaries from the project include the many researchers from the participating institutions in India and Nepal who have had the opportunity to benefit from the capacity building element of the project. Furthermore, the integrated database developed for the Modi Khola will also be a useful output which can be made use of by future researchers.

6.4 Follow-up research to promote findings to achieve development benefit

In order to maximise the benefits from the study, there is much potential to provide greater awareness-raising through additional dissemination workshops. These have not been budgeted for in this project, but it would be extremely beneficial to plan and deliver such events in other parts of the region, notably Pakistan, Bhutan and Bangladesh. It is hoped that some future funding opportunity may provide the chance to take this issue further in the future. It is also hoped that this could provide resources by which these outputs could be translated into appropriate languages.

6.5 Further studies

There is little doubt that there is much need for further studies. Huge uncertainties associated with both meteorological and hydrological modelling mean that the results from this project need to be verified to build confidence in the findings. On the basis of the recommendations from the workshops, it is clear that communities are keen to be more explicitly involved in water resource planning and the development of climate policies. Much more awareness raising has been called for at all levels. One particular area of interest which would benefit from further work would be the development of participatory monitoring of key indicators in high altitude zones. In addition, there is a clear need for strategic research into cropping patterns and crop types to cope with future climate change impacts.

6.6 Availability of outputs to intended users

All the outputs from this part of the project are listed in Appendix 4 of this report. Full size posters have been distributed to project beneficiaries in Nepal, India, Bhutan and Bangladesh. Representatives from the other HKH region countries will be sent the CD of the workshop findings and other outputs, and they will be able to print these and use them as they wish. Other material will also be available from the project website.

6.7 Project policy briefing notes

As a mechanism to provide maximum opportunity to deliver research findings in a succinct way to policy makers and other stakeholders, two-page policy briefing notes have been generated for distribution. One of these is specifically targeted at institutions in Nepal, while the other is aimed at a wider audience across the HKH region. If it were considered appropriate, it would be useful to translate these to relevant languages for wider distribution.

7. References

Alford, D., 1992. Hydrological Aspects of the Himalayan Region, ICIMOD Occasional Paper No. 18, Kathmandu, 1992, 68pp

Ali, A., 1999. Climate change impacts and adaptation assessment in Bangladesh. Climate Research, CR Special 6, 12(2/3), pp 109-116.

Arnell, N.W., 1999. Climate change and global water resources. Global Environmental Change, 9(1999). S31-S49.

Bartarya, S. K., 1991. Watershed management strategies in the Central Himalaya: the Gaula River Basin, Kumaun, India. Land-Use Policy. 1991. 8(3), pp. 177-184.

Bhaskarn, B. and Mitchell, J.F.B., 1998. Simulated changes in southeast Asian monsoon precipitation resulting from anthropogenic emissions. International Journal of Climatology, 18, pp. 1455-1462.

Braun, L.N, Grabs, W. and Rana, B., 1993. Application of a conceptual precipitation-runoff model in the Langtang Khola Basin, Nepal Himalaya. In: Snow and Glacier Hydrology, Proc. Kathmandu Symposium, November 1992. IAHS Publ. No. 218, 1993. pp 221-237.

CBS, Central Bureau of Statistics, Nepal, Population census, 2001

Chu Ko-Chan, 1973. A preliminary study on the climate fluctuations during the last 5000 years in China. Scientia Sinica, 16, pp. 226-256.

Conway, D., Bhattari, K. and Shrestha, N.R., 2000. Population-environment at the forested frontier of Nepal. Applied Geography, 20, pp 221-242.

DFID (2000) *Target Strategy Paper: Water Resources and Sanitation* London

Down To Earth, 1999. Analysis – Glaciers Beating Retreat, 7(23), April 1999.

FAO, 1999. The State of Food Insecurity in the World 1999. Food and Agriculture Organization of the United Nations, Rome, Italy, 32pp.

Frederick, K.D., Major, D.C. and Stakhiv, E.Z., 1997. Water resources planning principles and evaluation criteria for climate change: Summary and Conclusions, Climatic Change, 37: 291-313.

Frontline, 2001. The receding Gangotri. Frontline, 18(7) March 31 – April 13, 2001.

Gomez-Landesa, E., Rango, A. and Hall, D.K., 2001. Improved snow cover remote sensing for snowmelt runoff forecasting. In: Remote Sensing and Hydrology 2000. Proc. Santa Fe Symposium, April 2000. IAHS Publ. No, 267, 2001. pp. 61-65.

Goudie, A., 1983. Environmental Change. Second Edition. Clarendon Press, Oxford. 258 pp.

Grabs, W.E. and Pokhrel, A.P., 1993. Establishment of a Measuring Service for Snow and Glacier Hydrology in Nepal – Conceptual and Operational Aspects. In: Snow and Glacier Hydrology, Proceeding of the Kathmandu Symposium, November 1992. IAHS Publ. No. 218, 1993, pp. 3 –16.

Haberli, W and Hoelzle, M., 2001. The World Glacier Monitoring Service. (http://www.nerc-bas.ac.uk/public/icd/icsi/WGMS.html)

ICIMOD, 2000. Climatic and Hydrological Atlas of Nepal (ed. by S.R.Chalise), International Centre for Integrated Mountain Development, Kathmandu, Nepal.

Iglesias, A., Erda, L. and Rosenzweig, C., 1996. Climate change in Asia: a review of the vulnerability and adaptation of crop production. Water, Air and Soil Pollution, 92, pp 13-27.

IPCC, 1996b. Climate Change 1995. Impacts, Adaptation and Mitigation of Climate Change: Scientific and Technical Analyses. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. [Watson, R.T., Zinyowera, M.C. and Moss, R.H. (eds.)] Cambridge University Press, Cambridge, 1996. 879pp.

IPCC, 1998. The Regional Impacts of Climate Change: An Assessment of Vulnerability. Special Report of IPCC Working Group II Intergovernmental Panel on Climate Change. [Watson, R.T., Zinyowera, M.C. and Moss, R.H. (eds.)] Cambridge University Press, Cambridge, 1998, 517pp.

IPCC, 2001a. Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. [McCarthy, J.J., et al. (eds)]. 1032 pp.

IPCC, 2001b. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. [Houghton, J.T., et al. (eds)]. 881 pp.

Ives, J.D, and Messerli, B., 1989. The Himalayan Dilemma: Reconciling Development and Conservation. Routledge, London, UK. 336 pp.

Khanal, N.R., Rijal S.P & Shrestha M., 2003. Water and Livelihoods in Mountain Areas: Livelihood Impact Analysis of Deglaciation in the Modi/Kaligandaki River Corridor. SAGARMATHA Project Report. CEH Research Project.

King, John M.. - Livestock water needs in pastoral Africa in relation to climate and forage /. - Addis Ababa : International Livestock Centre for Africa, 1983. - (ILCA research report ; no.7)

Lamb, H.H., 1970. Volcanic dust in the atmosphere: with a chronology and assessment of its meteorological significance. Philosophical Transactions Royal Society of London, A, 266, pp. 425-533.

Lowe, A and Collins, D.N., 2001. Modelling runoff from the large glacierized basins in the Karakoram Himalaya using remote sensing of the transient snow line. IAHS Publication no. 267

Matthews, R.B., Kropff, M.J., Bachelet, D. and Van Laar, H.H., 1995. Modeling the Impact of Climate Change on Rice Production in Asia. International Rice Research Institute (Philippines) and CAB International, Wallingford, Oxon., UK, 289pp

McMichael, A.J., Haines, A., Slooff, R. and Kovats, S. (eds.), 1996. Climate Change and Human Health. WHO/EHF/96.7, prepared on behalf of the World Health Organization, the World Meteorological Organisation and the United Nations Environment Programme, Geneva, Switzerland. 297pp.

Messerli, B. and Ives, J.D. (Eds.), 1997. Mountains of the World – A Global Priority. A contribution to Chapter 13 of Agenda 21. The Parthenon Publishing Group, London. 495 pp.

MNES, 2001. Ministry of Non-Conventional Energy Sources, Government of India, World Wide Web site (http://mnes.nic.in/poten.htm)

Mountain Agenda, 1998. Prepared for the UN Commission on Sustainable Development 1998 Spring Session 'Strategic Approaches to Freshwater Management', Inst. Geog., University of Bern, Switzerland.

Nepal Energy Agency (2003) *Generation*, Vol. 1

New Scientist, 1999. "Flooded Out: Retreating glaciers spell disaster for valley communities", 5th June, 1999, p. 18.

New Scientist, 2001. "Total Meltdown", New Scientist Archive (http://archive.newscientist.com/), 9 June 2001.

New, M.G., Hulme, M. and Jones, P.D., 2000. Representing twentieth-century space-time climate variability. Part II: Development of 1901-1996 monthly grids of terrestrial surface climate. Journal of Climate 13, pp 2217-2238.

Pebley, A.R., 1998. Demography and the environment. Demography, 35 pp 377-389.

Pretty, J., Guijt, I., Thompson, J. and Scoones, I. (1995) Participatory Learning and Action: A Trainer's Guide. IIED, London.

Ramakrishnan, P.S., Purohit, A.N., Saxena, K.G. and Rao, K.S., 1994. Himalayan Environment and Sustainable Development. Diamond Jubilee Publication of the Indian National Science Academy, New Delhi, India,. 84pp.

Rijal, S.P. 2002. Water and Livelihoods in Mountain Areas: A Case Study of Modi Khola Watershed, Nepal. SAGARMATHA Project Report. CEH Research Project.

Sharma, S., 2001. The Ganges Crisis – Government lacks strategic plan. In Proc.: Bonn 2001- International Conference on Freshwater., Bonn, Germany, 3- 7, December 2001.

UNICEF, 1999. UNICEF Statistical Data. United Nations Children's Fund, New York, USA.

World Bank, 1997. World Development Indicators. World Bank, Washington DC, USA. 231 pp.

World Bank, 2000. The World Bank Group – India Country Brief 2000.

World Glacier Monitoring Service (WGMS) (1998) Into the second century of worldwide glacier monitoring – prospects and strategies. (Eds. Haeberli, W., Hoelzle, M. and Suter, S.). UNESCO Studies and reports in hydrology No. 56.

Worldwatch News Brief (2000) Melting of Earth's Ice Cover Reaches New High, March 2000

Appendices 1 - 4

Appendix 1: Survey Methodology & Instruments

A1.1 Water and Livelihoods in Mountain Areas: Conceptual Framework

A1.2 Household Survey Questionnaire

A1.3 Participatory Rural Appraisal (PRA) Procedure

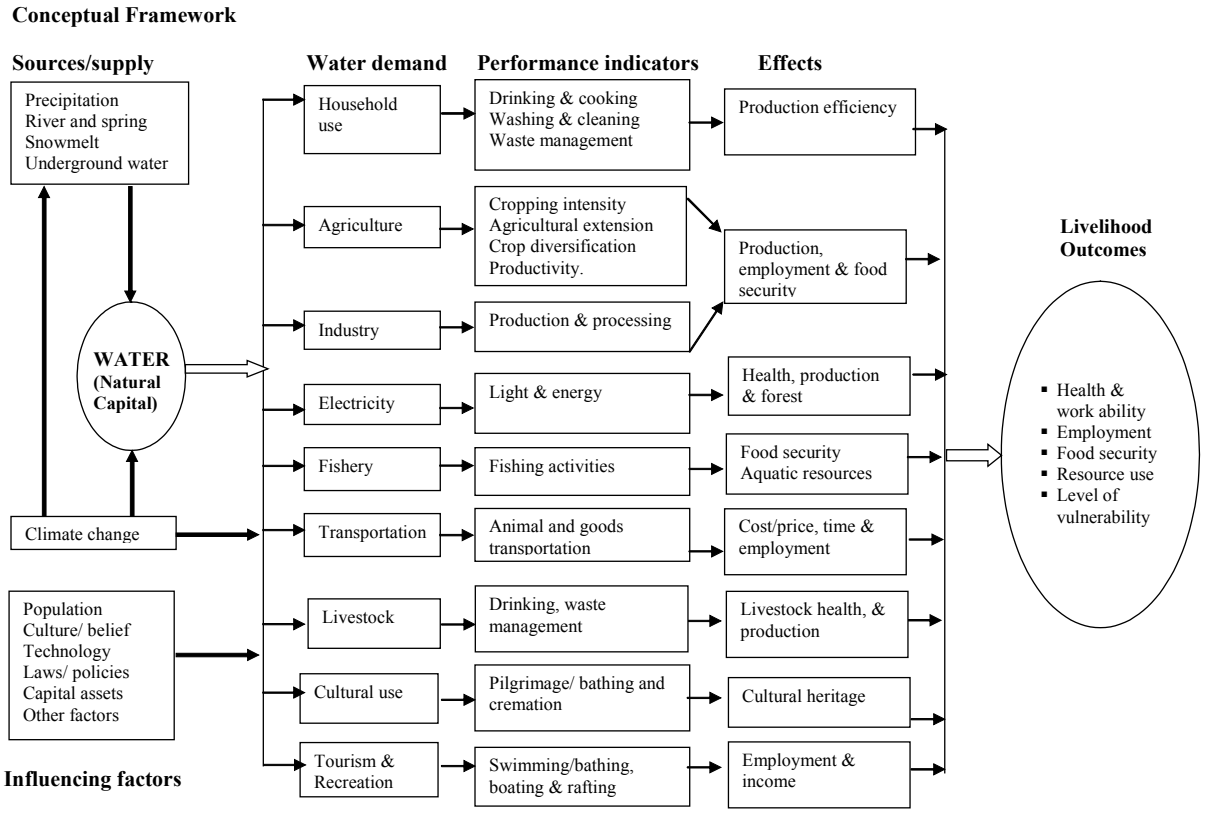
A1.4 Check list for group discussion/PRA and recording schedule for water use survey

A1.5 Table of group participants by survey settlement

A1.6 Photographs: Community Survey/Water Use Inventory

Appendix 1.1

Water and Livelihoods in Mountain Areas: Conceptual Framework



Appendix 1.2
Household Survey Questionnaire

Water and Livelihoods in Mountain Areas
(Questionnaire for Household Survey)

1. Background information
   Date of Survey: ……Name of the interviewer: ……
   District: …… VDC:…… Village…….……. House No……
   Name of the Respondent:……
   Ethnicity:……. Religion:……. Mother tongue:……

2. House type and ownership
   Roof type:……..Wall type: ……..Window type:…….…….…… Floor type…….. Number of room:…..……
   Story:…… ……. Ownership: a) Own b) Rented

3. Facilities available in the house
   a) Radio b) Television c) Wall clock d) Electricity
   e) Wall mirror f) Bio-gas plantg) Improved stoves h) Solar power
   i) Water tap j) Improved latrine k) Refrigerator l) Sewing machine
   m) Furniture (chair, table, cupboard etc.) n) Others (specify)……..

4. Migration: a) Native b) Migrant

   If migrant: a) Year of in-migration: …… b) Place of origin :…….……
   c) Place of birth if different…… d)Reasons for migration:.……
   ……

5. Family size: Total family members……Member present…… Member absent……

SN	Family members	Age	Sex	Marital status	Education	Occupation		Working outside village			Remarks
						Primary	Secondary	Work Place	Duration	Earning (monthly)	
1	Head										
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											

Note: Marital status: 1 = unmarried, 2 = married, 3 = widow/widower, and 4 = divorced
Work place: 1 = within VDC, 2 = outside VDC within district, 3 = other district within country, and 4 = other countries

6. Land distribution by ownership (in Ropani)

Ownership	Khet	Bari	Kharbari	Pasture	Forest	Abandoned land	Other if specify
Own land							
Land rented in							
Land rented out							
Total land							

7. Area and production of major crops by irrigation status

Crops	Irrigated area				Non irrigated area			
	Local seed		Improved seeds		Local seed		Improved seed	
	Area	Production	Area	Production	Area	production	Area	Production
Paddy								
Maize								
Wheat								
Barley								
Potato								
Vegetables								
Fruit orchards								
others								

8.Is there any difference in productivity of crops between areas irrigated from Modi River and other rivers? a) Yes b) No

If yes, how much and why?

…….....

9. Area by cropping intensity and irrigation status (in Ropani)

Irrigation facility	One crop	Two crops	Three crops
Through out the year			
Only in rainy season			
Only in winter season			
No irrigation at all			

10. Use of agricultural inputs by irrigation status:

Major crops	Labor (Number)	Manure		Chemical fertilizer		Pesticides	
		Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated
Paddy							
Maize							
Millet							
Wheat							
Barley							
Potato							
Others....							

11. Changes in area and productivity of major crops (within 10 years)

Major crops	Area		Productivity	
	Increased/decreased/same	Reasons for change	Increased/decreased/same	Reasons for change
Paddy				
Maize				
Millet				
Wheat				
Barley				
Potato				
Others				

12. Types and number of trees in private land

Types	Number by types	
	At present	10 years ago
Fruit trees		
Fodder trees		
Other trees		

13. Livestock: Number by types

Types	Number		Types	Number	
	Local	Hybrid		Local	Hybrid
Cow			Sheep		
Oxen			Pig		
Yak/Nak			Horse/Mule		
She buffalo			Chicken/Duck		
He buffalo			Pigeon		
Goat			Others (specify)……		

14. Animal grazing (place, duration and distance):

Types	Number	Place	Duration	Distance from house
Cow/oxen				
Yak/Nak				
Buffaloes				
Goat				
Sheep				
Others				

Total man days spent for animal grazing (yearly):…….

15. Who graze the animal (% involvement)
a) Male …… b) Female ….……c) Children …. ...……d) Whole family……...

16. If transhumance is practiced, specify the rotation and movement cycle……..
……

17. Production and sale of livestock, and livestock products (last year)

Product types	Production quantity	Amount sold	Changes in production during 10 years		
			More	Less	Same
Milk products					
Meat					
Egg					
Live animals					
Wool					
Skin/hide					
Others…..……..					

18. Food sufficiency by own production in months: a) At present…… b) Ten years ago…… If changed, causes of change:
……

19. If deficit, how you manage?: ……..……
…….
.....
....

20. If surplus, how do you use?

a) Exchange other goods c) Store for next years

d) Sale in local markets: Place……e) Other uses (specify)……..…

21. Persons affected by common diseases (last years)

Waterborne diseases	Persons affected	Other diseases	People affected
Diarrhea		Whooping cough	
Dysentery		Tuberculosis	
Typhoid		Asthma	
Jaundice		Common cold	
Worms		Pneumonia	
Scabies		Eye irritation	
Others……..		Others……	

22. Industrial production (last year)

Types	Employment	Duration of operation	Production	% sale	Remarks
Brick and tile					
Cement blocks/Hume pipes					
Liquor making					
Wool materials					
Leather materials					
Jute Materials					
Paper making					
Limestone (Chun)					
Wooden materials					
Bamboo materials					
Ghatta (water mill)					
Power generation					
Metal works					
Candle making					
Others……..…….					

23. Sources of energy

Types	Purpose of use				Remarks
	Lighting	Heating	Cooking	Production purposes	
Fuel wood					
Kerosene					
Electricity					
Bio-gas					
Solar power					
LPG gas					
Others …….					

24. Annual expenditure of last year (%)

Food…….. . Clothing……

Education……..Health…… Transport…… Fuel wood ……

Tax/donation…… Wages……. Electricity/kerosene…….Social ceremonies……. Other (specify)…….……

25. Investment during last 10 years (in Rs)

a) Land purchase…… b) Land improvements…… c) Irrigation……. d) House ……. e) Cottage industry……f) Business……..

g) Bus/trucks etc…… h) Loan to others…….. i) Others (specify)……

26. Status of loan/borrowing

Sources	Purpose	Amount	Interest rate
Banks/ Cooperatives			
Community funds			
Local merchants			
Relatives			
Other if any……			

27. Sources of family income (last year)

Source	Yes/No	Annual income (in Rs)
Crop production		
Fruits		
Vegetables		
Livestock		
Industrial production		
Business (shops)		
Tourism /hotel/ lodge		
Wages/Portage		
Service		
Remittances		
Pensions		
Rent (house and other)		
Sale of forest products		
Other sources……..		

28. Water use:

i) Agriculture (Irrigation)

Sources	Irrigated area			Canal/ pipe distance	Adequacy	If inadequate Reasons
	Year round	Summer	Winter			

ii) Use of water for household

Use type	Sources	Quantity	Quality	Distance	Adequacy	Remarks
Drinking and cooking						
Washing and bathing						
Livestock						
Others……..						

iii) Industrial use of water

Types	Source	Quantity	Distance	Adequacy	Remarks
Brick and tile factory					
Cement blocks/Hume pipes					
Liquor making					
Wool processing					
Leather processing					
Jute processing					
Paper making					
Limestone (Chun making)					
Wood carving					
Ghatta (Water mill)					
Power generation					
Metal works					
Candle making					
Bio-gas plant					
Others……..…….					

iv) Cultural and religious use of water

- Ghat a) yes b) No If yes, place……

.....
..

- Religious bath a) yes b) No If yes, place and frequency……

.....
....

- Raise/offer at temple a) yes b) No If yes, place and frequency……

.....

v) Fish/ Acquaculture a) yes b) No If yes, source…..……

.....
..

vi) Transportation

- Goods a) yes b) No If yes, place……...

.....
..

- People a) yes b) No If yes, place……...

.....
..

vii) Swimming/recreation a) Yes b) No If yes, place……...

viii) Waste management a) Yes b) No If yes, work……...

.....
..

ix) Construction works a) Yes b) No If yes, source……

.....
..

x) House cleaning/ washing a) Yes b) No If yes, source and frequency…….……

.....
..

xi) Other uses (specify)……..a) Yes b) No

……..

……
…

29. Water use conflict

Conflicts on use	Types and causes of conflicts	Frequency	Process of conflict management
Irrigation			
Irrigation and household use			
Irrigation and Industrial use			
Household use			
Household use and industrial use			
Industrial use			
Other use			

30. Participation in water use and management committee

Use type	Institutions/ committee	Membership	Types and amount of contributions
Irrigation			
Household use			
Industrial use			
Other use			

31. Water induced disaster and loss/damages of property

Types	Recurrence interval	Last event (Year)	Loss/ damages			
			Land	Crop	Animals	Other properties
Floods						
Draught						
Landslides/debris flow						
Snow/ Avalanches						
Hail storm						
Storms						

32. How would it effect you if the river flow would reduce?……..

……
…

.....
....

.....
...

33. If present source of water would not functioning, where would you get your water supply?
……
……..
.....
.
.....
..
.....
...
34. How would it influence your farming if the cold weather continued until March? ……..
..……
…
35. If the weather would become hotter, would it be good or bad for:

i)	Crops:	a) good	b) bad	c) No change
ii)	Animals:	a) good	b) bad	c) No change
iii)	People:	a) good	b) bad	c) No change
iv)	Forest:	a) good	b) bad	c) No change
v)	Infrastructure:	a) good	b) bad	c) No change

36. If there would be more rainfall, would it be good or bad for

i)	Crops	a) good	b) bad	c) No change
ii)	Animals	a) good	b) bad	c) No change
iii)	People	a) good	b) bad	c) No change
iv)	Forest	a) good	b) bad	c) No change
v)	Infrastructure	a) good	b) bad	c) No change

37. Would it be better for people if the river would become

a) Bigger b) Smaller c) The same

38. Overall perception on environmental change in locality

Sectors	Changes within 20 years			Reasons for change	Future trend
	Increase	Decrease	Same		
1. Agriculture					
• Agricultural Area					
• Area under cereal crops					
• Area under fruits					
• Area under vegetables					
• Diversity of crops					
• Intensity of crops					
• Productivity					
• Use of improved seeds					
• Use of fertilizer					
• Use of pesticides					
2. Forest					
• Area of forest					
• Number of tree species					
• Crown cover					
• Availability of fuel wood					
• Availability of timber					
• Availability of fodder					
• Availability of litter					
• Availability of herbs					
• Forest foods					
• Wildlife					
3. Pasture/grassland					
• Area under pasture					
• Productivity of pasture					
4. Waste land					
• Area of waste land					
• Use of waste land					
5. Environmental hazards					
• Surface runoff					
• Soil erosion					
• Landslides					
• Floods					
• Pests and diseases					
• Forest fire					
5. water					
• Quantity					
• Quality					
• Distance for collection					
6. Weather					
• Rainfall					
• Temperature					
• Snow line					
• Volume of river flow					
• Changes in seasons					

39. General comment on climate change and water availability if any:.....

.....

....

Appendix 1.3

Participatory Rural Appraisal (PRA) Procedure

Community level information about resources/assets (natural, physical, human, social and financial) distribution and present utilization pattern and perceptions regarding climate change and its relation to livelihoods of the local people were collected using PRA techniques. For this purpose, groups consisting of 5-10 persons with representation from different occupational groups, elected persons, social workers and farmers, wherever available, were formed for group discussion. Mostly senior persons of the community were included in the group. A total of 12 groups were organized for discussion, one per each selected settlement. The researcher facilitated discussions and one assistant recorded the responses, views and conclusion of the group. During discussion, participants also made maps in the ground (with sticks) showing snow cover area and changes in area and density of forest and pasturelands. These maps were checked with the help of topographical map of the area. Views were recorded on consensus. In some cases views of majority was recorded. A checklist was used for discussion and (see Appendix 1.4). Topographical maps were used to locate infrastructure and the distribution of resources; their present condition and their utilization pattern. A number of informal discussions with different individuals or groups were also conducted. Details of group composition by community are shown in Appendix 1.5.

Appendix 1.4

Check list for group discussion/ PRA and recording schedule for water use survey

Water and Livelihoods in Mountain Areas

(Check list for group discussion/ PRA)

1 Natural Resources

- Existing condition of the natural resources -Land, Forest, Water, and Pasture
- Access right on these resources and households benefited
- User's committee (number, size, decision making process, problems)
- Conflict between committees or within community over the use of these resources with particular focus on water and pasture
- Changes on the status of resources over time
- Availability of forest products and related issues
- Area and production of crops, cropping intensity, use of inputs, changes over time, major export items, irrigation coverage, and major problems related to agricultural development.
- Use of energy and its availability (types, number, size, ownership, effectiveness, problems and prospects)

2 Physical Resources

- Existing road links and their condition
- Availability and frequency of public transport
- Post offices, and telephone services, health institutions and facilities available
- Schools by types and level and their condition
- Piped water distribution and coverage and its management
- Industries, major products and potentials
- Development trend of physical resources (roads, electricity, piped water etc.)
- Fulfillment of local needs and sustainability
- Existing/ongoing and future plans/programs related to physical resources.
- Water mills and power generation (number, quality and problems)

3 Human resources

- Accessibility of information -Sources and benefited groups
- Use of modern technologies by community members (radio, television, email, internet)
- People's feeling about sources and reliability of information sources
- Perception about government policies with particular focus on water use.
- Availability skilled and semi-skilled manpower
- Employment opportunities

4 Financial capital/resources

- Types of financial service organizations available and types of services provided
- Access to these organizations
- Households getting remittances and utilization

5 Social capital/Resources

- Number of CBOs, traditional social organizations and formal groups (extent of membership)
- Degree of participation on decision making.
- Kin, income and occupational structure of the group
- Social problems in the community (types and degree)
- Religious and cultural ceremonies
- Religious bath (place, frequency, problems)

6 Climate change and relations

- Perception of people regarding climate change (temperature, rainfall, snow cover area)
  How would people's life change, if the weather become a) Hotter and drier b) Wetter/more rainy c) More colder d) Season changed
- What would people do, if there were
  a) More landslides b) The forest died c) Decrease tourist d) Difficult to grow staple crops

7 Cropping calendar and cropping pattern

8 Infrastructure Mapping

- Irrigation

ID	Type of irrigation	Command area	Household benefited	Water sufficiency	Conflict and management

- Water mill (Ghatta)

ID	Ownership	Duration of operation	Household benefited	Monthly income	Water sufficiency

- Water for household use

ID	Source type	Household benefited	Quality of water	Adequacy of water	Conflict and management

- Ghat/ Religious and cultural use of water

Location (ID)	Description

9 Seasonal calendar

Months	Activities	Impact of climate change	
		More precipitation	Less precipitation

Appendix 1.5

Group participants by survey settlement

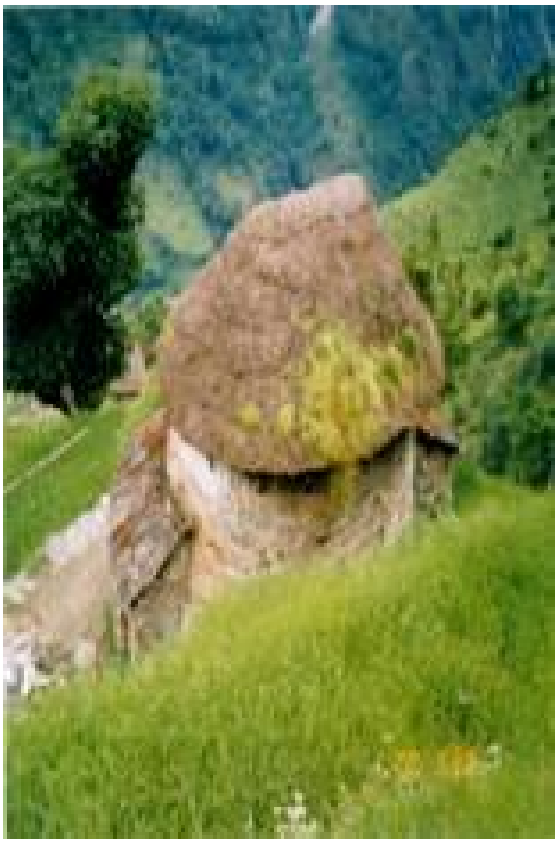
Settlements	Participants	Group composition
Chhomrong	9	Ward chairman and chairperson of mother's group, businessman, farmers and electricity users committee members (Chairman and Secretary)
Melache	5	Teachers and farmers (1 female)
Ghandruk	7	Ward chairman, female representatives (Chairperson and member of mother's group), teacher, and farmers
Landruk	9	Ward chairman, teacher, businessman and farmers
Syaulibazar	5	Teacher, farmers and businessman
Moharia	6	Ward chairman and farmers
Rele/Halzure	6	Farmers (1 female)
Halhale	10	Social worker, VDC secretary, and farmers
Bajung	5	Vice chairman of VDC, teacher, farmers
Jhorbang	5	Teachers, social workers and farmer
Chuwa	5	VDC chairman, and farmers
Katuwa Chapari	7	Social worker, teacher and farmers

Appendix 1.6
Photographs: Community Survey/Water Use Inventory

1.6.1 View of Annapurna Himal from Ghandruk

1.6.2 Ghandruk Village

1.6.3 A settlement with surrounding environs in Bajung



1.6.4 Typical farm house in Landruk

1.6.5 Group Discussion at Chhomrong

1.6.6 Irrigation canal, Gyandi

1.6.7 Buffaloes in the pond at Jhorbang

1.6.8 A local woman weaving Bhangra at Syaulibazar

1.6.9 Water based woodcarving workshop at Melanche

1.6.10 Landslides at Ghurjung

1.6.11 Rafting in the Kali Gandaki River

1.6.12 Paper-making

Appendix 2: GIS Mapping

A2.1 Background to GIS Approach: Application of Geographic Information Systems to Water Resources and Livelihoods in the Himalayas

A2.2 Modi Khola Scale Mapping

A2.2.1 Modi Khola: Study Area

A2.2.2 Modi Khola: Study Zones and Study Settlements

A2.2.3 Modi Khola: Water Use: Irrigated Agriculture & Micro-Hydro Generation

A2.2.4 Modi Khola: Water Use: Domestic and Drinking Supply

A2.2.5 Modi Khola: Services and Markets

A2.3 Modi-Kaligandaki Corridor Scale Mapping

A2.3.1 Modi-Kaligandaki: rivers, major hydraulic schemes, cultivated land and major towns

A2.3.2 Modi-Kaligandaki: close-up of area around major hydropower scheme with distribution of settlements and cultivated land

A2.4 Nepal Scale Mapping

A2.4.1 Nepal: Existing & Planned Hydropower Development

A2.4.2 Nepal: Number of Watermills Running by Snow Fed Rivers (Traditional & Improved)

A2.4.3 Nepal: Irrigated Land from Snow Fed Rivers

A2.4.4 Nepal: Rafting Rivers and Number of Tourists

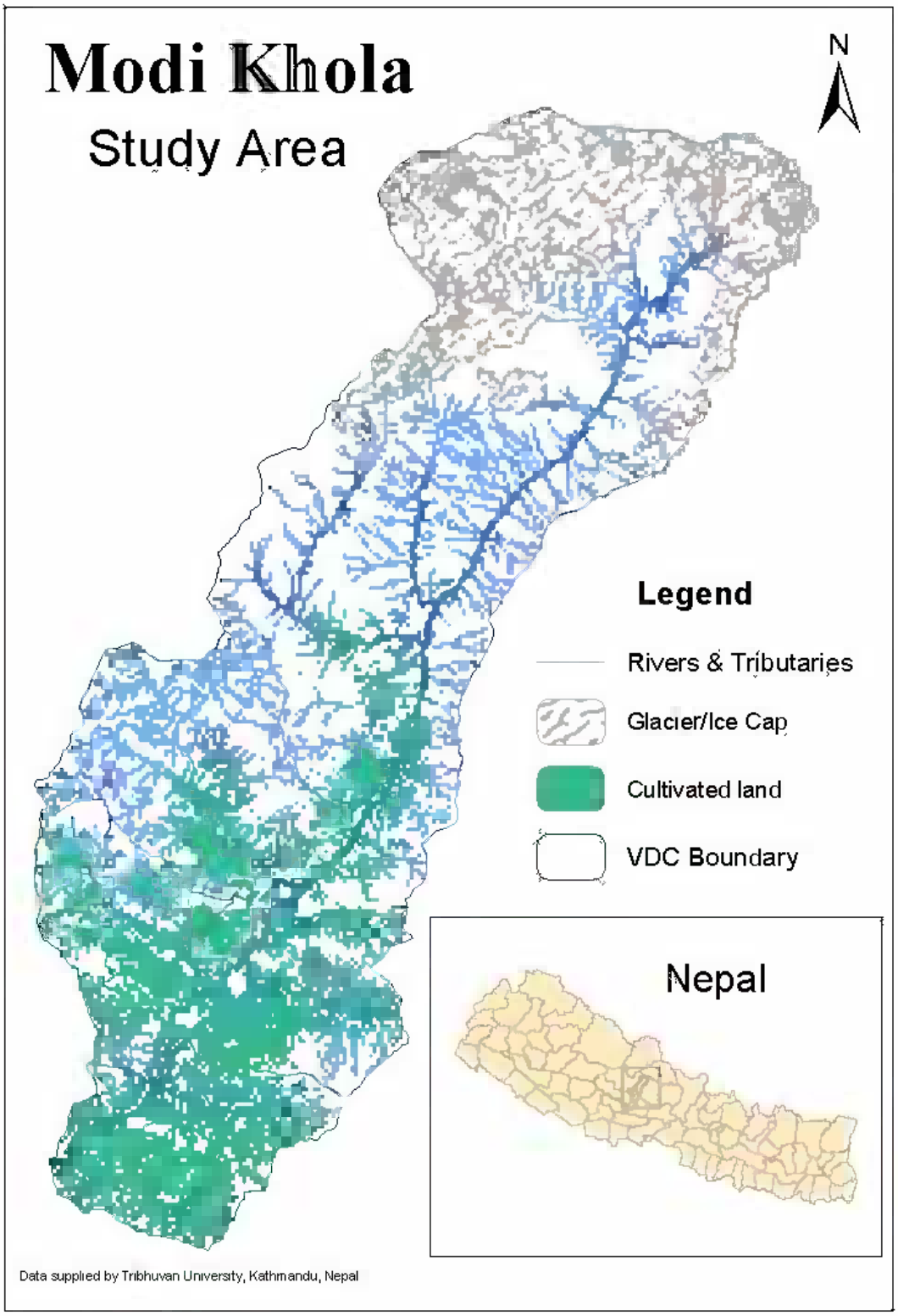
Appendix 2.1

Background to GIS Approach: Application of Geographic Information Systems to Water Resources and Livelihoods in the Himalayas

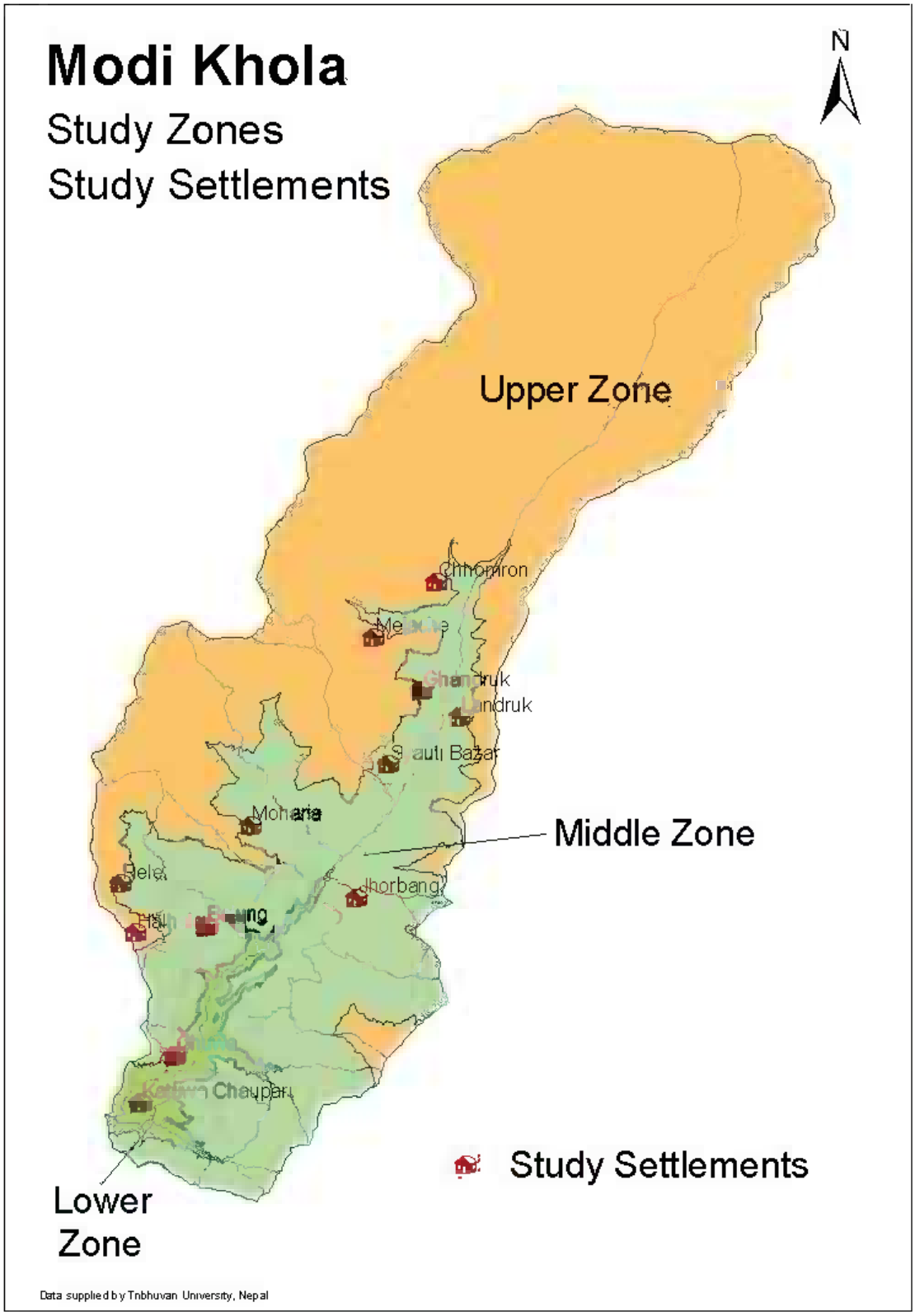
Natural resource management and planning for sustainable development require the collection and integration of data from many sources. The use of Geographic Information Systems (GIS) is regarded as an effective and powerful tool for the integration and analysis of often disparate datasets from environmental and socio-economic research. The ability to integrate social, economic and biophysical data for analysis and display enables policy-makers, managers and decision-makers at all levels to formulate effective strategic development tools, and the mapping of spatial information can be an effective tool for education and stakeholder participation. GIS approaches are increasingly being used for research in sustainable mountain development, by ICIMOD (see the website *GIS for Sustainable Mountain Development* at www.icimod-gis.net/) and other organisations (see special GIS edition of *Mountain Research and Development,* Volume 23, Number 4, November 2003).

Research for the SAGARMATHA project carried out in Nepal involved the development of a spatial database to i) enable a better understanding of water use in the study areas and across the country; ii) examine the relationship between water resources and livelihoods; and iii) to assess the potential impacts of deglaciation in the region. Data and information were collected at different locations and at different scales, representing the household level, the community level, the watershed level, the regional level, and the national level. The GIS database was developed from the digitization of existing maps and data (such as elevation, major rivers, land use and land cover, administrative boundaries, roads, and settlements), from the georeferencing of primary data from an inventory of water uses carried out along the snow and ice-fed rivers of Nepal, and from data collected during the case study in Modi Khola. Details of the data collection and surveys can be found in the background documents attached to the SAGARMATHA Final Technical Report. Data were integrated using *ArcGIS* software and techniques and mapped at the national, regional (Modi-Kaligandaki Corridor) and watershed (Modi Khola) scales.

Appendix 2.2.1
Modi Khola: Study Area

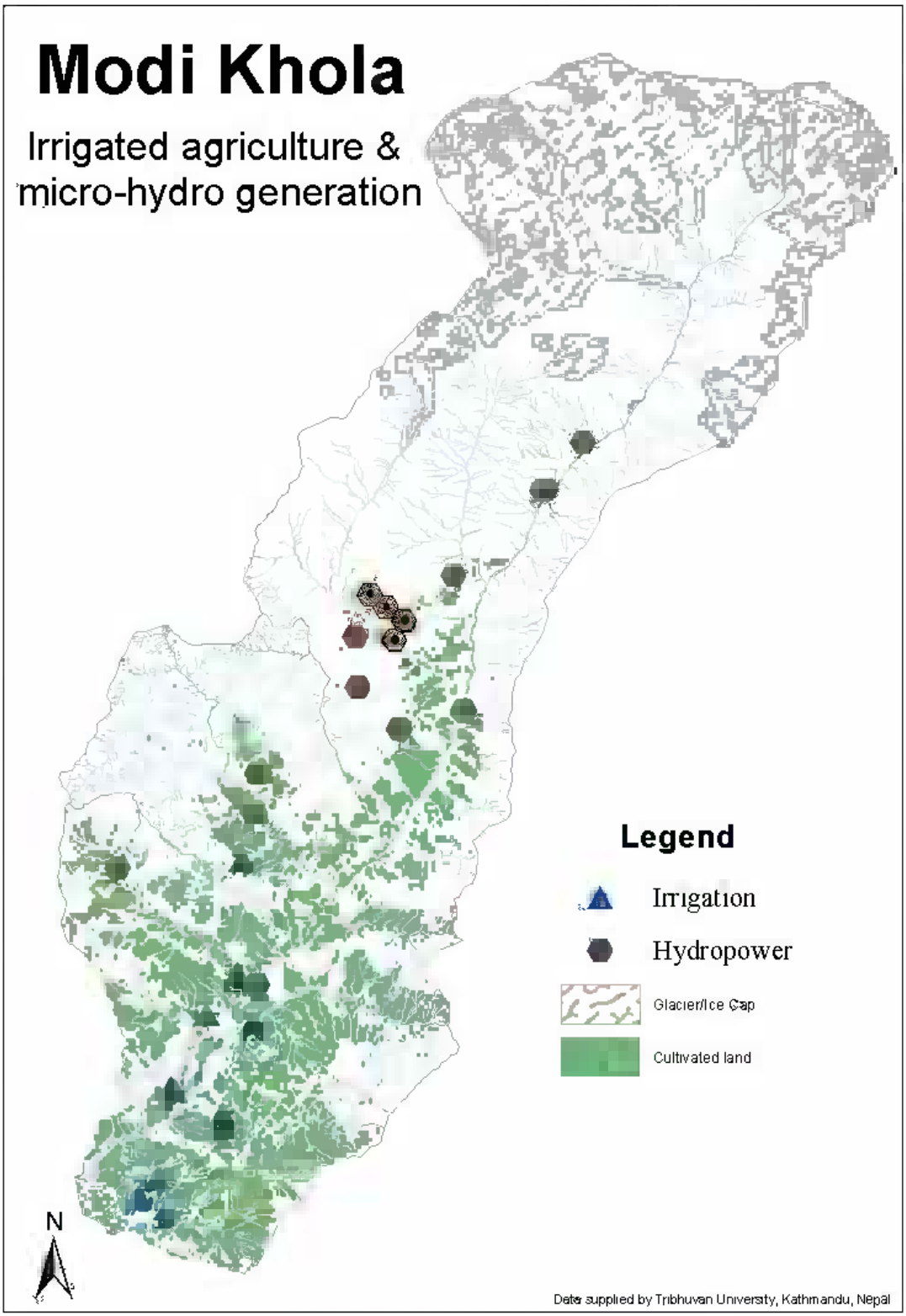


Appendix 2.2.2
Modi Khola: Study Zones and Study Settlements



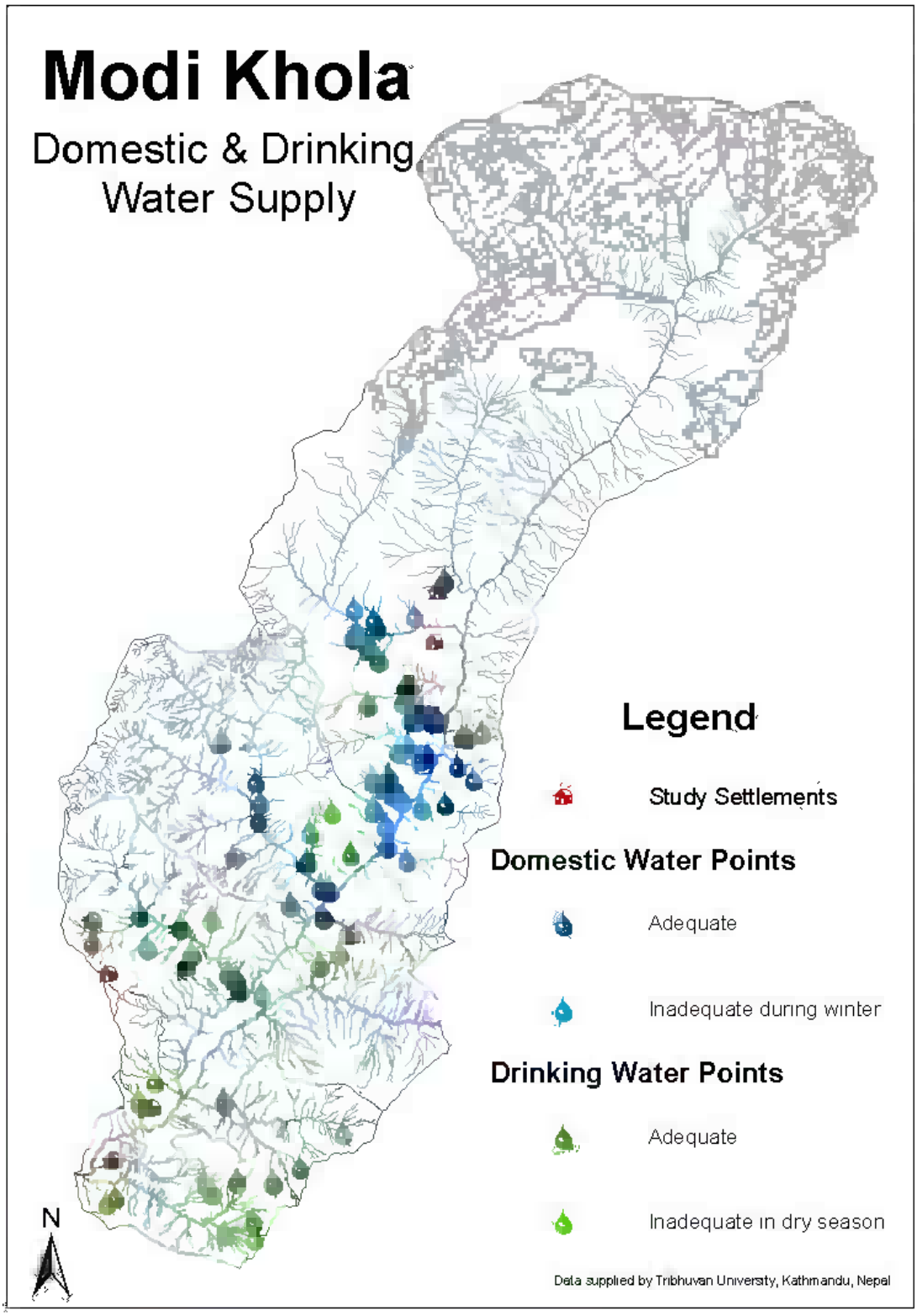
Appendix 2.2.3

Modi Khola: Water Use: Irrigated Agriculture & Micro-Hydro Generation

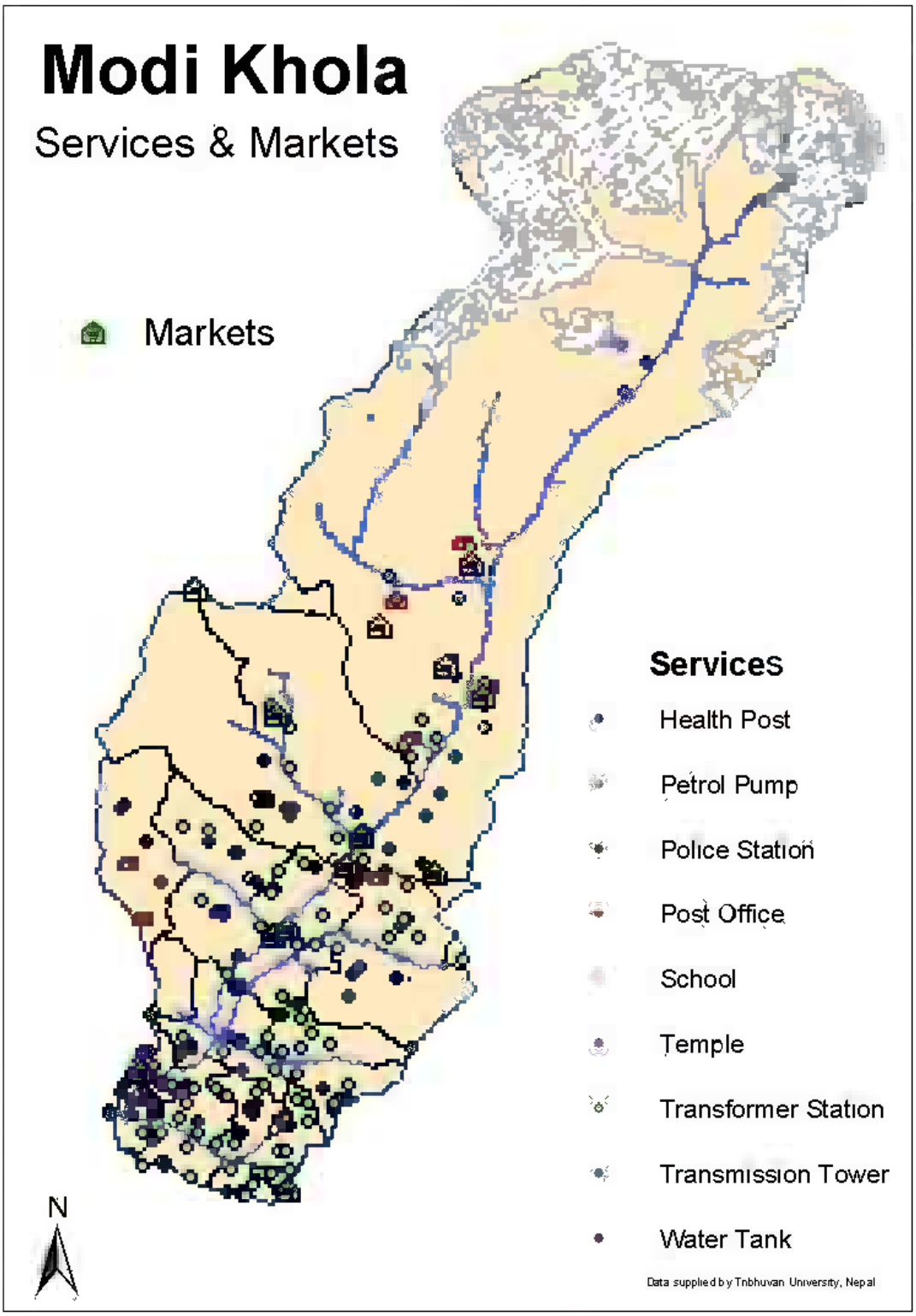


Appendix 2.2.4

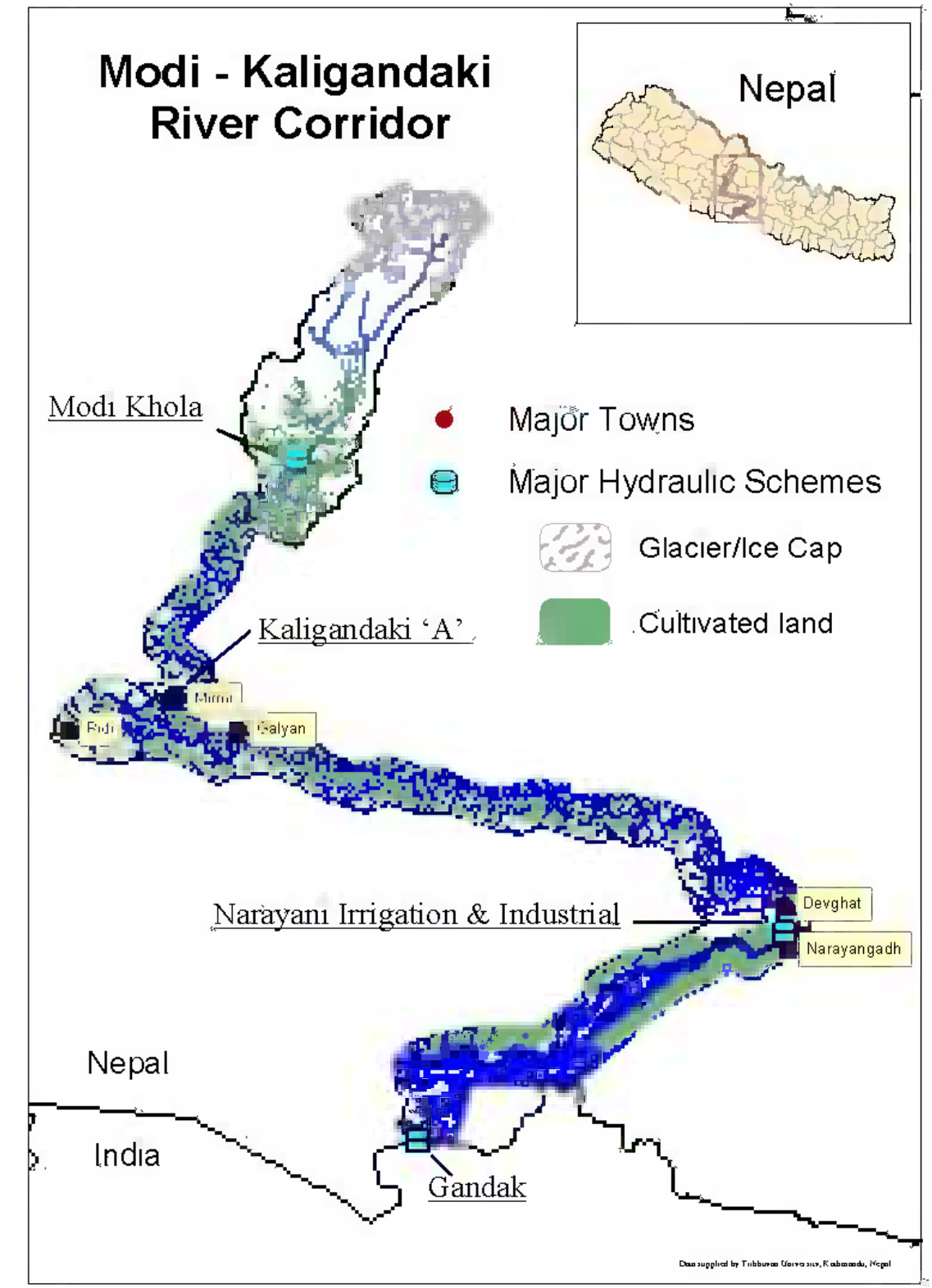
Modi Khola: Water Use: Domestic and Drinking Supply



Appendix 2.2.5
Modi Khola: Services and Markets

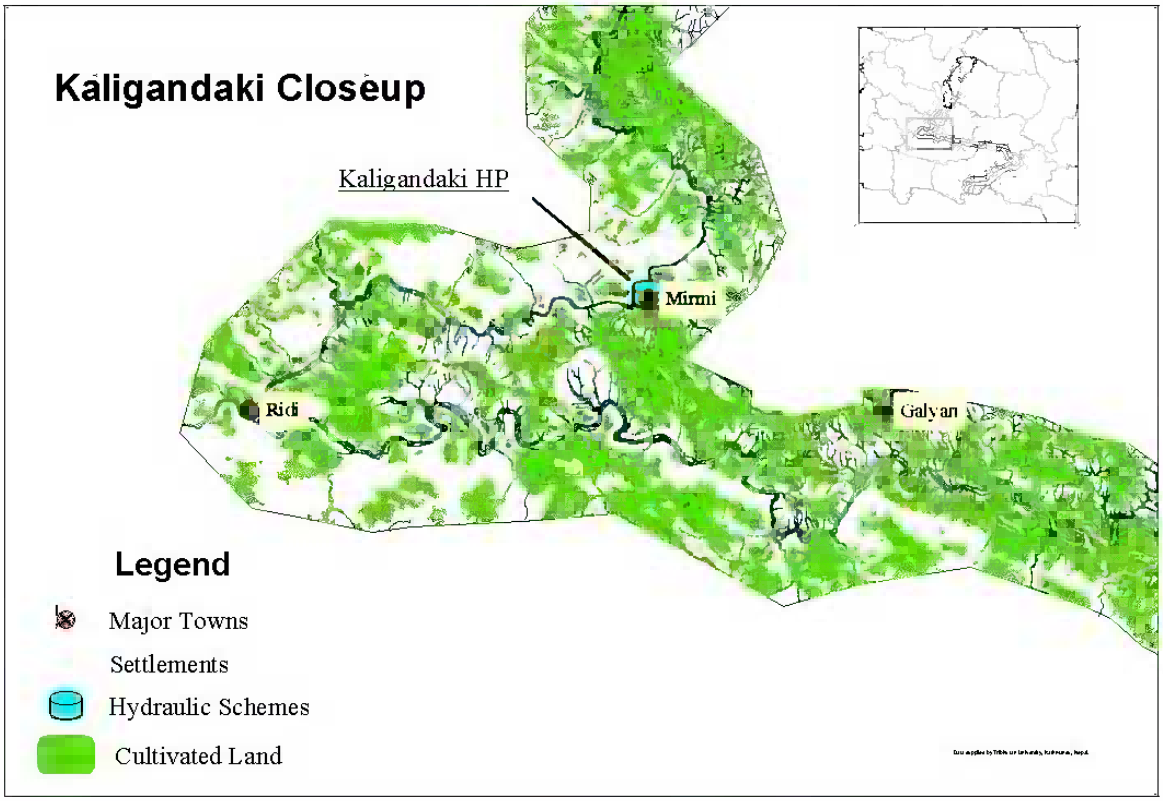


Appendix 2.3.1
Modi-Kaligandaki: rivers, major hydraulic schemes,
cultivated land and major towns



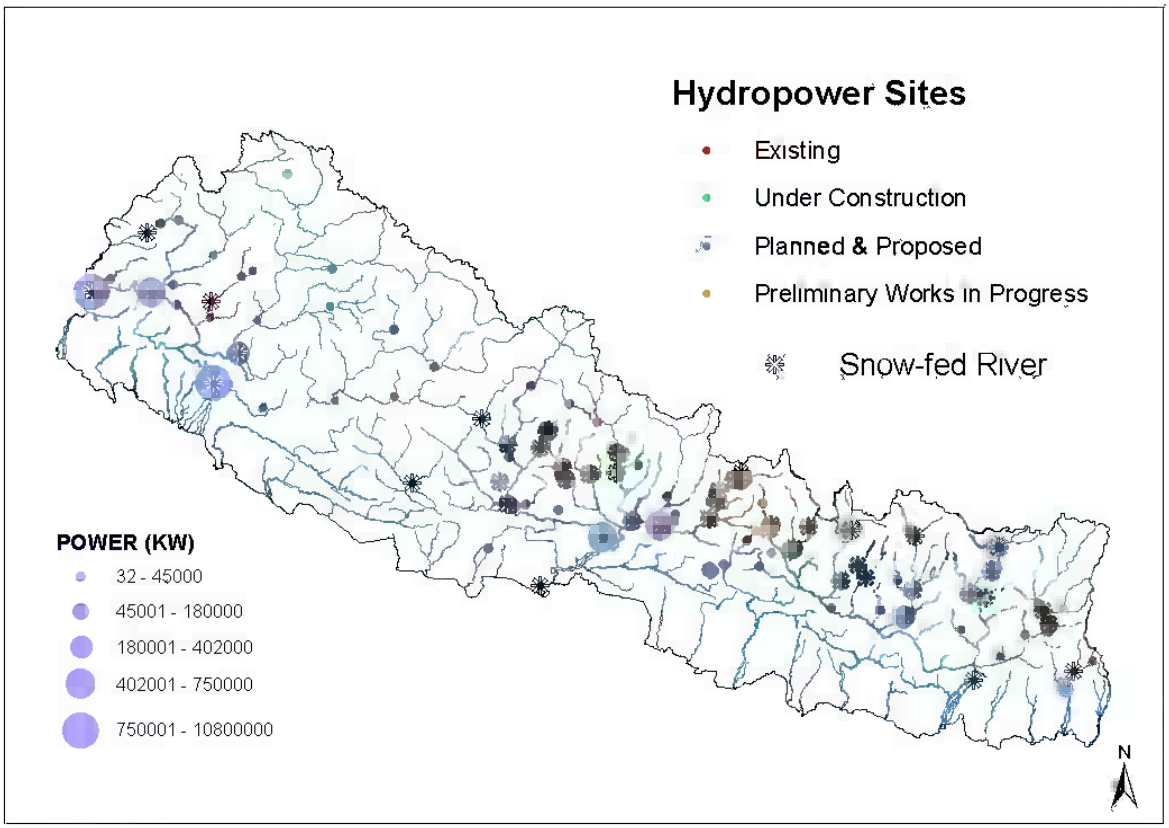
Appendix 2.3.2

Modi-Kaligandaki: close-up of area around major hydropower scheme with distribution of settlements and cultivated land



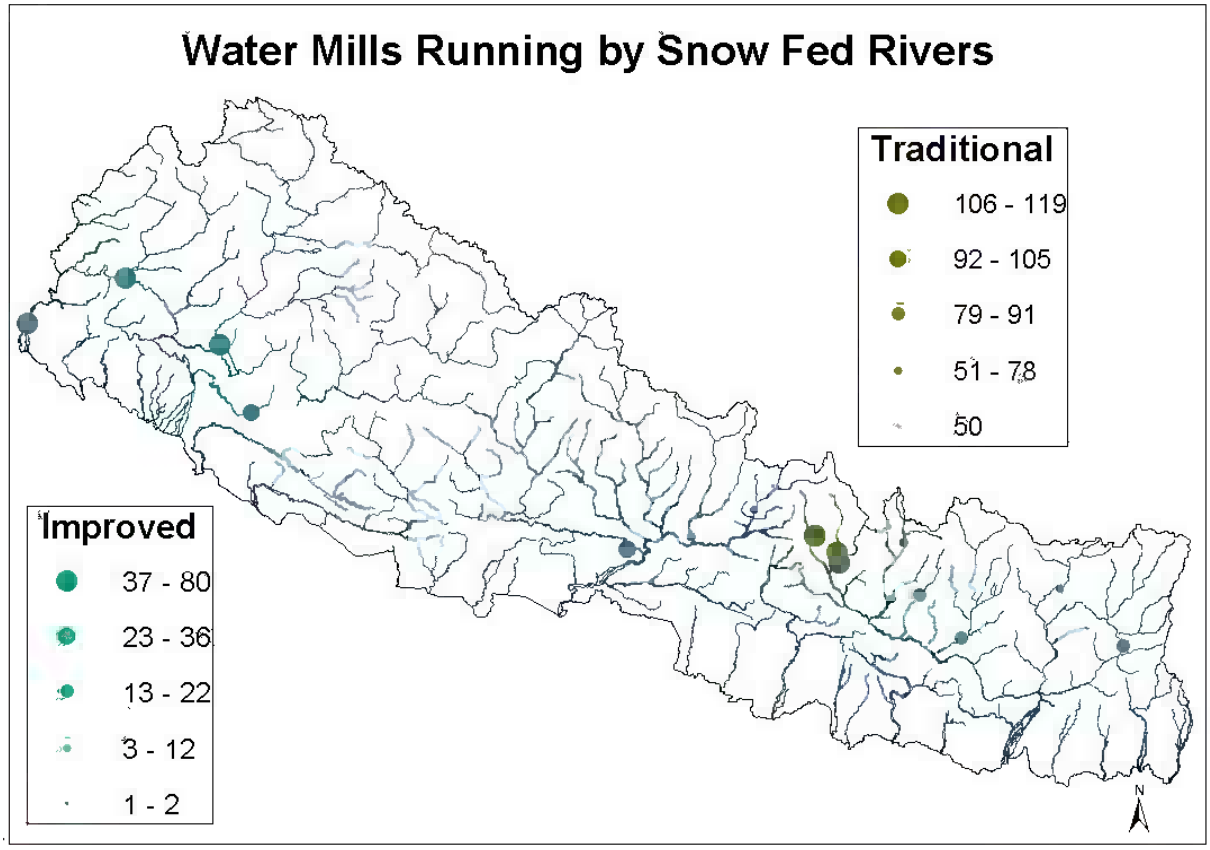
Appendix 2.4.1

Nepal: Existing & Planned Hydropower Development



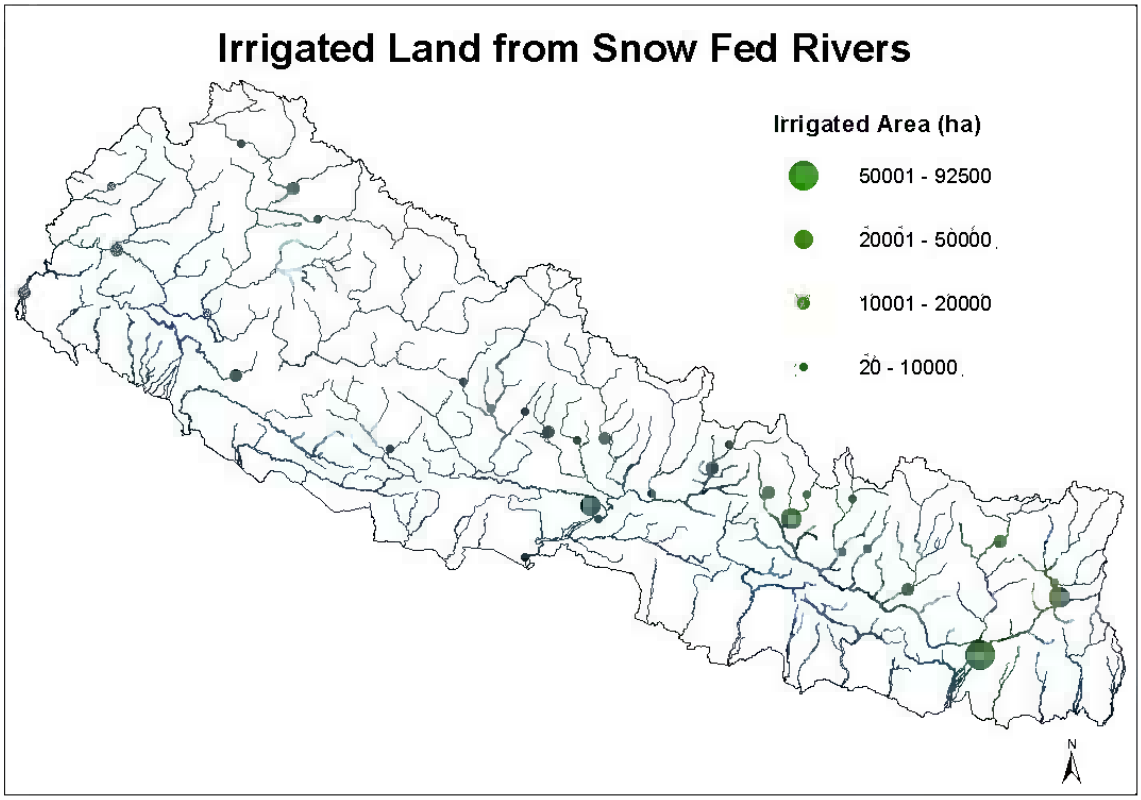
Appendix 2.4.2

Nepal: Number of Watermills Running by Snow Fed Rivers (Traditional & Improved)

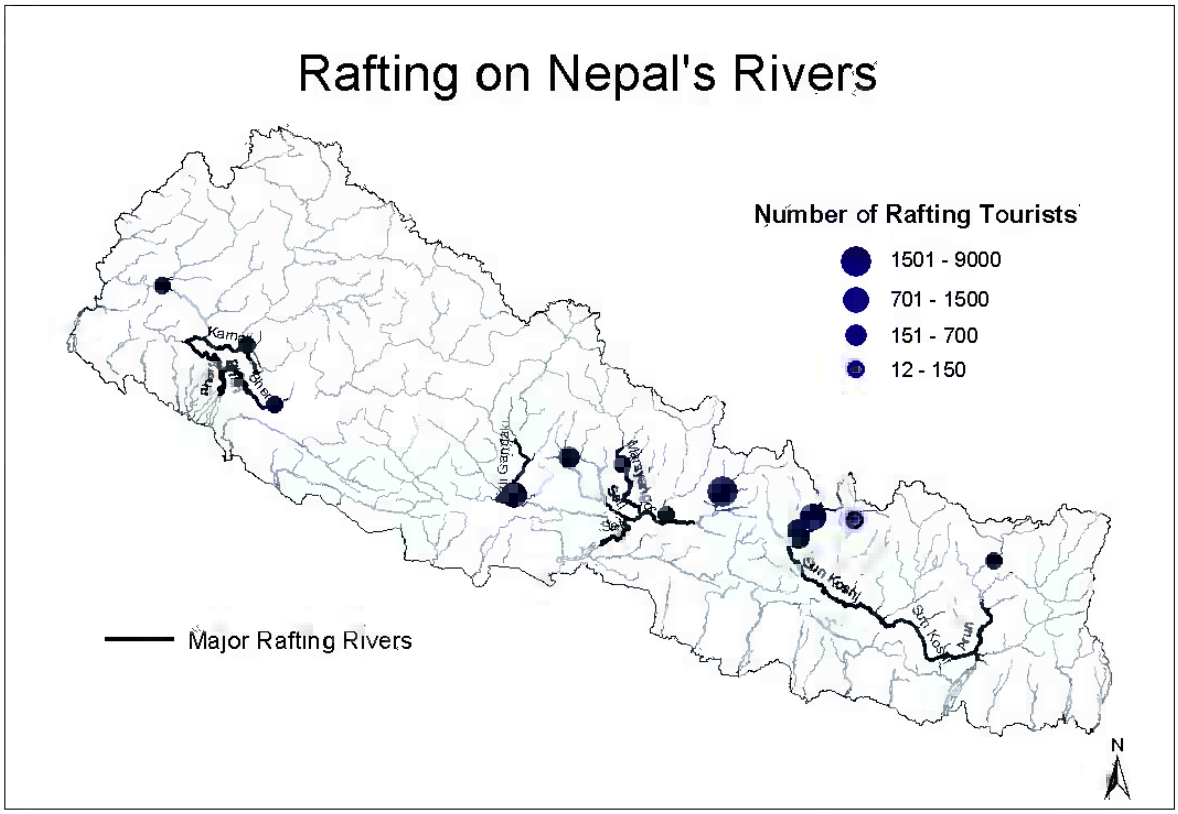


Appendix 2.4.3

Nepal: Irrigated Land from Snow Fed Rivers



Appendix 2.4.4
Nepal: Rafting Rivers and Number of Tourists



Appendix 3: Stakeholder Consultation Workshops

A3.1 Community Workshops, Kusma & Ghandruk, Nepal, March 2004

A3.1.1 Participant List

A3.1.2 Participant Feedback Sheet: Adaptation Strategies

A3.1.3 Photographs

A3.1.4 Background Document 1 (Mountain Livelihoods and Climate Change leaflet)

A3.1.5 Background Document 2 (project objectives, methodology and major findings of the survey - (Nepali)

A3.2 Corridor Workshop, Pokhara, Nepal

(Snow and Glacier Aspects of Water Resources Management in the Himalayas (SAGARMATHA): Kaligandaki Stakeholder Consultation Workshop, Pokhara, Nepal, April 21, 2004)

A3.2.1 Agenda (English & Nepali)

A3.2.2 Participant List

A3.2.3 Minutes

A3.2.4 Photographs

A3.2.5 Background Document (English & Nepali)

A3.2.6 Participant/Breakout Group Feedback Sheet: Adaptation Strategies (English & Nepali)

A3.2.7 Participant/Breakout Group Feedback: Draft policy briefing note (also used at Delhi workshop) (English & Nepali)

A3.3 International Workshop, New Delhi, India

(Deglaciation: Impacts and Adaptations for Water Resources and Livelihoods in the Himalayas: Stakeholder Consultation Workshop, India International Centre, New Delhi, India, April 27-28, 2004)

A3.3.1 Agenda

A3.3.2 Participant List

A3.3.3 Minutes

A3.3.4 Photographs

A3.3.5 Breakout group guidelines

A3.3.6 Participant/Breakout Group Feedback Sheet: Sectoral Impacts and Adaptation Strategies

A3.3.7 Participant/Breakout Group Feedback: Draft policy briefing note (see Appendix 3.2.7)

A3.3.8 Results from Corridor Workshop (presented to Delhi participants after breakout discussions)

Appendix 3.1.1
Community Workshops: Participant List

Local Stakeholder Consultation in Modi Khola Basin
List of participants

S.N.	Name	Address	Occupation
1	Mr. Dhan Raj Sharma	Chuwa 9, Parbat	Business
2	Ms. Man Kumari Giri	Siwalaya 4, Parbat	Social work
3	Mr. Ram Prasad Acharya	Siwalaya 3, Parbat	Social work
4	Mr. Keshav Das Bairagi	Katuwa Chaupari, Parbat	Social work
5	Ms. Sima Mallik	Rural energy Dev. Branch, Kusma	Service (Energy Dev. Officer)
6	Mr. Tanka Prasad Poudel	Salyan 9, Kaski	Agriculture
7	Mr. Chudamani Sharma Paudel	Salyan 9, Kaski	Agriculture
8	Mr. Shiva Sharma Poudel	Katuwa Chaupari 3, Parbat	Industry (Diary)
9	Mr. Ms. Maya Subedi	Chuwa 8, Parbat	Agriculture
10	Mr. Dal Bahadur Malla	Bajung 7, Parbat	Social work
11	Mr. Prem Poudel	Bajung 3, Parbat	Social work
12	Mr. Tek Prasad Luitel	District Agriculture Office, Kusma	Service (Agronomist)
13	Mr. Devi Prasad Pathak	Drinking water Office, Kusma	Service
14	Mr. Mahesh Bahadur Khadka	District Road, Kusma, Parbat	Service
15	Mr. Tek Bahadur Grung	Ghandruk 4, Kaski	Hotel/ business
16	Mr. Purna Bahadur Gurung	Ghandruk 6, Kaski	Hotel/ business
17	MrKrishna Prasad Poudel	Ghandruk 5, Kaski	Teaching
18	Mr. Jagadish Gurung	Ghandruk 5, Kaski	Teaching
19	Mr. Lila Nath Bhandari	Ghandruk 3, Kaski	Medical practitioner
20	Mr. Rameshwar Gurung	Ghandruk 8, Kaski	Hotel/ business
21	Mr. Purna Prasad Gurung	Ghandruk 6, Kaski	Teaching
22	Ms. Kanya Gurung	Ghandruk 2, Kaski	Tourism activity
23	Ms. Pyari Gurung	Ghandruk 3, Kaski	Social work
24	Mr. Damber Bahadur G.C.	Ghandruk 1, Kaski	Agriculture
25	Mr. Om Bahadur Gurung	Ghandruk 9, Kaski	Agriculture

Appendix 3.1.2

Community Workshops: Participant Feedback Sheet 1 - Adaptation Strategies

Community Workshop Feedback Sheet: Adaptation Strategies

Group Name: ……

Page 1

	Adaptation strategy	Potential responses	Practicality
☐	Changes in cropping patterns, substitution of crop varieties and species		Easy to adopt Difficult to adopt ***Comments:***
☐	Promotion of social networks		Easy to adopt Difficult to adopt ***Comments:***
☐	Changes in the location of fishing activities, promotion of fish breeding and river stocking		Easy to adopt Difficult to adopt ***Comments:***
☐	Changes in the appropriate location of certain tourism activities such as rafting		Easy to adopt Difficult to adopt ***Comments:***

☐	Changes in animal husbandry techniques		Easy to adopt Difficult to adopt ***Comments:***
☐	Human migration		Easy to adopt Difficult to adopt ***Comments:***
☐	Changes to design specifications for water and other infrastructures, and modification of existing structures		Easy to adopt Difficult to adopt ***Comments:***
☐	Development of management strategies to cope with reduced water availability in an equitable way to prevent conflicts		Easy to adopt Difficult to adopt ***Comments:***

Appendix 3.1.3
Community Workshops: Photographs

Participants of the Local Stakeholder Consultation in Kusma, 7 March, 2004

See also Section 4.4.2 of this report

Appendix 3.1.4

Community Workshops: Background Document 1: Mountain Livelihoods and Climate Change leaflet

(Side 1)

Mountain livelihoods and climate change

Global climate change

- People everywhere are noticing changes in their weather and climate.
- The IPCC (1996) estimates suggests that global glacier mass will be reduced by some 25% by 2050.
- Between 1991 and 1996, the annual mean temperature change in Nepal has been 0.07°C.

Potential impacts of climate change

Global temperatures will rise, with changing average levels of rainfall, and increasing variability. This means that both worse droughts *and* worse floods can be expected.

How water influences livelihoods

- Water is a factor of production in agriculture and industry;
- Water availability influences people's health, especially for women and children;
- When people have to spend a lot of time collecting water, it means they have less time to be involved in productive work;
- A healthy aquatic environment provides ecosystem services to communities (eg fish).
- Pollution, and demand from large scale users can cause conflicts

Group Discussion at Landruk

Group Discussion at Chhomrong

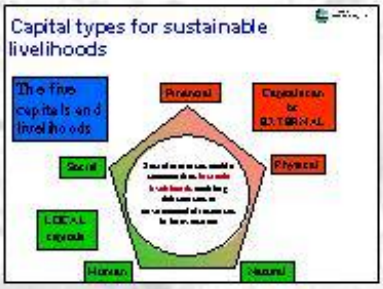
Research Approach

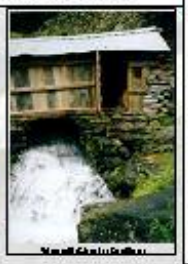
Household surveys 12 settlements were randomly selected (from all settlements in the catchment), representing different eco-zones in the Modi Khola watershed, on the basis of altitude. A total of 360 households were surveyed.

Group discussions Informal discussions were carried out in a total of 12 groups representing different occupational groups, elected persons, social workers and farmers in each selected community. Community level information about distribution of assets and present utilization pattern of these were collected using standard PRA approaches. In addition, perception regarding climate change and its relation to livelihoods of local people were examined.

Inventory of water uses and mapping An inventory of different water uses was made through consultation with local people and field observation. These were mapped using GPS and recent topographic maps. The water uses included water mills, irrigation canals, power plants, woodcarving workshops, piped water supply, hot Springs, and religious and culturally important places.

Field observation Extensive field observation was made as a supplementary method to techniques mentioned above.



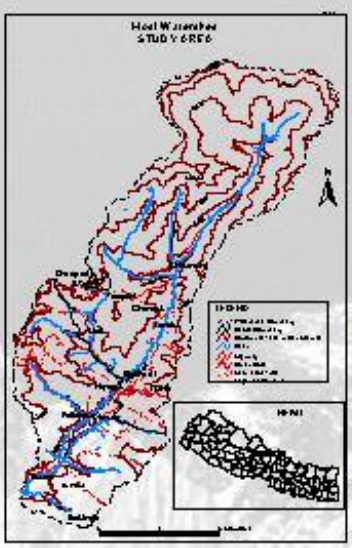


Livelihood options in the Modi Khola

Agriculture
Remittances
Tourism
Services
Forest utilisation
Fishing
Wage labour
Brewing
Weaving and other

Note: in spite of these various options, about 56% of households produce insufficient food supplies, and they have to buy food from other sources, requiring a cash income

(Side 2)



People in the Modi Khola

- In 2001, the population of the Modi Khola watershed was estimated to be about 75,000 in 17,000 households. The average family size of 4.6 varied between 4.1 persons in Sankhar Pokhari to 5.7 in Ghandruk.
- Average literacy rate in the watershed was 64.8 percent, ranging from 51.7% in Arther Dandakharka and highest in Mudikuwa (80.7%)

Land size (ha)	Downstream sub-region			Upstream sub-region		Total
	Lower zone	Middle zone	Upper zone	Middle zone	Upper zone	
	%	%	%	%	%	%
No land	1.7	0.0	0.0	1.1	**6.7**	2.2
Below 0.5	36.7	20.0	**41.7**	28.9	33.3	31.9
0.5-2.0	48.3	51.7	51.7	60.0	54.4	**53.9**
Above 2.0	13.3	**28.3**	6.7	10.0	5.5	11.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

Household incomes

Many of the households in this area do not have much access to financial capital, although a significant proportion do receive money from outside.

Income sources	Lower zone Rs	%	Middle zone Rs	%	Upper zone Rs	%	Total Rs	%
Agriculture	34,896	24.1	22,995	20.6	18,272	13.0	23,407	18.0
Business	29,673	20.5	7,280	6.5	5,320	3.8	10,557	8.1
Tourism	484	0.3	3,091	2.8	29,393	20.8	13,646	10.5
Wage	2,619	1.8	7,253	6.5	5,261	3.7	5,799	4.4
Service	40,148	27.7	29,711	26.6	5,849	4.1	20,918	16.0
Remittance	18,,564	12.8	29,007	25.9	58,977	41.8	40,679	31.2
Pension	3036	2.1	7,772	7.0	17,232	12.2	10,820	8.3
Other	15,264	10.6	4,679	4.2	749	0.5	4,528	3.5
Total	**144,685**	**100**	**111,787**	**100**	**141,053**	**100.**	**130,354**	**100**

Only 18 % of household income comes from agriculture/crops, 10% from tourism, 16% from services

Livelihood vulnerability

Vulnerability exists when resources are limited and access to them is tenuous;
Human vulnerability to climate change is influenced by poverty, capacity and geographical conditions;
Poor and politically weak groups are likely to be more vulnerable than others;
Changes in ecological conditions arising from climate change (eg changes in river water temperatures and chemistry) are likely to influence fish spawning activities and influence fisheries in other ways;
Livelihoods which are dependent on water inputs as a power source, or as another factor of production will be particularly vulnerable, especially in times of low flows.

Some perceptions of climate change

Over 58% of hhs reported losing crops due to hailstorms over the last 10 years
20% reported losing crops due to landslides
16.9% lost crops due to drought
13.6 % lost crops due to floods

Potential adaptation strategies

- Changes in cropping patterns, substitution of crop varieties and species;
- Changes in the location of fishing activities, promotion of fish breeding and river stocking;
- Changes in the appropriate location of certain tourism activities such as rafting;
- Changes in animal husbandry techniques;
- Human migration;
- Changes to design specifications for water and other infrastructures, and modification of existing structures;
- Development of management strategies to cope with reduced water availability in an equitable way to prevent conflicts.
- Promotion of social networks

The funding for this work has been provided by the UK Department for International Development. The views here do not necessarily represent those of DFID.

For More information, please contact
Shiba Prasad Rijal, Tribhuvan University, Kathmandu, Nepal.
Email: sprijal@wlink.com.np

Appendix 3.1.5

Community Workshops: Background Document 2 (project objectives, methodology and major findings of the survey - (Nepali)

सगरमाथा अध्ययन परियोजना

(Snow and Glacier Aspects of Water Resources Management in the Himalayas)

Stakeholder Consultation in Modi Khola Watershed

१.पृष्ठभूमि

जीविकोपार्जनका लागि पानी अपरिहार्य छ । नदीको पानी जीविकोपार्जनको प्रमुख आधार हो । हावापानीको परिवर्तन तथा तापक्रममा आएको वृद्धिले हिउँ पग्लने गति तिव्र भई नदीमा पानीको बहावमा परिवर्तन भईरहेको पाइन्छ । तापक्रम बढी हुनाले हिमनदी पग्लेर पछाडि खुम्चने कार्य तिव्र भईरहेको छ । आगामी ४० वर्षमा हिमालयका हिमनदीहरु लोप हुँदै जाने अनुमान केहीले गरेका छन । फलस्वरुप नदीहरुमा केहि समय पानीको बहावमा वृद्धि हुने र केही समय पछि घट्ने निश्चित छ । यसरी बहावमा परिवर्तन हुदा जीविकोपार्जनमा प्रत्यक्ष एवम् परोक्ष प्रभाव पर्ने कुरा निश्चित छ । नदीमा पानी कुन समयमा कति घटबढ हुने र त्यसबाट उत्पन्न हुने असरहरु बारे स्पष्ट भन्न कठीन छ।

नदीको बहावमा अल्पकालिन तथा दीर्घकालिन परिवर्तन हुँदा जीविकोपार्जनमा के कस्ता नकारात्मक असरहरु पर्न सक्छन र ती असरहरुबाट बच्न एवं नोक्सानी कम गराउन के कस्ता भावि रणनीतिहरु अपनाउनु वेश हुन्छ भन्ने पत्ता लगाउने उद्धेश्यले सगरमाथा अध्ययन परियोजना (Snow and Glacier Aspects of Water Resources Management in the Himalayas) सुरु भएको हो । DFID को आर्थिक सहयोगमा संचालित यस परियोजनामा ICIMOD, श्री ५ को सरकार हावापानी विभाग, त्रिभुवन विश्वविद्यालय, भारतको जवाहरलाल नेहरु विश्व विद्यालय, संयुक्त अधिराज्यका ऋभ्ज र साल्फोर्ड विश्वविद्यालय जस्ता संस्थाहरु संलग्न छन । यस सगरमाथा अध्ययन परियोजनाका दुई पक्षहरु छन् ।

- भौतिक पक्ष (development of regional hydrological model)
- सामाजिक तथा आर्थिक पक्ष (socio-economic component)

हिमालय क्षेत्रका नदीमा पानीको बहावमा हुने परिवर्तनको भविश्यबाणी गर्नु पहिलो पक्षको उद्धेश्य रहेको छ भने दोश्रो पक्ष हावापानीको परिवर्तनबाट नदीको बहावमा आएको परिवर्तनले जीविकोपार्जनमा पर्ने असरसंग सम्बन्धित छ । नदी बहावको परिवर्तनले जिविकोपार्जनमा पर्ने असरहरु पत्ता लगाउन पश्चिमाञ्चल विकास क्षेत्रको मोदीखोला बेशीको छनौट गरि तथ्याङ्क संकलन एवं विश्लेषण गर्ने कार्य सम्पन्न भईसकेको छ।

२. सामूहिक छलफलको उद्धेश्य

सामाजिक तथा आर्थिक पक्षमा बिगतमा भएको अनुसन्धानको नतिजा स्थानीय व्यक्ति तथा प्रतिनिधि समक्ष प्रस्तुत गर्नुका साथै सामूहिक छलफल गरि नदी बहावमा हुने परिवर्तनबाट जीविकोपार्जनमा पर्ने प्रतिकूल अवस्थाबाट बच्न अवलम्बन गर्नुपर्ने भावि कार्यक्रमको बारेमा स्थानिय बासिन्दाहरुको बिचार संकलन गर्नु यस सामूहिक छलफल तथा भेलाको प्रमुख उद्धेश्य रहेको छ।

३.सामाजिक तथा आर्थिक सर्वेक्षण

३.१ अनुसन्धान पद्धति

पानीको उपयोग एवं जीविकोपार्जनको अवस्था पत्ता लगाउन मोदी खोला जलाधार क्षेत्रमा २०५९ को अशोज (२००२ सेप्टेम्बर) मा सर्वेक्षण गरियो । सम्पूर्ण जलाधारक्षेत्रबाट १२ वटा गाउँहरु छनौट गरी प्रत्येक छानिएका गाउँबाट ३० घरका दरले कुल ३६० घर छनौट गरी तथ्याङ्क संकलन गरिएको छ । साथै तथ्यङ्क संकलनमा सामूहिक छलफल, पानीको उपभोगको नक्साङ्कन जस्ता विधि पनि अपनाइएको छ ।

३.२ सर्वेक्षणको नतिजा

३.२.१ आर्थिक पक्ष

- मोदी जलाधारक्षेत्रका मानिसहरु जीविकोपार्जनका लागि विविध कृयाकलापमा संलग्न रहेको पाइयो । ति कृयाकलापहरुमा कृषि, नोकरी, व्यापार, पर्यटन व्यवसाय तथा ज्यालादारी पमुख छन् । पारिवारिक आम्दानीको ३१.२ प्रतिशत रेमिटेन्सबाट पूर्ति भएको पाइयो । कृषि (१७.९२ प्रतिशत), नोकरी (१६ प्रतिशत), पर्यटन व्यवसाय (१०.५ प्रतिशत) र व्यापार (८.१ प्रतिशत) पारिवारिक आम्दानीको प्रमुख श्रोतहरु हुन् ।
- जमिनको वितरणमा असमानता छ । करीब ५४प्रतिशत परिवारसंग ०.५ देखि २ हे. जमिन रहेको छ भने झण्डै ३२ प्रतिशतसँग ०.५ हेक्टर भन्दा कम जमिन रहेको छ । प्रति परिवार औषत जमिन १.१ हेक्टर रहेको पाइयो।
- घरपालुवा पशुहरुमा भैसी, भेडाबाखा, तथा कुखुरा प्रमुख छन । प्रति परिवार २ वटा भैसी, १.३ गाईगोरु तथा १.७ भेडाबाखा पालेको पाइयो । पशुपालनबाट गत वर्ष १४२७ रुपैयाँ औषत आम्दानी भएको पाइयो ।
- ४४ प्रतिशत घरपरिवारलाई मात्र आफ्नो उत्पादनले वर्षभरि खान पुग्ने र बाँकी ५६ प्रतिशतलाई खान नपुगेको पाइयो । माथिल्लो क्षेत्रको तुलनामा तल्लो क्षेत्रमा खाद्यान्नमा आत्मनिर्भर हुनेहरुको संख्या बढी पाइयो।
- माथिल्लो भेगमा पर्यटन व्यवसाय जीविकोपार्जनको अभिन्न अगं भएको पाइयो । होटल व्यवसाय, पसल, गाइड गर्ने तथा भारी बोक्ने कार्य यस क्षेत्रका पर्यटन व्यवसायसँग सम्बन्धित कृयाकलापहरु हुन ।
- बसाईसराइ पनि जिविकोपार्जनको प्रमुख पक्ष हो । काम गर्ने उमेरको जनसंख्याको ठूलो हिस्सा कामको लागि गा.बि.स.बाहिर गएको पाइयो । कामका लागि बाहिर गएका मध्ये ५० प्रतिशत विदेशमा गएको पाइयो ।

३.२.२ पानीको उपभोग

मोदी खोला तथा यसका सहायक नदीहरुको पानी विभिन्न उद्देश्यले प्रयोग गरेको पाइन्छ । सिचाइ, घरायसी उपभोग, औद्योगिक प्रयोग, माछा मार्ने, तथा सामाजिक

- तथा धार्मिक प्रयोजनमा प्रयोग गरेको पाइन्छ । यस क्षेत्रमा ५५ पानी घट्ट, १७ विद्युत प्लान्ट (साना जलविद्युत तथा पेल्टिक सेट सहित), ११ वटा सिंचाइ योजना तथा ठूलो संख्यामा साना तथा ठूला खानेपानी आयोजनाहरु रहेका छन ।
- पानीघट्टबाट ३३०० भन्दा बढी परिवार लाभान्वित भएको पाइन्छ । ४० प्रतिशत घट्टहरु वर्षायाममा मात्रै संचालित हुने गरेको पाइयो । पानीघट्टको ठूलो संख्या सुख्खा याममा बन्द भएको पाइयो ।
- धेरैजसो बस्तीहरुमा खानेपानी तथा सिंचाइ आयोजनाहरुमा सुख्खा याममा पानीको अभाव भएको पाइयो । सुख्खा याममा पानीको अभाव विशेषत तल्लो भेगमा पाइयो ।
- माछा मार्ने कार्य सिमित रहेको र विशेषत तल्लो भेगमा बढी पाइयो ।
- खोलाको पानी सामाजिक तथा धार्मिक प्रयोजनमा पनि प्रसस्तै उपयोग गरेको पाइयो ।

३.२.३ मौसम परिवर्तन प्रति जनधारणा

- हावापानी परिवर्तन सम्बन्धी जनधारण बुझ्न सामूहिक छलफल गरियो । १२ वटा समूह मध्ये ६ वटा समूहले तापक्रम बढ्दै गएको बताए । कुल समूहको एक तिहाइले वर्षाको मात्रा बढेको बताए भने ९ वटा समूहले हिउँले ढाकिएको क्षेत्र घटेको बताए ।
- उत्तरबाताहरुको ठूलो संख्याले बढी वर्षा हुनाले बालीनाली, घरपालुवा पशु, मानिस, बनजंगल तथा भौतिक पूर्वाधारहरुमा नकारात्मक असर पर्ने बताए । माथिल्लो भेगका ९२ प्रतिशतले बाली बिगार्ने ८० प्रतिशतले घरपालुवा पशु तथा मानिसलाई नकारात्मक असर पर्ने बताए । त्यसैगरी ५० प्रतिशतले जंगल र ८३ प्रतिशतले भौतिक पूर्वाधारमा नकारात्मक असर पार्ने बताए । त्यसैगरी तापक्रम बढी भएमा विभिन्न पक्षमा नकारत्मक असरहरु हुने कुरा तल्लो भेगका मानिसहरुको धारणा रहेको पाइयो ।

४. मोडल (Model) को नतिजा

Regional glacier melt model ले के तथ्य स्पष्ट पारेको छ भने 0.1^{0} C/yr तापक्रम बढेमा १०० वर्षमा मोदी खोलाको बहावमा हिउँद याममा माथिल्लो क्षेत्रमा ५० प्रतिशत र तल्लो क्षेत्रमा २० प्रतिशत सम्म गिरावट आउने छ । त्यसैगरी नदीको औसत बहावमा माथिल्लो क्षेत्रमा १० देखि २० प्रतिशत र तल्लो क्षेत्रमा ५ देखि १० प्रतिशत गिरावट आउने संकेत गर्दछ ।

[

५. निष्कर्ष

मोदी जलाधारक्षेत्रका मानिसहरुको जीविकोपार्जनमा मोदी खोलाको पानीको महत्वपूर्ण भूमिका छ । नदी बहावमा गिरवट आउनाले पानी उपयोगका विभिन्न पक्षहरु जस्तै जलविद्युतको उत्पादन, सिंचाइ, पिउनेपानी तथा पानी घट्ट समेतमा पानीको अभाव भई कृषि लगायत उद्योग धन्दा, पर्यटन व्यवसाय जस्ता जीविकोपार्जनका आधारभूत विकल्पहरुमा प्रत्यक्ष तथा परोक्ष रुपमा नकारात्मक असर पर्न सक्दछ । तसर्थ भविश्यमा नदी बहावको गिरावटबाट हुने नकारात्मक असरहरुबाट जोगिन त्यस तर्फ उचित ध्यान दिनु जरुरी देखिन्छ ।

Appendix 3.2.1
Corridor Workshop: Agenda (English & Nepali)

Centre for
Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Snow and Glacier Aspects of Water Resources Management (SAGARMATHA)

Kali Gandaki Stakeholder Consultation Workshop

April 21, 2004

Organized by

International Centre for Integrated Mountain Development (ICIMOD)
and
Centre for Ecology and Hydrology (CEH), UK

Facilitated by
Society of Hydrologist and Meteorologist (SOHAM), Nepal

Supported by

Department for International Development (DFID), UK

PROGRAMME

Time	Programme
09:30 – 09:55	**Registration**
10:00 – 10:30	**Opening Session** • Welcome Remarks by Dr. Binayak Bhadra, Director of Programmes, ICIMOD • Opening Remarks by Mr. Adarsha Prasad Pokhrel, Chairman, SOHAM • Opening Remarks by Mr Gwyn Rees, CEH, UK • Remarks by the Chief Guest • Remarks by the Chair • Vote of Thanks
10:30 – 11:00	***Tea Break and Group Photo***
11: 00 – 11:15	Project background and objectives of workshop, Ms. Mandira Shrestha, ICIMOD
11:15 – 11:30	Results of the hydrological model, Mr. Gwyn Rees, CEH

11:30 – 11:45	Context: Livelihoods, socio-economic aspects, water and climate changes, Dr Caroline Sullivan, CEH
11:45 – 12:00	Outcomes of the Local Stakeholder Consultations, Mr. Shiba Rijal, TU
12:00 – 12:30	Discussion
12:30 – 12:40	Briefing on Group Discussion, Mr. Adarsha Pokhral, SOHAM/ Mr. Shiba Rijal
12:40 – 12:50	Formation of three break-out groups and distribution of worksheets
12:50 – 13:00	Remarks by the chair
13:00 – 14:00	***Lunch Break***
14:00 – 15:30	Break-out group discussion continued
15:30 – 16: 30	Break out group feedback and synthesis group (Facilitator - Dr Caroline Sullivan, CEH and Ms. Mandira Shrestha, ICIMOD)
16:30 - 16:50	Final discussion: recommendations for adaptation strategies (Facilitator - Dr Caroline Sullivan, CEH and Ms. Mandira Shrestha, ICIMOD)
16:50 - 17:00	Closing remarks and vote of thanks
17:00 – 17:30	***Tea***
	End of Day

Note: Topics for the 3 Break-out Groups:

1. Impact on hydropower/water mills
2. Impact on Agriculture/Irrigation
3. Impact on Tourism and Livelihood

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

ICIMOD

"जलस्रोत व्यवस्थापनमा हिम तथा हिमनदीको भूमिका"

(Snow and Glacier Aspects of Water Resources Management in the Himalayas)

कार्यक्रम

समय	कार्यक्रम
१०.०० - १०.३०	रजिष्ट्रेशन
१०.३० - ११.००	उद्घाटन समारोह: • स्वागत मन्तव्य: डा. विनायक भद्रा निर्देशक इसीमोड • मन्तव्य: श्री आदर्श प्रसाद पोखेल अध्यक्ष सोहम-नेपाल • मन्तव्य: श्री गुइन रिस सी इ एच, संयुक्त अधिराज्य • प्रमुख अतिथी नि.क्षेत्रीय प्रशासक श्रीमान् बोधराज अधिकारीज्यूबाट उद्घाटन तथा उद्घाटन मन्तव्य • धन्यवाद ज्ञापन • कार्यक्रम सञ्चालक: श्रीमती मन्दीरा श्रेष्ठ:
११.०० - ११.२०	*चियापान र समुह फोटो*
	प्रथम सत्र
	सभापति:
	कार्यक्रम सञ्चालक: श्री सुरेश मरहट्टा
११.२० - ११.३०	परियोजनाको उद्देश्य, भूमिका तथा उपलब्धी – श्रीमती मन्दीरा श्रेष्ठ
११.३० - १२.००	जल विज्ञानीय प्रारुपको निश्कर्ष – श्री गुइन रिस/ डेभिड कोलिन्स
१२.०० - १२.१५	परियोजनाको सामाजिक आर्थिक पक्ष – श्रीमती क्यारोलिन
१२.१५ - १२.३५	सरोकार समूहको गोष्ठीको उपलब्धी – सिव प्रसाद रिजाल
१२.३५ - १३.००	छलफल तथा सभापतिको मन्तव्य
१३.०० - १४.००	*खाना*
	दोस्रो सत्र
	सभापति:
१४.०० - १४.१०	समूह विभाजन, प्रश्नावली वितरण
१४.१० - १५.३०	समूहगत छलफल:-
१५.३० - १६.००	समूहहरुको निष्कर्ष प्रस्तुती
१६.०० - १६.३०	छलफल
१६.३० - १६.५०	कार्यशालाका निष्कर्ष
१६.५० - १७.००	कार्यक्रम विसर्जन तथा धन्यवाद ज्ञापन
१७.०० - १७.३०	*चियापान*
	समाप्त

Appendix 3.2.2

Corridor Workshop: Participant List

S.N.	Name of Participant	Organization	Designation
1	Mr. Bodh Raj Adhikari	Regional Administration Office	Regional Administrator
2	Mr. Ambika Prasad Sapkota	Regional Administrative Office	Section Officer
3	Mr. Kamal Man Gurung	District Development Committee	Chairperson
4	Mr. Gopal Prasad Manandhar	Western Regional Irrigation Directorate	Senior Divisional Engineer
5	Mr. Sampat Yadav	Western Regional Forestry Directorate	Asst. Forest Officer
6	Mr.Kishore Shakya	Dept of Water Supply & Sewage	Chief, Regional Office
7	Mr.Ramesh Rijal	Nepal Water Supply Corporation	A. Manager
8	Mr. Girindra Jha	DWIDP Pokhara	Overseer
9	Mr. Dol Raj Paudyal	(ACAF)	Chairman
10	Mr. Shishu Koirala	ACAP	Community Dev. Officer
11	Dr. Krishana KC	P.N. Campus	Associate Professor
12	Mr.Indra Bd. Chand	NEWAH	Technical Officer
13	Mr. Ved Prakash Upadhya	Tourism Office Pokhara	Office Chief
14	Dr. Tek Bahadur Gurung	Fisheries Research Centre	Senior Scientist - 4
15	Mr. Ram Prasad Dhakal	Fisheries Research Centre	Technician
16	Mr.Bishnu Narayan Gurung	Narayani Basin Office, DHM	Senior Divisional Meteorologist
17	Mr.Ram Gopal Kharbuja	Narayani Basin Office, DHM	Hydrologist Engineer
18	Mr. Gokarna B. Motra	Western Region Campus	Campus Chief
19	Mr. Shiva Pd. Rijal	T.U.	Lecturer
20	Mr.Beda Nath Baral	Bijayapur River Water User Group	Secretary
21	Mr.Bishnu Ghimre	Western Regional Irrigation Directorate	Agro economist
22	Mr.Rameshwor Gurung	Hotel Manisha	Hotel manager
23	Ms. Sima Malik	Rural Energy Dev Section	Energy Dev. Officer
24	Ms.Man Kumari Giri	Jana Kalyan Samajik Mahila Samuha	Chair person
25	Mr. Pream Pd. Poudel	Acid-Asia	Chairman
26	Mr.Tara Bahadur chhetri	Water Transport	Member
27	Mr. Madan Bd. Karki	District Development Committee	Vice Chairman
28	Mr. Rajendra Pd. Adhikari	Dept. of Irrigation	Senior Divisional Engineer
29	Mr. Govinda Pd. Poudel	Shree Gyaneswi Shiv Mandir	Member secretary
30	Mr. Mahendra Man Bethita	District Development Committee	Legal Advisor
31	Mr. Ram Charitra Mahato	Narayani Irrigation Management Division	Irrigation Chief
32	Dr. Binayak Bhadra	ICIMOD	Director Programmes
33	Ms. Mandira Shrestha	ICIMOD	Water Resources Specialist
34	Mr. Ritesh Pd. Gurung	ICIMOD	Research Assistant
35	Mr. Gwyn Hefin Rees	CEH, Wallingford	Senior Hydrologist
36	Mr. Dermot O'Regan	CEH, Wallingford	Researcher
37	Dr. Caroline Sullivan	CEH, Wallingford	Head of Water Policy & Mgt.
38	Prof. David Collins	University of Salford	Senior Research Scientist
39	Mr.Adarsha Pd. Pokhrel	SOHAM- Nepal	Chairman
40	Mr. Suresh Marahatta	SOHAM- Nepal	Secretary

Appendix 3.2.3
Corridor Workshop: Minutes

Snow and Glacier Aspects of Water Resources Management In the Himalayas (SAGARMATHA)

Kali Gandaki Stakeholder Consultation Workshop
April 21, 2004

Organised by

International Centre for Integrated Mountain Development (ICIMOD)
and
Centre for Ecology and Hydrology (CEH), UK

Facilitated by
Society of Hydrologist and Meteorologist (SOHAM), Nepal

Supported by

Department for International Development (DFID), UK

Opening Session

Chair: Mr. Kamal Man Gurung, Chairperson,

Dr. Binayak Bhadra, Director of Programmes, International Centre for Integrated Mountain Development (ICIMOD) welcomed all the participants to the consultation. He informed that the consultation workshop funded by the UK Department for International Development (DFID) would focus on the issues of climate change and on the development of adaptation strategies to cope with the impacts of deglaciation.

He said that there is growing awareness of climate change and its impacts including global warming. The quantity of water in the rivers fed by glaciers would be affected and the prediction of availability would not be an easy task. There has also been an increase in the number of water induced disasters like cloud burst, flash floods, etc. He stressed on the importance of developing adaptation strategies to cope with the impacts of climate change for which the support of the stakeholders would be critical. He thanked all the participants for their participation and wished success to the consultation.

Mr. Adarsha Prasad Pokhrel, Chairperson, Society of Hydrologist and Meteorologist (SOHAM), Nepal said that Nepal is a country rich in water resources. Nepal has great potential for hydropower development, which could help the whole country develop. Although rich in water resources, Nepal faces the problem of water scarcity and it is the children and the women who are affected the most. He said that the country is also affected to a great extent by water induced disasters, which could be reduced if a database is developed.

Climate change occurs and an increase in the global temperature has been observed. He informed that the average increase of temperature in the Himalayan region is 0.12 °C per year, which has caused rapid melting of snow and glaciers.

He mentioned that some progress has been made in understanding some of these issues through this project. He said that the aim of the consultation is to disseminate the findings of the project as well to develop adaptation strategies to cope with the impacts of deglaciation.

Mr. Gwyn Rees, Centre for Ecology and Hydrology (CEH), UK said that the project had started after claims were made in 1999 that glaciers in Himalayas would disappear in 40 years and the project was developed to study the impacts of deglaciation in the Himalayan Region. CEH had contacted scientist, meteorologist and specialist from DHM, Nepal, ICIMOD, TU, Nepal and the University of Salford, UK and a proposal was prepared and submitted to DFID. He mentioned that the aim of the project is to assess the seasonal and long term water resources in snow and glacier fed rivers originating in the Himalayan region, and to determine strategies for coping with impacts of climate change induced deglaciation on the livelihood of people in the region. The findings of the study were being disseminated at various levels: from the local to the international level and the international dissemination workshop would be held in New Delhi, India. He thanked all the participants for attending the consultation. He thanked ICIMOD and SOHAM for organising the workshop.

Mr. Bodh Raj Adhikari, Regional Administrator, Western Development Region thanked the organisers for inviting him to the workshop and said that global ecological imbalance has caused temperature increase, ozone layer depletion and melting of glaciers. It would also result in flooding. Nepal suffers from the problem of either too much or too little water and the condition was aggravated by ecological imbalance. He stressed the importance of having climate change as a national issue. He said that water induced disasters cannot be stopped but can be controlled. He concluded by wishing success to the consultation.

Remarks by the Chair

Mr. Kamal Man Gurung said that many of the rivers in Nepal are snow fed and thus the issue of climate change and water resources management is important. The amount of water available would definitely change because of climate change. Sharing his recent experiences he said that a glacial lake outburst flood occurred at the Modi River and the people there were greatly affected. However, adequate resources were not available to reconstruct the roads destroyed by the floods. He informed that Annapurna Base Camp and Ghandruk are important tourist sites and climate change would definite affect tourism at those locations.

He informed that the settlements along the banks of the Khirna Khola, a tributary of Modi Khola, is in the danger of being flooded because of a dam formed by landslide. The breach of the dam would most likely affect the Modi Project at the downstream. The water level in the dam was being lowered naturally but it was not happening at a good rate. He said that the issue of climate change is of great importance and wished success to the workshop.

In her vote of thanks, **Dr. Caroline Sullivan, CEH** said climate change is challenging issue in mountainous regions and therefore the project was important. She thanked the Chairperson of the session Mr. Kamal Man Gurung and the Chief Guest Mr. Bodh Rah Adhakari. She thanked Dr. Binayak Bhadra, Mr. Adarsha Pokhrel and Ms. Mandira Shrestha for their contribution to the project and to the workshop. She thanked Mr. Shiba Rijal, TU for his efforts in collection of the socio-economic data. She thanked the participants of the workshop and DFID for their support. She mentioned that the people of Nepal were very helpful and provided a lot of support in the study. She thanked all the Nepali communities and said that the results of the study would be useful to help other mountain communities as well.

Working Session I
Chair: Dr. Kishore Shakya, Senior Divisional Engineer, Regional Water Supply Directorate

Project background and objectives of the workshop, Ms. Mandira Shrestha, ICIMOD

Ms. Shrestha provided a background of ICIMOD. About 80% of the total rainfall in Nepal occurs in the four monsoon month from June to September and hence there is either too little

or too much water. There is an increase in water demand because of population increase and change in the lifestyle of the people. There are growing evidences that the higher elevations were more affected by climate change. There are also evidences of increase in the number of extreme events. Water is used for various reasons in the Himalayan region including irrigation, livestock, fishing, hydropower, and tourism industry.

She presented the objective of the project and informed it has two components viz.: regional hydrological model and the socio-economic component. The regional hydrological model was developed to estimate average annual and monthly runoff and model was used to forecast the extent of deglaciation and its impacts on future river flows in the region.

The socio-economic study was done to assess the present livelihood and the adaptation strategies adopted by the people of the Modi Khola Watershed. A water use survey was also done for the Modi Khola and the Kali Gandaki Corridor and both primary and secondary data was collected during the survey.

She presented the project outputs and informed that the object of the consultation is to disseminate the findings of the studies conducted, to obtain stakeholder perception on climate change and potential impacts, and to develop a better understanding of potential adaptation strategies of stakeholders. The expected outcomes of the consultations were presented.

Introduction of Participants

Following the presentation, the participants introduced themselves.

Results of the hydrological model, Prof. David Collins, University of Salford, UK and Mr. Gwyn Rees, CEH

Prof. Collins provided a global outlook of deglaciation and provided experiences from Alps in Switzerland. He pointed out that climate change would affect runoff both directly and indirectly. The temperature record of the last 250 thousand years show fluctuation in the mean global temperature and the current temperature rise may be part of it. The rise in temperature the discharge of a snow-fed river might increase but it may not be true for a rain-fed river.

He said that the rainfall pattern of a region influences the flow in a river and the percentage contribution of glacier melt would be small in rivers flowing through an area of intense rainfall whereas it would be high in rivers flowing through dry regions. The rate of glacier melt would depend on the distribution of the volume of ice in the glacier.

Mr. Rees said that the glaciers in the region had melted to some extent. He said that the model developed by the project gave different climatic scenarios for the prediction of the amount of deglaciation and a macro-scale model for the Indus, Ganges and the Brahmaputra was developed. He expressed the difficulty in developing a model for all the glaciers in the region and added that a regional glacier melt model representing many glaciers in a grid cell was required. He said that a temperature increase of 0.03 °C/year would cause very little change in the existing flow of the rivers and for a temperature rise of 0.1°C/year, the amount of water in the rivers would peak in the next 45-50 years and would then be reduced drastically. He mentioned that the model indicated that the Western Himalayas would be more affected than the Eastern Himalayas.

He said that different climatic scenarios predicted different impacts both at local and regional level. Water shortages as forecasted are unlikely to happen in for many decades and the threat that glaciers in the Himalayan regions would disappear was ill-founded.

Livelihoods, socio-economic aspects, water and climate changes, Dr Caroline Sullivan, CEH

Dr. Sullivan said that the rise in global temperature could cause more extreme events and glacial shrinkage. The impact would be more pronounced at elevation more than 1800 m. It would also affect the ecological conditions of the rivers.

She said that all livelihoods depend on water and it is important for both agricultural as well as for industrial purposes. It is the women and children who are more affected by scarcity of water and the poor are more vulnerable to the impacts of climate change. The reduction of water supply coupled with population increase would make it very difficult to manage water resources. She stressed on the need to design infrastructures on the basis of future prediction rather than on past data and mentioned that the livelihoods that directly depend on water are more. Although most of the households in the Himalayan region tend to use multiple livelihood strategies about 56 % of the population included in the study were not able to produce enough food.

She mentioned that some part of the world would be more affected by climate change than others and efforts should be made towards adaptation to new conditions rather than trying to revert to previous conditions.

The mountain communities had expressed awareness of changes in climate. During the household survey over 58% of household reported losing of crops due to hailstorm in the last ten years. The impacts of climate change would be felt more strongly on the western parts of the Himalayan region than on the eastern side.

Outcomes of the Local Stakeholder Consultations, Mr. Shiba Rijal, TU

Mr. Rijal presented the results of the socio-economic survey and the local stakeholder consultations. The component tried to identify the impacts on livelihoods due to changes in water availability. Two types of surveys were carried out within the component: socio-economic survey and water use survey. The socio-economic survey was carried out at the Modi Khola Watershed and the water use survey was done at both Modi Khola Watershed and Kali Gandaki Corridor. The socio-economic data was collected through household survey, group discussion, field observation and literature review, and water use data was collected through water use inventory and mapping, and group discussion.

Presenting the major findings of the study he said that the average landholding in the Modi Khola watershed is about 1.1 ha and 53.9 % of the household have landholdings between 0.5 and 2 ha. He mentioned that 95.6 % of the households have either an animal or a bird and that remittance is the main sources of livelihood. He also pointed out that 56% of the household do not have sufficient food production.

He presented the perception of the communities on climate change and the results of the water use survey. He that two local stakeholder consultations were held in Kusma and Ghandruk in the Modi Khola watershed. He presented the adaptation strategies of the local stakeholder consultation, which are as follows:

- Changes in cropping patters, substitution of crop varieties and species;
- Changes in animal husbandry techniques;
- Promotion of social networks;
- Development of early waning systems;
- Development of fish ponds and fish breeding;
- Promotion of cultural tourism;
- Migration;

- Changes in the design specifications for water and other infrastructure and modification of existing structures; and
- Development of management strategies to cope with reduced water availability in equitable way to prevent conflict

Remarks by the chair

Mr. Shakya said that it was an interesting technical session. He thanked Ms. Shrestha for providing the background of the project. He mentioned the presentation by Prof. Collins was very helpful in understanding how glaciers behave. He expressed his happiness that the study findings showed that deglaciation would not affect the river in Nepal to a great extent through reduction in flows. He mentioned that temperature is rising and disasters like floods are more common. He also pointed out that there are more frequent floods and draughts. He mentioned that the results should enable better water resources management and thanked all the presenters and the participants.

Working Session II

Chair: Dr. Binayak Bhadra, Director of Programmes, ICIMOD

The participants were divided into three breakout groups. They were requested to fill a feedback sheet with their view on climate change and potential adaptation strategies.

In this session, participants were allocated to groups to provide a good cross section in each. They then spent the first part of the breakout period discussing adaptation strategies which were distributed on feedback sheets. After discussion they developed a group response to the listed issues and recorded these on the sheets (one for each group). These were also supported by flip chart sheets which were used to enable feedback to the plenary group after the discussion session, by a rapporteur in each group. The results of these group discussions are shown in Table 1, 2 and 3.

Group 1.

Topic	Positive advantages	negative disadvantages
Change in cropping patterns, new varieties etc	Traditional ways of agriculture should be continued along with the introduction of new technology	Introduction of new species would lead to the need for improvement in eating habits. New species should be identified on the basis on senstivitiy to climate change
Promotion of soc networks	Social mobilisation and networking across geographical boundaries should be promoted, including inter-caste marriage	There may be a negative effect on culture, may create conflict between different groups
Changes in location of activities,fishing etc	Local species of fish must be conserved and developed. Improved species should be cultivated and increased in production . Fish ponds should be developed	none
Changes in appropriate location of tourism	On the basis of feasibility studies, proper management of rivers for tourism use, rafting etc should be introduced	pollution could lead to ecological imbalance
Changes in animal husbandry techniques	Selection of local species of livestock for further improvement and development of the breed.	new diseases could be introduced
Migration	Migration from rural area should be discouraged	People may become more narrow minded
Changes in design of infrastructure	More equitable water allocation should be porsued and infrastructure developed accordingly	This could be costly and some existing infrastructure may no longer be of use
Development of management strategies to cope with changes in water	build awareness of the proper utilisation of water	changes in availablity may make management more difficult
Additional policies for local stakeholders	stakeholder consultation should be incorporated to reduce possible conflicts	existing policies may be inequitable
Important recommendations for policy	give priortiy to HEP based on small scale community involvement and investment, as well as in water supply and irrigation	conflicts must be minimised, some policies are conflicting, need integration of policies

Group 2.

Topic	Positive advantages	Negative disadvantages
Change in cropping patterns, new varieties etc	Introduction of new high yielding varieties, especially for different ecological regions	Danger to biodiversity. Threat to indigenous vegetation
Promotion of soc networks	Informal education for awareness raising. Empowerment of local user groups	Group conflict. Resource constraints
Changes in location of activities,fishing etc	Introduction of improved species, taking account of local ecology. Encouragement of private fish production through the development of pond fishing	Marketing problems, ecosystem and biodiversity impacts
Changes in appropriate location of tourism	Identification of new tourism destinations, development of eco friendly tourism infrastructure, and heritage based tourism	cultural pollution and environmental degradation
Changes in animal husbandry techniques	introduction cross breeds and hybrids to build stock resilience, improvement in fodder production	new breeds may be more suceptible to diseases and worms
Migration	Development of detailed land use maps to identify good locations for human settlements	socio-cultural conflicts
Changes in design of infrastructure	Development of multipurpose dams, integrated basin wide water development plans and prioritisation of water uses	resource constraint
Development of management strategies to cope with changes in water	participatory water development plan needed	water rights problems may arise
Additional policies for local stakeholders	more social equity, employment generation policies and educational awareness promoted	none
Important recommendations for policy	More user empowerment, policy on water quality, demand driven water uses	beneficiary conflict, resource constraints, paradoxical stategies and policies

Group 3.

Topic	Positive advantages	Negative disadvantages
Change in cropping patterns, new varieties etc	Increases in yield possible, taking advantage of new conditions (more rain, hotter weather etc) potential gain from new varieties if patents are put in place for new cultivars. Promotion of biodiversity conservation	lack of patent rights could cause the loss of all benefits
Promotion of soc networks	Public awareness raising on potential natural disasters and development of warning systems. Promotion of indigenous knowledge and skills.	could create social conflicts and worry
Changes in location of activities,fishing etc	ponds	none
Changes in appropriate location of tourism	could promote employments opportunities as an alternative to tourism	difficult to find markets and poor transport create limitations to this
Changes in animal husbandry techniques	Community based livestock management schemes	Marketing problems, erosion through over grazing
Migration	Encourage push back migration and discourage rural emigration	lack of jobs and adequate housing in situtations of growing population
Changes in design of infrastructure	Plans should be made so as to not disturb the environment	environmental and socio-economic disruption, degradation
Development of management strategies to cope with changes in water	Better implementation of existing laws with more participation in enforcement	If not done properly, could increase conflict
Additional policies for local stakeholders	Establishment of water user groups etc., promotion of water conservation techniques	conflicts could arise if shortages develop
Important recommendations for policy	Implement a poverty reduction programme through better water resources	underutilisation of water could be wasteful

Policy briefing note consultation

All participants were given a consultation document relating to the proposed policy briefing note. These were discussed as a group, and a group version was produced, but in addition, these sheets were also completed on an individual basis to enable more detailed information to be collected, and to ensure full representation of all issues raised. Preliminary analysis of individual feedback sheets was made to provide information to the plenary group about what had been said by individuals. This was analysed more comprehensively after the workshop. The following suggestions were made by the group on issues to be included in the policy briefing note:

1. The nature of mountain livelihoods should include farming, tourism, external remittances, small scale industry and handicrafts. Key issues suggested by stakeholders were: livestock and dairying, the cultivation of medicinal plants and herbs, and the promotion of community forestry and NTFPs (non-timber forest products).

2. Current problems in mountain communities

Depopulation, Unemployment, Unpredictability of seasons and poverty were agreed as main issues, with other problems including lack of infrastructure being given significance, along with inappropriate farming policies

3. Research findings to be included

- Modelled outputs suggesting changes in water availability
- Potential impacts on communities
- Potential adaptation strategies which would be suitable and acceptable
- Issues which are important for health and welfare of human populations
- Promotion of more equitable water management
- The need for more awareness raising re Climate change impacts

4. Policy recommendation suggestions

Participants were asked to rank a selection of issues as important to be included in policy recommendations. Those considered to be most important were:

8. Build awareness of the impacts of climate change
9. More participation in development of climate response policy
10. Better monitoring and data collection about conditions in upper mountain areas
11. Participatory survey on selected indicators of climate change implemented in key areas
12. Develop mechanisms to support and promote adaptation strategies
13. Investigate potential for water saving techniques
14. Encourage the development of experimental cropping (in conjunction with the Ministry of Agriculture)

Other issues which were also considered, but seen as less urgent were:

- Investigate scale of impacts on infrastructure in key basins
- Assess appropriate infrastructure responses
- Investigate potential for early warning
- Investigate potential need for water storage facilities

Other suggestions for inclusion made by individuals were:

- Research findings should be disseminated widely to people at all levels of society, not just policy makers
- Identification of geographical locations which might be safe from hydrological accidents and other natural disasters
- Introduction of a comprehensive (environmentally friendly, participatory, equitable) water use act by the government
- Development of a mountain database
- Restoration of forests in upper catchment areas (near glaciers)
- Need for more participation by women and marginalized people, including lower caste groups
- More integration and coordination between government departments, NGOs etc.
- Implementation of participatory watershed conservation projects and afforestation programmes
- Promotion and fostering on existing social heritage in tourism development

5. Concluding remarks – Dr. Bhadra, Dep. DG ICIMOD

Dr Bhadra provided the concluding remarks for the workshop in which he summarised a number of issues raised during the breakout feedback session. He congratulated the participants on their diligence and interest in the topic, and the variety of suggestions and comments received. He pointed out that it was important to consider the effect of the rain-shadow in certain places in the catchments in the high mountain areas.

Dr. Bhadra further mentioned that he was very happy with the recommendations made by the groups. He said that farming of medicinal plants would really be of great use. He said that it would be good if there were legislations governing farming techniques. He mentioned that animal husbandry techniques would require more focus. He said that there are problems such as lack of infrastructure and unemployment and stressed on the need of an integrated plan to address these issues. He mentioned that a more detailed monitoring is required at the upper regions and priorities should be given to building awareness and participation survey. He added that harmonisation of strategies would also be beneficial. He supported the policies that would help reduce poverty by better management of water resources. He mentioned that the policies should also take into consideration the water quality aspects. He concluded by saying that the workshop was successful in meeting the expected outcomes. He thanked the participants for there contribution.

The meeting concluded at 7pm with full participation for the whole day. A heavy hailstorm event occurred during the meeting, providing a perfect example of the problems which can be faced as a result of extreme events. Much damage to vegetation (including crops) in the area was observed.

Appendix 3.2.4
Corridor Workshop: Photographs

Kali Gandaki Stakeholder Workshop Participants, Pokhara, Nepal, April 21, 2004

See also Section 4.4.3 of this report.

Appendix 3.2.5
Corridor Workshop: Background Document (English & Nepali)

Snow and Glacier Aspects of Water Resources Management In the Himalayas (SAGARMATHA)

Kali Gandaki Stakeholder Consultation Workshop
April 21, 2004

Organised by

International Centre for Integrated Mountain Development (ICIMOD)
and
Centre for Ecology and Hydrology (CEH), UK

Facilitated by
Society of Hydrologist and Meteorologist (SOHAM), Nepal

Supported by
Department for International Development (DFID), UK

Background:

The SAGARMATHA (Snow and Glacier Aspects of water Resources Management in The Himalaya) project is a three-year project initiated in April 2001 and supported by DFID, U.K. The aim of the project is to assess the seasonal and long term water resources in snow and glacier fed rivers originating in the Himalayan region, and to determine strategies for coping with impacts of climate change induced deglaciation on the livelihood of people in the region. The project has two components: i) the development of a regional hydrological model, and ii) the socio-economic component. For the socio-economic study the Modi Khola and the corridor along the Kali Gandaki Basin were selected. The hydrological model was also developed for the Modi Khola Basin. As part of the project, studies have been conducted on the use of water along the Modi Khola Basin and the Kali Gandaki Corridor.

The aim of the stakeholder consultation is to disseminate the findings of the studies that have been conducted so far. The consultation also aims to obtain feedback from the stakeholder along the corridor to develop adaptation strategies to help the downstream communities cope with the impacts of deglaciation.

Objective:

- To disseminate the results of the studies conducted by the project so far
- Propose adaptation strategies based on the result of the water use survey
- To obtain feedback on the proposed adaptation strategies
- Finalisation of the adaptation strategies

Expected Outcomes

- Adaptation strategies that would help the communities cope with the impact of deglaciation.

Date and Venue

The regional stakeholder consultation will be held on April 21, 2004 at Pokhara, Nepal.

Expected Participants

The participants will include stakeholders from the Kali Gandaki Basin.

Number of Participants

The total number of participants for the consultation will be approximately 40.

Contact Addresses:

Mr. Adarsha Prasad Pokhrel
Chairman
Society of Hydrologist and Meteorologist (SOHAM), Nepal
GPO Box: 1339
Kathmandu, Nepal
Tel: +977-1-5538770
Email: adarsha@mos.com.np

Mr. Suresh Marathha
Society of Hydrologist and Meteorologist (SOHAM), Nepal
Putlisadak, Kathmandu Nepal
Tel: 977-1-4352707
Mobile: 977-1-9841223521
Email: recham@ntc.net.np

Mr. Shiba Prasad Rijal
Department of Hydrology and Meteorology
Tribhuvan University
Kirtiur, Lalitpur
Nepal
Tel: 977-1-4288972
Email: sprijal@wlink.com.np

Ms. Mandira Shrestha
Water Resources Specialist
International Centre for Integrated Mountain Development
GPO Box: 3226
Jawalakhel, Lalitpur, Nepal
Tel: 977-1-5525313
Fax: 977-1-5524509
Email: mshrestha@icimod.org.np

Mr. Ritesh Prasad Gurung
International Centre for Integrated Mountain Development
GPO Box: 3226
Jawalakhel, Lalitpur, Nepal
Tel: 977-1-5525313
Fax: 977-1-5524509
Email: rgurung@icimod.org.np

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

ICIMOD

"जलस्रोत व्यवस्थापनमा हिम तथा हिमनदीको भूमिका"

(Snow and Glacier Aspects of Water Resources Management in the Himalaya)

आयोजकः-

अन्तर्राष्ट्रिय एकिकृत पर्वतिय विकास केन्द्र (**ICIMOD**) तथा सेण्टर फर इकोलोजी एण्ड हाइड्रोलोजी (**CEH**)

सहयोगी संस्थाः-

अन्तर्राष्ट्रिय विकास विभाग, संयुक्त अधिराज्य (**DFID**)

व्यवस्थापकः-

जल तथा मौसमविद् समाज – नेपाल
(सोहम–नेपाल)

१. पृष्ठभूमिः

"जलस्रोत व्यवस्थापनमा हिम तथा हिमनदीको भूमिका" (Snow and Glacier Aspects of Water Resources Management in the Himalaya SAGARAMATHA) संयुक्त अधिराज्यको अन्तर्राष्ट्रिय विकास विभाग (DFID) को आर्थिक सहयोगमा सञ्चालीत एक अनुसन्धान परियोजना हो । जलवायु परिवर्तनको कारणले तापक्रम वृद्धिहुंदा हिमालयको हिमभण्डार बिस्तारै नासिंदै जाने कारणले हिमालयबाट उत्पन्न भएका नदीहरुको बहावमा अल्पकालीन तथा दीर्घकालीन परिवर्तन भई त्यस क्षेत्रका बासिन्दाको जीविकोपार्जनमा के कस्ता असरहरु पर्न सक्दछन् र सो परिवर्तनसँग समायोजन गर्न के कस्ता भावि रणनीतिहरु अवलम्वन गर्नु वेश हुन्छ भन्ने कुराको खोजी गर्नु यो परियोजनाको उद्देश्य रहेको छ । यस परियोजनाका दुई पक्षहरु छन्:

क) क्षेत्रीय जलविज्ञानीय-प्रारुपको निर्माण (**Development of Regional Hydrological Model**)
ख) सामाजिक-आर्थिक पक्ष (**Socio-Economic Aspect**)

यस अनुसन्धान परियोजनामा अन्तर्राष्ट्रिय एकिकृत पर्वतिय विकास केन्द्र ९क्ष्यक्षइम्०, श्री ५ को सरकार, जल तथा मौसम विज्ञान विभाग, नेपाल, त्रिभूवन विश्वविद्यालय, भारतको जवहारलाल नेहरु विश्वविद्यालय, संयुक्त अधिराज्यको सेण्टर फर इकोलोजी एण्ड हाइड्रोलोजी (CEH) र साल्फर्ड विश्वविद्यालय संयुक्त अधिराज्य जस्ता संस्थाहरु संलग्न छन् ।

२. अध्ययन क्षेत्र:-

यस परियोजनाको अध्ययन क्षेत्र निम्नानुसार पर्दछ ।

क) मोदी खोला जलाधार क्षेत्र ।

ख) मोदी-कालीगण्डकी दोभानदेखि नेपाल भारत सिमाको भैंसालोटनको क्षेत्रसम्म । यस अध्ययनमा नदीको दुवै तर्फ २.५ कि.मी. गरी जम्मा ५ कि.मी. क्षेत्रमात्र समेटीएको छ ।

३. समूहिक छलफल:-

यस समूहिक अन्तरक्रियाको मूख्य उद्देश्य निम्न अनुसार छन्:

क) जल विज्ञानीय-प्रारुपको अध्ययनबाट नदी वहावमा पर्ने दीर्घकालीन परिवर्तन सम्बन्धी नतिजा प्रस्तुत गर्ने,

ख) जलवायू परिवर्तनका कारणले नदीको वहावमा देखिने परिवर्तनबाट जीविकोपार्जनमा पर्ने असरहरुको लेखा जोखा गर्ने,

ग) सकारात्मक/नकारात्मक असरहरु सम्बन्धमा सरोकार समूहसाग अन्तरकृया गरि सुझाव संकलन गर्ने,

घ) प्राप्त सुझावका आधारमा भावी रणनीति तय गर्ने ।

४. आशातित प्रतिफल:

जलवायु परिवर्तनले हिमक्षेत्र नासिंदै जादा तल्लो तटीय वासिन्दाहरुले बदलिंदो परिस्थितिसाग समायोजन गर्न अपनाउनु पर्ने संभाव्य भावि रणनीति तय गर्नु नै यस छलफलको उपलब्धी हुनेछ ।

५. छलफलको स्थान तथा समय

यो सामूहिक छलफल कार्यक्रम २०६१ सालको बैशाख ९ गते (अप्रिल २१, २००४)
पोखरामा हुनेछ ।

६. छलफलमा सहभागीता:

गण्डक क्षेत्रका जलसरोकार समूह तथा अनुसन्धान परियोजनामा संलग्न व्यक्तिहरु यस कार्यशालामा सहभागी हुनेछन् । सहभागीको संख्या ५० को हाराहारीमा हुनेछ ।

थप जानकारी/सूझावका लागि:-

१. श्री आदर्श प्रसाद पोखेल
अध्यक्ष, जल तथा मौसमविद् समाज नेपाल (सोहम-नेपाल)
पो.ब.नं. २१०६१, काठमाण्डौं, नेपाल ।
फोन नं.:- ०१-५-५३८७७०
इमेल:- adarsha@mos.com.np

२. श्रीमती मन्दीरा श्रेष्ठ
जलस्रोत विज्ञ
अन्तराष्ट्रिय एकिकृत पर्वतिय विकास केन्द्र ९ध्क्ष्कइम०
पो.ब.नं. ३२२६,
ललितपुर, नेपाल ।
फोन नं.:- ०१-५-५२५३१३
फयाक्स नं.:- ०१-५-५२४५०९
इमेल:- mshrestha@icimod.org.np

३. श्री राम गोपाल खर्बुजा
इन्जिनियर-हाईड्रोलोजिष्ट
नारायणी बेसिन कार्यालय,
पार्दी पोखरा ।
फोन नं.:- ०६१-५-२०२९९

Appendix 3.2.6
Participant/Breakout Group Feedback Sheet: Adaptation Strategies (English & Nepali)

Kaligandaki Stakeholder Consultation Workshop, Pokhara
Participant Feedback Sheet: Adaptation Strategies

Name: …… Institution:

……

Page 1

PART I Adaptation Strategies	POSITIVE SUGGESTIONS FOR ACTIONS	POTENTIAL NEGATIVE EFFECTS, DANGERS
Changes in cropping patterns, substitution of crop varieties and species		
Promotion of social networks Please suggest options for different places, regions etc. e.g. at the village level, at national level etc.		
Changes in the location of fishing activities, promotion of fish breeding and river stocking		
Changes in the appropriate location of certain tourism activities such as rafting		

Changes in animal husbandry techniques		
Human migration		
Changes to design specifications for water and other infrastructures, and modification of existing structures		
Development of management strategies to cope with reduced water availability in an equitable way to prevent conflicts		
Existing Policies in Water Use/ Irrigation/Water Supply/Hydropower/Other use		
Additional Policies to incorporate local stakeholder needs		
Most important issues to be included in recommendations for Policy		

कालीगण्डकी सरोकार समूह कार्यशाला, पोखरा

सामूदायिक कार्यशाला प्रतिक्रिया तालिका: समायोजन रणनीति

(Regional Workshop Feedback Sheet: Adaptation Strategies)

वि.सं. २०६१ बैशाख ९ (April 21, 2004)

समूहको नाम:.....

समायोजन रणनीति	कार्यक्रमका रुपमा अगाडी बढाउनु पर्ने सकारात्मक सुझावहरु	सम्भाव्य नकारात्मक असर तथा खतराहरु
बाली प्रणालीमा परिवर्तन, बालीको प्रकार र जातमा प्रतिस्थापन (Changes in cropping patterns, substitution of crop varieties and species)		
सामाजिक संजालमा वृद्धि (Promotion of social networks)		
माछा मार्ने स्थानमा परिवर्तन, नश्ल सुधार तथा माछा उत्पादनमा वृद्धि (Changes in the location of fishing activities, promotion of fish breeding and river stocking)		
पर्यटकीय क्रियाकलापको स्थान परिवर्तन जस्तै जलक्रिडा (Changes in the appropriate location of certain tourism activities such as rafting)		

पशुपालन प्रविधिमा परिवर्तन (Changes in animal husbandry techniques)		
बसाईसराइ (Migration)		
पानीसँग सम्बन्धित तथा अन्य भौतिक पूर्वाधारहरुको बनावटमा परिवर्तन तथा सुधार (Changes to design specifications for water and other infrastructures and modification of existing structures)		
पानीको उपलब्दतामा फरक भई उत्पन्न हुनसक्ने द्वन्दको समाधानको लागि उचित व्यवस्थापन कार्यक्रमको विकास गर्ने (Development of management strategies to cope with changes in water availability in an equitable way to prevent conflicts)		
स्थानिय सरोकार समुहका आवश्यकतानुरुप थप गर्नुपर्ने नीतिहरु (Additional Policies to incorporate local stakeholder needs)		
नीति भित्र राख्न सिफारिस गर्नुपर्ने सर्वाधिक महत्वका मुद्दाहरु (Most important issues to be included in recommendations for Policy)		
जलउपयोग सम्बन्धी वर्तमान नीति: सिंचाई/ जलविधुत/ घरायसी उपयोग/ अन्य) (Existing policies in water use/ irrigation/ water supply/ hydropower/ other use		

Appendix: 3.2.7

Participant/Breakout Group Feedback: Draft policy briefing note (also used at Delhi workshop) (English & Nepali)

POLICY BRIEFING NOTE

Mountain livelihoods, water resources and climate change

The nature of mountain livelihoods

People who live in mountains tend to be resilient and resourceful. They often have considerable ecological knowledge and from experience, have good understanding of how climate variation can influence local livelihoods. In the mountain communities of the Himalayan region, people tend to depend largely on farming, tourism, external remittances, small scale industry and handicrafts……

What else do you think should be included here……..

Current problems in mountain communities

Depopulation, Unemployment, Unpredictability of seasons, Poverty

How would you like to see these discussed –suggestions please

Research findings

Modelled outputs suggesting changes in water availability
Potential impacts on communities
Potential adaptation strategies which would be suitable and acceptable
Issues which are important for health and welfare of human populations

What do you think should be included here

ADAPTATION STRATEGIES

Please list what you think are the most important things that should be done to take account of the impacts of climate change in mountain areas

POLICY RECOMMENDATIONS

PLEASE ASSIGN NUMBERS IN THE APPROPRIATE BOXES TO INDICATE WHAT YOU THINK IS MOST IMPORTANT FROM THE LIST ABOVE.

PLEASE GIVE ANY OTHER SUGGESTIONS YOU MAY HAVE.

ISSUE	Your ranking of this issue
1. Better monitoring and data collection about conditions in upper mountain areas	
2. Participatory survey on selected indicators of climate change implemented in key areas	
3. More participation in development of climate response policy	
4. Build awareness of the impacts of climate change	
5. Develop mechanisms to support and promote adaptation strategies	
6. Encourage the development of experimental cropping (in conjunction with the Ministry of Agriculture)	
7. Investigate potential for water saving techniques	
8. Investigate scale of impacts on infrastructure in key basins	
9. Assess appropriate infrastructure responses	
10. Investigate potential for early warning	
11. Investigate potential need for water storage facilities	
Other suggestions here please!	

Contact: Put your contact details here (voluntary)

नीति सम्वन्धी सारांश टिप्पणी
पर्वतीय क्षेत्रमा जिविकोपार्जन, जलस्रोत तथा जलवायू परिवर्तन

पर्वतीय क्षेत्रको जिविकोपार्जनको प्रकृति

पर्वतीय क्षेत्रमा वसोबास गर्ने मानिसहरु प्राकृतिक स्रोत सम्पन्न देखिन्छन् । पर्यावरणीय ज्ञान तथा अनुभवका आधारमा जलवायू परिवर्तनले स्थानीय जिविकोपार्जनमा के असर पार्दछ भन्ने ज्ञान प्राय जसोमा हुन्छ । हिमाली क्षेत्रका वासिन्दाहरु खास गरेर खेती, पर्यटन व्यवसाय, वैदेशिक रोजगारी, लघु उद्योग तथा हस्तकला व्यवसायमा निर्भर गर्दछन् ।

तपाईको विचारमा के कस्ता अन्य व्यवसायहरु अपनाउंछन् ?

पर्वतीय समुदायका वर्तमान समस्याहरुःघट्दो जनसंख्या, वेरोजगारी, मौसमको अनिश्चितता, गरिवि हुन् भने

तपाईको विचारमा यी समस्याहरुलाई कुन प्रकारले हेरिनु पर्दछ ?

अनुसन्धानको नतिजा

जलउपलब्धतामा भएको पविर्तन जलविज्ञानीय प्रारुपले देखाएको छ । समुदायमा असर हुने सम्भावना देखिन्छ ।

सम्भाव्य समायोजन रणनीति भरपर्दो तथा स्वीकार्य हुनुपर्दछ । स्वास्थ्यका लागि महत्वपुर्ण तथा जनकल्याणकारी मुद्धाहरु पनि छन्

तपाईंलाई यस सम्बन्धी अरु के जानकारी छ ? .

समायोजन रणनीति

पर्वतिय क्षेत्रमा जलवायु परिवर्तनबाट पर्ने असरलाई कम गर्न के गर्नु पर्दछ, कृपया सिलसिलेबार हिसावमा उल्लेख गर्नुहोस् ।

नीति सम्वन्धी शिफारिस (प्राथमिकता क्रमानुसार अंक दिनुहोस्) ।

क्र.सं.	मुद्धा	प्राथमिकता (क्रम १,२,३.....)
१	उपल्लो पर्वतीय क्षेत्रको अवस्था सम्बन्धी तथ्याङ्क संकलन तथा अनुगमन अझ राम्ररी गर्ने ।	
२	प्रमुख स्थानहरुमा जलवायू परिवर्तन सूचक सर्वेक्षण गर्ने ।	
३	जलवायू परिवर्तन असर सम्बन्धी नीति विकास गर्न अझ बढी सहभागिता जुटाउने ।	
४	जलवायू परिवर्तनबाट पर्ने असरहरुका सम्बन्धमा व्यापक जनचेतनाको अभिवृद्धि गर्ने ।	
५	समायोजन रणनीतिलाई सघाउ पुग्ने संयन्त्रको विकास गर्ने ।	
६	प्रयोगात्मक वालीको विकासका लागि हौसला दिने ।	
७	पानी बचत गर्ने प्रविधिका संभाव्यताको खोजी गर्ने ।	
८	प्रमुख जलाधारक्षेत्रका संरचनाहरुमा पर्ने असरहरुको लेखाजोखा गर्ने ।	
९	संरचनामा पर्ने असरहरुको मुल्याङ्कन गर्ने ।	
१०	पुर्वानुमान संभाव्यता अध्ययन गर्ने ।	
११	जलभण्डार सुविधाको आवश्यकता सम्बन्धी संभाव्यता अध्ययन गर्ने ।	
	अन्य सुझावहरु :	

कृपया आफ्नो नाम तथा ठेगाना उल्लेख गर्नुहोस् ।

नाम:

ठेगाना:

फोन:

Appendix 3.3.1
International Workshop: Agenda

His Majesty's Government of Nepal
Department of Hydrology & Meteorology

ERSITY ICIMOD

DEGLACIATION: IMPACTS AND ADAPTATIONS FOR WATER RESOURCES AND LIVELIHOODS IN THE HIMALAYAS

Stakeholder Consultation and Dissemination Workshop

India International Centre, New Delhi, India

April 27-28, 2004

Jointly organized by

Centre for Ecology and Hydrology, Wallingford, UK
Jawaharlal Nehru University, New Delhi, India
International Centre for Integrated Mountain Development, Nepal

Facilitated by
HIGHICE, New Delhi, India

A contribution to the

Hindu Kush – Himalayan Flow Regimes from International Experimental and Network Data (HKH–FRIEND) project of the UNESCO International Hydrology Programme

Supported by the

UK Department for International Development (DFID) funded project
"Snow and Glacier Aspects of Water Resources in the Himalayas" (SAGARMATHA)

DFID Department For International Development

HIGHICE India

friend

Day 1, Tuesday, April 27, 2004

Time	Programme	
09:00 – 9:30	**Registration**	
09:30 – 10:20	**Inaugural Session** **Chair: Prof. R. K. Saxena, Rector, JNU**	
9.30	Welcome Remarks	Prof. R. K. Saxena
9.35	Workshop Objectives	Prof. Syed I. Hasnain, VC, Calicut University
9.45	Opening Remarks	Mr. Gwyn Rees, CEH, and Ms Mandira Shrestha, ICIMOD,
10.00	Inaugural Address by Chief Guest	Shri S.K. Das, Member, (D&R), Central Water Commission, Government of India
10.10	Address	Dr. B. Lal, Additional Director General, IMD
10.15	Vote of Thanks	Prof. V. Subramanian, School of Environmental Sciences, JNU
10:20 – 10:45	***Tea Break and Group Photo***	
	Session 1: Introduction **Chair: Prof. Syed I. Hasnain, VC, Calicut University**	
10:45 – 11:00	Outline of the SAGARMATHA project and objectives of the workshop	Mr. Gywn Rees, CEH.
11:00 – 11:30	Introduction of participants	
	Session 2: Aspects of Deglaciation **Chair: Mr. A. Pokhrel, SOHAM, Nepal**	
11:30 – 11:50	Global perspective on deglaciation	Prof. David Collins, Salford University, UK
11:50 – 12:10	Deglaciation in the Himalayas: evidence & potential impacts	Prof. Syed I. Hasnain, VC, Calicut University
12:10 – 12:30	Linking livelihoods to deglaciation	Dr. Caroline Sullivan, CEH.
12:30 – 13:00	Discussion	
13:00 – 14:00	***Lunch Break***	
	Session 3: Impact of deglaciation on Himalayan water resources **Chair: Mr. S.K. Chowdhury, Bangladesh Water Development Board**	
14:00 – 14:30	Representing deglaciation regionally	Mr. Gwyn Rees, CEH
14:30 – 15:00	Implications for Himalayan water resources	Prof. David Collins and Mr. Gwyn Rees
15:00 – 15:15	Discussion	
15:15 - 15:30	***Tea Break***	
	Session 4: Modelling Results and Country Presentations **Chair: Mr. K. Chhophel, Hydrometeorological Services Division, Bhutan**	
15:30 – 15:55	Dissemination of results	Dr. Rajesh Kumar, JNU & Mr Gwyn Rees
15:55 – 16:35	Perspectives on Climate Change and Water Resources in the Region: - Bangladesh - Nepal - Bhutan - India	
16:35 – 16:50	Discussion	
16:50 – 17:00	Concluding summary of Day 1.	Prof David Collins

Day 2, Wednesday, April 28, 2004

Time	Programme	
09:30 – 09:40	Review Day 1	Mr. Gwyn Rees
09:40 – 09:45	Objectives for day 2	Dr. Caroline Sullivan
	Session 5: Livelihood impacts and adaptations **Chair: Dr. Caroline Sullivan, CEH**	
09:45 – 10:30	Impact analysis Concept and approach Community-level – Modi Khola Watershed, Nepal Basin-level – Kali Gandaki Corridor, Nepal Regional level – Some examples of diversity in the HKH Region	Ms. Mandira Shreshta Mr. Shiva Rijal, Tribhuvan University Ms. Mandira Shreshta Mr. Dermot O'Regan, CEH
10:30 – 11:00	***Tea Break***	
11:00 – 12:30	**Impacts & adaptations breakout group discussions 1: Consultation** Discussion on regional impacts and adaptation strategies for: – hydropower – food production and food security – commerce (industry, tourism, employment)	
12:30 – 13:00	Feedback to the plenary session: ***Sectoral impacts and adaptations***	
13:00 – 14:00	**Lunch**	
14:00 – 14:30	Results from earlier consultations - Community-level consultation - Basin level consultation	Mr. Shiva Rijal, Tribhuvan University Dr. Caroline Sullivan
14:30 – 15:00	**Impacts & adaptations breakout group discussions 2: Policy Recommendations**	
15:00 – 15:10	**Tea break**	
15:10 – 15:40	Feed back to the plenary session: ***Policy recommendations***	
15:40 – 15:50	Discussion	
15:50 – 16:00	Review of impacts and adaptations: Summary & potential recommendations	Ms. Mandira Shreshta
16:10 – 16:30	**Closing session** Closing remarks Vote of thanks	JNU, ICIMOD and Mr. Gwyn Rees
14:30 – 17:00	**End of workshop**	

Appendix 3.3.2
International Workshop: Participant List

Deglaciation: Impacts and Adaptations for Water Resources and Livelihoods in the Himalayas

April 27 - 28, 2004
India International Centre
New Delhi, India

Attended the Workshop and registered their Signature

	Regional Participants	Address	Email
	Nepal		
1	Mr. Gopal Basnet	Senior Divisional Engineer, Dept. of Electricity Development, Bijuli Bazar, Ktm	
2	Mr. Purna Bhakta Tandukar	Under Secretary, Trecking and Mountaineering Section, Tourism Industry Division, Ministry of Culture/Tourism & Civil Aviation, Tourism Industry Division, Bhrikuti Mandap, Kathmandu	pbtandukar@hotmail.com
	Bhutan		
3	Mr. Karma Chhophel	Superintending Engineer/Head, HMSD, Department of Energy, Ministry of Trade and Industry, Royal Government of Bhutan, PO Box: 106, Thimpu, Bhutan	chhophel@druknet.bt
	Bangladesh		
4	Sazedul Karim Chowdhury	Executive Engineer, North Eastern Measuremnet Division, Surface Water Hydrology, Bangladesh Water Development Board, Dhaka	sazed123@hotmail.com
	New Delhi, INDIA		
5	Mr. S. K. DAS	Member (D&R), Central Water Commission (CWC) Seva Bhavan, West Block, R K Puram, New Delhi -110066, India	**Chief Guest**
6	Dr. L. S. Rathore	Scientist- G (Advisor), National Centre for Medium Range Weather Forecasting (NCMRWF), Mausam Bhawan Lodhi Road, New Delhi-110003	lsrathore@ncmrwf.gov.in
7	Dr. Someshwar Das	Director/Scientist - F, National Centre for Medium Range Weather Forecasting (NCMRWF), Mausam Bhawan Lodhi Road, New Delhi-110003	somesh@scientist.com; somesh@ncmrwf.gov.in

8	Shri K.K. Gupta	Senior Joint Commissioner (ER), Ministry of Water Resources, New Delhi	
9	Dr. Rajesh Kumar Mall	Central Ground Water Authority, A-2W-3, Curjan Road, Barrack, Kasturba Gandhi Marg, New Delhi-110 001	cgwa@rediffmail.com, mall_raj@rediffmail.com
10	Dr. K. K. Singh	Scientist- D, Agromet Advisory Services, NCMRWF, Mausam Bhawan Lodhi Road, New Delhi-110003	kksingh@ncmrwf.gov.in
11	Dr. A. K. Gosain	Indian Institute of Technology, Delhi, Hauz Khas, New Delhi- 110 016	gosain@civil.iitd.ernet.in
12	Mr. Ramveer Singh	Technology Bhavan, Department of Science and Technology, New Mehrauli Road, New Delhi- 110 016	rambir@yahoo.com
13	Mr. Shankar Mahato	Director, Hydrology Division, Central Water Commission, Seva Bhavan, West Block, R K Puram, New Delhi -110066, India	
14	Prof. Rajeev K Saxena	Rector, Jawaharlal Nehru University, New Delhi - 110 067	
15	Ms. Richa Bansal	CEFS, New Delhi	
16	Mr. Raj Librahan	Director, India Habitat Centre, Lodhi estate, New Delhi - 110 003	
17	Mr. R.N. Nandwani	II-C-101, Lajpat Nagar, New Delhi-110 024	
18	Capt. Rajiv ojha	D-16, Press Enclave, Saket, New Delhi- 110 017	
19	Mr. A. K. Mandal	Heritage World Wide, New Delhi	
	Press		
20	Ms. Shruti Rajan	Indo-Asian News Service, New Delhi	
21	Mr. S. Suresh	United News Agency, New Delhi	
22	Ms. Chandrika Mago	Times of India, 7, Bahadur shah Zafar Marg, New Delhi- 110 055	
23	Ms. Sonu Jain	Indian Express, C-6, Kutab Institutional Area, New Delhi - 110 016	
	Outside New Delhi, INDIA		
24	Dr. Prapat Singh	Natioal Indtitute of Roorkee, Jal Vigyan Bhawan, Roorkee - 247667 (Uttaranchal), India	pratap@nih.ernrt.in
25	Dr. Arun Kumar	Head, Alternate Hydro Electric Centre, Indian Institute of Technology, Rourkee	akumafah@iitr.ernet.in, ahec@iitr.ernet.in, ahec@vsnl.com
26	Mr. Manohar Arora	Natioal Indtitute of Roorkee, Jal Vigyan Bhawan, Roorkee - 247667 (Uttaranchal), India	

27	Dr. Deepak Srivastava	Director, Glaciology Division, Geological Survey of India (GSI), Northern Region, Aliganj, Lucknow, U.P., India	geodetnr@sancharnet.com.in
28	Dr. Sarfraz Ahmed	Department of Geology, Aligarh Muslim University, Aligarh, Uttar Pradesh	sarfaraz71@yahoo.com
	Project team		
29	Mr. Adarsha Pokhrel		
30	Ms. Mandira Shrestha		
31	Mr. Shiba Rijal		
32	Prof. Syed Hasnain	Vice Chancellor, University of Calicut, Mollapuram, Kerala 673 635, India	iqbalhasnain@hotmail.com
33	Dr. Rajesh Kumar	Glacier Research Group, School of Environmental Sciences, Jawaharlal Nehru University, NewDelhi- 110 067	
34	Mr. Anurag Linda	do	anuraglinda@yahoo.com
35	Mr. David Collins		
36	Mr. Gwyn Rees		
37	Dr. Caroline Sullivan		
38	Mr. Dermot O'Regan		
39	Mr. Ritesh Prasad Gurung		
	Working Group (Delhi)		
40	Mr. Swagata Pyara	Centre for Atmospheric Sciences, Indian Institute of Technology,Hauz Khas. New Delhi - 110 016	spayra@yahoo.com
41	Ms. Shruti	Glacier Research Group, School of Environmental Sciences, Jawaharlal Nehru University, New delhi- 110 067	sakshishruti@yahoo.com
42	Mr. Permanand Sharma	do	
43	Mr. Shrestha Tayal	do	t_shrestha@yahoo.com
44	Ms. Meenakshi Yadav	do	

Appendix 3.3.3
International Workshop: Minutes

DEGLACIATION: IMPACTS AND ADAPTATIONS FOR WATER RESOURCES AND LIVELIHOODS IN THE HIMALAYAS

Stakeholder Consultation Workshop

India International Centre, New Delhi, India

April 27-28, 2004

Organized by
HIGHICE-India, New Delhi
Jawaharlal Nehru University, New Delhi
Centre for Ecology and Hydrology, Wallingford, UK
and the
Water, Hazard and Environmental Management Programme of
International Centre for Integrated Mountain Development

A contribution to the
Hindu Kush – Himalayan Flow Regimes from International Experimental and Network Data (HKH–FRIEND) project of the
UNESCO International Hydrology Programme

Supported by the
UK Department for International Development (DFID) funded project
"Snow and Glacier Aspects of Water Resources in the Himalayas" (SAGARMATHA)

DAY I: April 27, 2004

Opening Session

Chair: Prof. R K Saxena, Jawaharlal Nehru University (JNU), India

In his welcome address **Prof. Saxena** said that water is essential for all communities. The growing use of fossil fuels has degraded the environment to certain extent. It is however, possible to achieve development while preserving environment. Drying of rivers is one of the most difficult problems caused by climate change. He expressed his happiness that JNU is contributing to a project addressing these issues.

Prof. Syed I. Hasmain, Vice Chancellor, Calicut University, India provided background of the project and said that its objective is to o assess the seasonal and long term water resources in snow and glacier fed rivers originating in the Himalayan region, and to determine strategies for coping with impacts of climate change induced deglaciation on the livelihood of people in the region. The regional hydrological model developed by the project predicts flows in the rivers of India, Ganges and the Brahmaputra Basins. The project result would also be disseminated through the Hindu Kush Himalayan Flow Regimes form International Experimental and Network Data (HKH-FRIEND), International Hydrological Programme (IHP) of UNESCO and International Commission for Snow and Ice (ICSI). The second phase of the project will not be funded by DFID and stressed on the need of the support of member countries.

In his opening remarks **Mr. Gwyn Rees, Centre for Ecology and Hydrology (CEH), UK** said that the project was initiated following claims that the glaciers in the Himalayan region would disappear in the next 40 years. CEH together with other partner institutions prepared and submitted a project proposal to DFID. The workshop is the second dissemination workshop of the project. The first was held in Pokhara, Nepal on April 21, 2004. He thanked all the participants for their presence. He also thanked Prof. Hasnain, Ms. Mandira Shrestha, ICIMOD and Dr. Rajesh Kumar, JNU for their contribution to the project as well as to the workshop.

Ms. Mandira Shrestha, International Centre for Integrated Mountain Development (ICIMOD) thanked all the participants attending the workshop. She said that during the past century, global temperatures have risen by 0.5^{o}C the largest increase in at least one thousand years. As a result, snow cover is decreasing, glaciers are retreating, lakes and rivers are warming, rainfall patterns are changing and El Nino episodes are occurring more often. Extreme weather, including thunderstorms flash floods, droughts, and rising sea levels further contribute to global distress. There is evidence that this increase in the temperature has resulted in the rapid melting of several of the glaciers of the Hindu Kush Himalayan Region, causing changes in the flow regime of the rivers. Continued melting of the glaciers is likely to result in an increase in glacial melt-water in the short-term, but a depletion of the resource in the longer-term. This could severely affect the communities that depend on the snow-fed rivers for their livelihoods.

She expressed happiness that ICIMOD could contribute to the project. She thanked DFID for their support.

Dr. S K Das, Member, Central Water Commission, Government of India mentioned that fresh water is closely linked to glaciers. The year 2003, apart from being the International Year of Fresh Water, was also declared as the Indian Year of Fresh Water. During 2003 programmes were being conducted to make the people aware of the importance of fresh water. There are about 15,000 glaciers draining into India through the Himalayas. There are settlements along the banks of the rivers and water is being used for various purposes. The central water Commission (CWC) issues seasonal forecasts and reports have been published since 1951. The National Hydrological Institute (NHI), under the Ministry of Water Resources, has developed hydrological model for the Chenab and Sutlej Basin.

The rise in temperature has resulted in rapid melting of glaciers and rise in sea level. The glaciers in the Himalayan Region are of great importance not only to India but also to other countries like Pakistan, Nepal, Bhutan and Bangladesh. The workshop is an important one since it focuses on these issues.

Dr. L S Rathore, Scientist, National Centre for Medium Range Weather Forecast (NCMRWF), India said that deglaciation by itself is not a disaster. However, disaster is caused as a result of deglaciation and focus should be given to the impacts. Climate change in the Himalayan Region should be considered as a different case altogether. There is also a need for more detailed observation in the region.

He mentioned that it is possible to predict weather over the Himalayas. The model developed by the project would help the NCMRWF in issuing forecasts. A road map should be prepared to reduce the rate of deglaciation.

Prof. V. Subraminium, School of Environmental Science, JNU thanked all the participants for attending the workshop. He thanked DFID for their support to the workshop as well as to the project. He thanked the JNU for facilitating the workshop.

Session I: Introduction

Chair: Prof. S I Hasnain, Calicut University, India

Outline of the SAGARMATHA Project and Objective of the Workshop: Mr. Gwyn Rees, CEH, UK

Mr. Rees provided the background of the project. The project has two components: the regional hydrological model and the socio-economic component. The hydrological model incorporates regional glacier melt model to forecast deglaciation and future flow of rivers in the Indus, Ganges and Brahmaputra Basin. He mentioned that the community level socio-economic survey was done at specific watershed and a desk study was done for the region.

He provided the objective of the workshop. Day I of the workshop would focus on the impacts of deglaciation and the hydrological model. Day II would focus on the socio-economic component of the project and the impacts of deglaciation on livelihoods.

Following Mr. Rees' presentation, the participants introduced themselves.

Session II: Aspects of Deglaciation

Chair: Mr. Adarsha Prasad Pokhrel, Society of Hydrologist and Meteorologist (SOHAM), Nepal

Global Perspective on Deglaciation, Prof. David Collins, University of Salford, UK

Prof. Collins said that glaciers have been sensitive indicators of global warming and there has been change in glaciers with changes in climate. There were a lot of glaciers about 200 years ago. Glaciers had retreated a lot between 1850 and 1890. Because of deglaciation there would be more glaciers but they would be smaller in size. The flow in the rivers in the 20th century is actually more than the quantity supported by precipitation only. Climate change would influence the runoff both directly and indirectly.
The reconstruction of temperature of the last 250 thousand years showed that there is a fluctuation in the mean global temperature; the temperature of last few years is the highest. It is so because this phase is an inter-glacier age and is also the end of ice age. Temperature increase is also because of carbon dioxide (CO_2). Infrastructures such as dams and bridges are generally built considering past records but it should be done by making assumption of the flow in rivers in future.

Deglaciation in the Himalayas: Evidence and Potential Impacts, Prof. S I Hasnain, Calicut University, India

Prof. Hasnain said that the glaciers in the Eastern Himalayas are bigger and at higher elevation than the glaciers in the Western Himalayas. The glaciers are monsoon driven fed by the south west monsoons. The accumulation of snow and melt of snow occurs at the same time in the Eastern Himalayas. There is also a lot of moisture present there during summer. Temperature increase in the last few years has resulted in the formation of a number of glaciers. The breach of the natural dams of these lakes could cause glacial lake outburst floods (GLOF). Because most of the glaciers are trapped in natural lakes, the impact of mass balance should be considered taking the change in mass balance of the glaciers and not the flow in glacier fed rivers.

Linking Livelihoods to Deglaciation: Dr. Caroline Sullivan, CEH, UK

Dr. Sullivan said that climate change is affecting the livelihoods of the people in the region. There are more cases of extreme events and climate change is also affecting the availability of water. The impacts are more felt at elevation more than 1800 m. Climate change could also cause more flooding, reduction in rainfall and runoff and change in the ecosystem, livestock, farmers and fisheries. Any change in the climate would bring about a change in the five major capitals viz. finance, infrastructure, social, physical and natural resources.

Dr. Sullivan said that people are vulnerable in different ways. Vulnerability increases because of population increase and poverty. Efforts should be made to reduce these vulnerabilities. Modern techniques should be combined with the indigenous knowledge to help the communities.

Discussion:

Mr. S K Chowdhury, Bangladesh Water Development Board (BWDB), Bangladesh asked about the increase or decrease in the crown in the Himalayan Region. Mr. Rees said that very little data were available but temperature has been increasing in the last few years and the snow line is receding.

Dr. Pratap Singh, National Hydrological Institute (NHI), India said that recent studies showed that there would be very little change in the Ganges Basin because of climate change but some change would occur in the Brahmaputra and the Meghna Basin. The change in rainfall pattern is different from temperature increase. There are some data that say that precipitation is decreasing.

Prof. Collins said that some changes are being noticed. Winters are now shorter and therefore, there is the time span for snowfall is reduced. Climate change might also cause it to rain when it should be snowing.

Mr. Chowdhury enquired if it is possible to make any prediction. Mr. Pokhrel said that no detail survey has been conducted on snow accumulation. The change in precipitation is not very distinct and it is not possible to say weather precipitation would increase or decrease. However, snowlines are receding.
Dr. Someshwar Dar, NCMRWF said that hundreds of lives are lost because of extreme events. Forecasts can be made to an accuracy of 80 % but these forecasts should be made available to the communities. He added that forecasts of cyclone in Orissa, India had considerable reduced the number of lives lost. Ms. Shrestha said that it is important to strengthen the process of dissemination. Mr. K K Gupta, Central Water Commission, India said that dissemination is the most important component.

Mr. Chowdhury said that the Bangladesh would be greatly benefited if hydrological and meteorological data were made available to them by India and Nepal. Dr. Singh said that extreme events such as flash floods do not depend on climate change. However, there are more cases of extreme events now.

Remarks by the Chair

The presentation clearly showed the impacts of climate change on water resources. It is also seen that climate change can affect livelihoods. The discussion was focused on dissemination of forecasts. Dissemination should be given priority.

Session III: Impact of deglaciation on Himalayan water resources

Chair: Mr. S K Chowdhury, BWDB, Bangladesh

Representing Deglaciation Regionally, Prof. David Collins, University of Salford, UK

Prof. Collins said that the glaciers at higher elevations are thicker than the once at lower elevation. It is difficult to determine the volume of a glacier since it is not geometrical in shape and therefore, the area is generally measured. There are growing evidences that both the area and the volume of glaciers are being reduced. He mentioned that very little temperature and glacier volume data are available. While developing a model assumptions are being made.

It is also very important to understand the relationship between glacier area, volume and discharge. It is being noticed that while the area and volume of glaciers are decreasing, the discharge is actually increasing. The contribution of glacier melt in river flows would be higher in a highly glaciated basin. The decrease in the glacier area would ultimately lead to the decrease in glacier discharge.

Implications for Himalayan Water Resources, Mr. Gwyn Rees, CEH, UK

Mr. Rees presented the results of the hydrological model. He said that deglaciation is occurring across the whole of the Himalayan Region and most of the glaciers are melting. The mean temperature of Nepal at elevation between 72 and 4100 m is increasing at the rate of 0.06°C/year and is increasing at the rate of 0.1°C/year at higher elevation. This has resulted in the formation of a number of glacial lakes.

A macro-scale model was developed to predict the impact of climate change in the Indus, Ganges and the Brahmaputra Basin. The model incorporates the first regional glacier melt

model. The model estimates runoff in a 20km X 20km grid. Climate change scenarios are then applied.

The model represents all the glaciers across the region. There might be more than one glacier contribution to a single cell in the grid. To avoid complexities all the glaciers contributing to a single cell is considered as a single glacier having an idealised shape. The area of this glacier is equal to that of the glaciers contributing to the cell. The glaciers are split into 20 elevation steps. Using lapse rate temperature as well as the type of precipitation is determined for specific elevation.

Applying different climatic scenarios, the amount of runoff is runoff is predicted. The results of the model showed that for an increase of temperature at the rate of 0.1°C/year the flow in the rivers would increase. Peak flow in these rivers will occur in the next 45-50 years and then the amount of water would be reduced drastically. For a temperature of 0.03 °C/year, there would be very little change in the river flows.

It was concluded from the analysis that there is a distinct difference in the impacts both at local and regional levels. The water shortages are unlikely to happen for many decades; some regions might actually receive more water. The threat that Himalayan glaciers would disappear in the next 40 years was ill-founded. However, deglaciation is occurring in the Himalayan region and the highly glaciated catchments are more vulnerable to climate change.

Discussion

Mr. Somehswar Das enquired about the validity of the model. Mr. Rees said that the model was developed by assuming future climate scenarios. The model could be more accurate if real time precipitation data were available. The use of medium range precipitation forecasts as issued by the NCMRWF would make it more realistic.

Dr. Singh said that the model should be validated. He mentioned that generally models are first tested and then applied at a regional scale, which just the opposite in this case. Mr. Rees said that the calibrating the model on a region scale was very difficult. The model could however, be calibrated at a local scale. He also mentioned that the model was developed using standard parameters and although it is not accurate, it would give a fairly good picture of the future scenarios. Prof. Collins added that the whole process would be very time consuming if it were done in detail.

Session IV: Modelling Results and Country Presentation

Chair: Mr. K Chhophel, Department of Energy, Royal Government of Bhutan

Dissemination of Results, Dr. Rajesh Kumar, JNU and Mr. Gwyn Rees, CEH

Dr. Rajesh Kumar demonstrated the regional hydrological model developed by the project. He mentioned that the model uses Visual Basic Executable as the front end tool. The model allows users to apply different climatic scenarios on a basin. This can be done by selecting a basin and then selecting the built-in scenarios. The model also shows the river drainage map of the Indus, Ganges and Brahmaputra Basins. Each line in these maps would give the information about the particular stretch of the river.

Perspectives on Climate Change and Water Resources in the Region

The delegates from Bangladesh, Bhutan, India and Nepal presented the perspective of climate change in their respective countries. It was mentioned that climate change induced deglaciation is affecting the water availability in the regional countries. Industries such as

hydropower, which are directly dependent on water availability, are affected the most. Deglaciation has also led to the formation of large number of glacial lakes. Some of these lakes are unstable and pose the threat of glacial lake outburst floods (GLOF). Most of the unstable lakes are in Bhutan and Nepal. In Bangladesh the flow of sea water into the mainland because of sea level rise has affected the fertility of the soil. The delegates from India, Nepal and Bhutan mentioned that the glaciers are melt at a fast rate, which has resulted in the reduction of snow covered areas.

DAY II: April 28, 2004

Prof. Collins provided the summary of Day I and Dr. Sullivan presented the objectives of Day II.

Session V: Livelihood Impacts and Adaptations

Chair: Dr. Caroline Sullivan, CEH

Impact Analysis: Concept and Approach, Ms. Mandira Shrestha, ICMOD

Ms. Shrestha presented the background of the socio-economic component of the study. She highlighted the methodology and provided information about the three levels of study: local, basin and regional. At local level Modi Khola catchment was selected based on its catchment area, basin characteristics (snow and glacier fed) and multiple use of water such as irrigation, drinking, water mill, recreation, religious uses and hydropower. Household surveys, group discussion were conducted including water use survey. At the basin level the Kali Gandaki basin down to the border of Nepal and India was surveyed for water use along a 2 km corridor. She informed that the details of the study would be presented subsequently by Mr. Rijal.

Impact Analysis at Community Level: Modi Khola Watershed, Shiba Rijal, Tribhuvan University (TU), Nepal

Mr. Rijal presented the results of the socio-economic and water use survey, as well as the results of the local stakeholder consultations. Both primary and secondary forms of data were collected during the survey. For socio-economic survey, data were collected through household survey, group discussion and field observation. For water use survey data were collected through water use inventory and mapping, and group discussion.

The communities in the study area perceived rise in temperature, increase in rainfall intensity and decrease in snow covered area. The following indicated the change in climate:

- Upward shifting of snow line
- Availability of snow at higher altitudes
- Changes in the snowfall pattern
- Changes in the amount and rainfall intensity
- Increase in floods and landslides
- Early ripping of crops
- Expansion of rice covers at higher altitude

He mentioned that the availability of water was influenced by water quality. This could greatly influence the livelihood in the region.

Discussion

Mr. Chowdury enquired about cropping intensity at the study area. Mr. Rijal said that the paddy was the most important crop in the lower reaches. About 2-3 types of crops were cultivated. Not all of the water available are being utilised for irrigation.

Mr. Pratap Singh said that that early ripening of crops is also noticed. Since not much of data were available it was not possible to say how it would affect the yield. More studies should be conducted in this line.

Impact Analysis at Basin Level: Kali Gandaki Watershed, Ms. Mandira Shrestha, ICIMOD

Ms. Shrestha mentioned that the socio-economic study at a basin level was done for the Kali Gandak basin in Nepal. She presented the water use in the Kali Gandaki Basin along the 2 km corridor. She said that it is important to consider changes in river flow while designing hydropower projects. Industries using water from rivers are likely to be affected because of variation in flow. Climate change could also affect irrigation projects, tourism and fisheries. Since the amount of water used for domestic purposes is very small, very little impact would be felt. However, if water quantity is reduced drastically, there could be negative impacts on humans as well as animal health.

Discussion

Mr. K K Gupta said that the project was successful in accessing the present scenario to certain extent but long term monitoring has to be done to predict climate change. Ms. Shrestha said that with the baseline information obtained by the project monitoring could be initiated.

Impact Analysis at Regional Level: Diversity in the HKH Region, Dermot O'Regan, CEH

Mr. O'Regan presented cases on water resources and livelihoods from India, Nepal and Pakistan. The rivers selected are as follows:

- Kali Gandaki River, Nepal
- Siran River, Pakistan
- Jhelum River, India

It was mentioned that temperature as well as rainfall intensity has been increasing in the region. Impacts were more pronounced at higher elevation. There would be an increase in the frequency of extreme events. Industries depending largely on water availability such as hydropower, fisheries would be the more affected.

Impact and Adaptation Breakout Group Discussion

Chair: Dr. Caroline Sullivan CEH

The participants were divided into three groups for discussion on impact of climate change on hydropower, food production and food security, and commerce. Following the discussion the groups presented the outcomes.

Food production and food security

It was mentioned that agricultural products would decrease because of fluctuation in water availability, change in span of seasons and increasing frequency of extreme events. It could also reduce employment. There could also be a change in the location of fisheries and tourism sites.

The group felt that change in cropping pattern could help improve production. Implementation of policies, development of infrastructures and employment would help reduce the impacts.

Hydropower

The impact of climate change would be different at different locations. A better assessment of extent of deglaciation and its linkages with climate change is required to predict impacts on hydropower. There has to be better monitoring of discharge and suspended sediments. Establishment of a long term database and availability of meteorological data would enable better management. It is likely that there would be no significant changes in the employment levels but could affect human migration. It was also mentioned that micro-hydro project would be more vulnerable to climate change.

Commerce

Floods and GLOF could destroy transport infrastructure such as road and bridges. Construction of all weather roads will help reduce impacts. Small-scale industries and tourism are also vulnerable to climate change. This would affect production, employment and revenue. Storage of raw materials and products would lessen impacts industries.

Remarks by the Chair

Dr. Sullivan said that there is a huge degree of uncertainty related with climate change. It would not be easy to advice policy makes at this stage. However, there is an urgent need to make both the policy makers and the public aware of the current scenarios. Climate change is a slow process and takes a lot of time to happen. This gives more time to prepare for the changes that would occur.

SESSION VI: POLICY RECOMMENDATION

Chair: Ms. Mandira Shrestha, ICIMOD

Results from Community Level Consultation, Mr. Shiba Rijal, TU

Mr. Rijal said that two local stakeholder consultations were held in the Modi Khola Watershed on March 4, 2004 and March 10, 2004. The objectives of the consultations were to disseminate the findings of the socio-economic survey, to obtain feedback of local stakeholders for the development of adaptation strategies. The participants were from district irrigation, drinking water and *Gramin Urja Bikash Offices*. It also included social workers, farmers and business entrepreneurs related to tourism activities.

Following are the adaptation strategies recommended by the participants:

- Changes in cropping pattern and husbandry techniques
- Promotion of social networks. - Development of early warning systems
- Development of fish ponds and fish breeding
- Promotion of cultural tourism
- Migration
- Changes in design specifications for water and other infrastructures and modification of existing structures
- Development of management strategies to cope with reduced water availability in an equitable way to prevent conflict

Discussion

Mr. Goswain said that the findings were very general. For sustainable development detail studies at local levels are required. Frameworks should be developed for monitoring and implementation. However, these frameworks should be acceptable to all. It can be done by doing a pilot study and then making recommendations based on the findings.

Results from Basin Level Consultation, Caroline Sullivan, CEH

Dr. Sullivan presented the outcomes of the regional stakeholder consultation held in Pokhara, Nepal. She mentioned that the participants had recommended promotional of traditional cropping pattern and social networks. Change in location of activities such as tourism should be done only after doing a feasibility study. The participants discouraged migration. They recommended that infrastructures should be developed with consultation with the communities, although it would be more costly and time consuming. Awareness building programmes on climate change would help the local communities better manage water resources. Development of hydropower would help the communities develop economically.

Plenary Session: Policy Recommendation

Mr. Chowdury enquired if Climate Change Impact Assessment (CCIA) should be practiced similar to Environmental Impact Assessment (EIA). Prof. Collins said that for implementation of CCIA a much longer perspective is required. Using data of the period, which are representative to the design/running period of the project, it is possible to predict the future climate scenarios and thus CCIA could be done.

Mr. Pokhrel said that although important, EIA sometimes slows down economic development. Comparisons of development and the negative impacts should be considered. There would be very little progress in the hydrological projects of CCIA is practiced.

Mr. Gupta said that CCIA cannot be project specific. It is an assessment to understand the phenomena as they occur. The data from the assessment should be incorporated as project parameters. Climate change is still very new issue and requires a great deal of monitoring.

Dr. Goswain said that EIA is very important for every project. Although EIA actually constraints most of the projects, it has to be done accurately. Dr. Sullivan said that EIA is mandatory but having a project by considering projections of future scenarios would make the project more environmental friendly. Ms. Shrestha mentioned that an integrated approach could be the possible solution. Integration could be done at various levels from community level to regional levels. It would bring together different organisation and agencies working in this line.

Dr. Goswain said that that it should be disused more in detail. The task should be assigned to some one. A pilot study could be done. The relevant organisations should generate and update information. This information should be sharable. It can be done by more than one organisation together. Prof. Hasnain said that the relevant organisation should come together and then get the government to join.

Summary of recommendation and suggestion

Ms. Shrestha summarised the recommendation of the workshop, which are as follows:

1. Need for more awareness raising at all levels, local, basin as well as regional levels.

2. Need for more participation in the development of climate response policy

3. More integration between relevant organizations and agencies

4. Proposal for participatory monitoring/survey on selected climate change indicators in upper catchments

5. Due to difficulty in separating deglaciation impacts from general climate change impacts better assessment of deglaciation and its linkages with climate change needs to be further researched.
6. There is a huge degree of uncertainty associated with the issue and need for more information. Long term data base needed along with continuous monitoring; systematic data collection has to be done to better understand the phenomenon of climate change

7. Regulatory framework and management strategy is needed for proper management.

8. Further research needed to quantify the perceptions and the need for development of a basic framework.

CLOSING SESSION

Prof. Hasnain made the closing remarks on behalf of JNU. He said that the model developed by the project has given interesting results. The model needs to be refined but it was a good start. Being a regional model it is of importance to the South Asian region.

He also stressed on the need of a database and better monitoring of hydrological and meteorological parameters in the Himalayan region. Water authorities of the region should come together and work in this line. They should also be joined by the government agencies. He thanked the participants for attending the consultation.

On behalf of ICIMOD, Ms. Shrestha said that ICIMOD is happy to be a part of the project. She hoped that findings of the project would initiate further activities on climate change. She thanked Prof. Hasnain and Dr. Rajesh Kumar for their contribution both to the project as well as the consultation workshop. The thanked the participants from CEH and the University of Salford and also the participants from the regional countries of Bangladesh, Bhutan, India and Nepal for their participation.

Mr. Rees introduced the regional network Hindu Kush Himalayan Flow Regimes from International Experiments and Network Data (HKH-FRIEND). He mentioned that the project is working very closely with the Snow and Glacier Group of this network. He invited the participants to join and contribute to the network.

He mentioned that working the Himalayan Region was a good experience. The thanked the organisers of the workshop and the India International Centre for providing the venue. He thanked the JNU, ICIMOD, Department of Hydrology and Meteorology, Nepal and TU for their contribution to the project as well as the consultations.

He said that the need for more detailed monitoring is clearly seen. The project and the series of consultation were able to identify potential areas of impacts.

He thanked the regional participants for their participant attending the consultations.

Appendix 3.3.4
International Workshop: Photographs

3.3.4.1 Team Leaders address the workshop participants

3.3.4.2 & 3.3.4.4 Discussion in breakout groups

3.3.4.5 Feedback from breakout groups

3.3.4.6 Project manager Gwyn Rees interviewed for television

3.3.4.7 Delegates from Nepal

Appendix 3.3.5

International Workshop: Breakout group guidelines

Breakout group guidelines

There will be two periods of group discussion planned in this workshop. The objective of this process is to give the opportunity for experts and stakeholders to express their views and share their knowledge, as a contribution to a better understanding of the potential impacts of deglaciation on people and economies in the region. It is also hoped that we will be able to generate some suggestions for appropriate coping strategies which could be implemented. A policy briefing note for distribution to all interested parties will be generated on the basis of this discussion.

Breakout session 1.

Group Discussion on regional impacts and adaptation strategies for:

- hydropower
- food production and food security
- commerce (industry, tourism, employment)
-

During the discussion, it is hoped that all participants will contribute their views either in their professional capacity as experts, or as stakeholders with a particular interest, or simply as human beings…. Ideally, we can all contribute in all three roles.

During this discussion session, the first thing to do will be to identify a chairperson for the group, and a rapporteur. The chairperson should try to ensure that all members of the group participate, and the rapporteur will be the one to report back to the plenary group at the end of the session. Flip charts will be provided to assist with this.

Feedback sheets are provided to enable the group to summarize the discussion. Please take ten minutes or so at the end of the session to record your own i**ndividual** perceptions of the group discussion. These will be collected at the end of the session, and later analyzed.
Just before lunch, there is a period for feedback to the plenary session on ***Sectoral impacts and adaptations,*** and this will be given by the rapporteur from each group**.**

Breakout session 2.

This session will take place after lunch, and will follow a brief presentation on earlier consultations carried out in the project.

The objective of this session is to generate inputs to be used for the policy briefing note. A stimulus sheet will be provided for this, and this will be used as a tool by which **individual**

feedback can be given, but again, reporting back from each group will be carried out just after tea, and again the rapporteur will provide this feedback to the plenary group. This group and individual feedback will be collected and used as the basis for the generation of ***policy recommendations*** from the workshop.

Finally, a preliminary summary of impacts and adaptations will be provided by a member of the project team.

Conclusion
Thank you very much for coming to the workshop and sharing your knowledge with us. Your inputs are very important, and very much appreciated! Soon after the workshop, you will be sent a CD with the proceedings of the workshop and the results of the consultation.

Appendix 3.3.6

International Workshop: Participant/Breakout Group Feedback Sheet: Sectoral Impacts and Adaptation Strategies

	SECTION 1 Potential impacts		Overall likelihood
❐	Changes in efficiency *Please describe how this would be manifested within the sector*	***Comments:***	Unlikely Quite Likely Very Likely **Impacts felt mostly at** Local scale Basin scale Regional scale All scales
❐	Reduction in employment levels *Please describe how this would be manifested within the sector*	***Comments:***	Unlikely Quite Likely Very Likely **Impacts felt mostly at** Local scale Basin scale Regional scale All scales

❒	Changes in appropriate location for activities *Please describe how this would be manifested within the sector*	***Comments:***	Unlikely Quite Likely Very Likely **Impacts felt mostly at** Local scale Basin scale Regional scale All scales
❒	Change in profitability *Please describe how this would be manifested within the sector*	***Comments:***	Unlikely Quite Likely Very Likely **Impacts felt mostly at** Local scale Basin scale Regional scale All scales

Appendix 3.3.7
International Workshop: Participant/Breakout Group Feedback: Draft policy briefing note

POLICY BRIEFING NOTE

Mountain livelihoods, water resources and climate change

The nature of mountain livelihoods

People who live in mountains tend to be resilient and resourceful. They often have considerable ecological knowledge and from experience, have good understanding of how climate variation can influence local livelihoods. In the mountain communities of the Himalayan region, people tend to depend largely on farming, tourism, external remittances, small scale industry and handicrafts……

What else do you think should be included here……..

Current problems in mountain communities

Depopulation, Unemployment, Unpredictability of seasons, Poverty

How would you like to see these discussed –suggestions please

Research findings

Modelled outputs suggesting changes in water availability
Potential impacts on communities
Potential adaptation strategies which would be suitable and acceptable
Issues which are important for health and welfare of human populations

What do you think should be included here

ADAPTATION STRATEGIES

Please list what you think are the most important things that should be done to take account of the impacts of climate change in mountain areas

POLICY RECOMMENDATIONS

PLEASE ASSIGN NUMBERS IN THE APPROPRIATE BOXES TO INDICATE WHAT YOU THINK IS MOST IMPORTANT FROM THE LIST ABOVE.

PLEASE GIVE ANY OTHER SUGGESTIONS YOU MAY HAVE.

ISSUE	Your ranking of this issue
1. Better monitoring and data collection about conditions in upper mountain areas	
2. Participatory survey on selected indicators of climate change implemented in key areas	
3. More participation in development of climate response policy	
4. Build awareness of the impacts of climate change	
5. Develop mechanisms to support and promote adaptation strategies	
6. Encourage the development of experimental cropping (in conjunction with the Ministry of Agriculture)	
7. Investigate potential for water saving techniques	
8. Investigate scale of impacts on infrastructure in key basins	
9. Assess appropriate infrastructure responses	
10. Investigate potential for early warning	
11. Investigate potential need for water storage facilities	
Other suggestions here please!	

Contact: Put your contact details here (voluntary)

Appendix 3.3.8
International Workshop: Results from Corridor Workshop
(presented to Delhi participants after breakout discussions)

Some results from the group discussion on possible adaptation strategies

Topic	Positive advantages	negative disadvantages
Change in cropping patterns	Traditiona ways of agriculture should be continued along with the introduction of new technology	Introduction of new species wouold lead to the need for improement in eathing habits. New spcies should be identified on the basis on senstivitiy to climate change
Promotion of soc networks	Social mobilisation and networking across geographical boundaries should be promoted, including inter caste marriage	There may be a ngative effect on culture, may create conflict between different groups
Changes in location of activities – fishing etc	Local species of fish must be conserved and developed. Impreoved species should be cultivatd and increased in production . Fish ponds should be developed	none
Changes in appropriate location of tourism	On the basis of feasibility studies, proper management of rivers for tourism use, rafting etc should be introduced	pollution could lead to ecological imbalance
Changes in animal husbandry techniques	Selection of local species of livestock for further improvement and development of the breed.	new diseases could be introduced
Migration	Migration from rural area should be discouraged	People may become more narrow minded
Changes in design of infrastructure	More equitable water allocation should be porsued and infrastructure developed accordingly	This couod be costly and some existing infrastructure may no longer be of use
Development of management strategies to cope with changes in water	build awareness of the proper utilisation of water	changes in availablity may make management more difficult
Additional policies for local stakeholders	stakeholder consultation should be incorporated to reduce possible conflicts	existing policies may be inequitable
Important recommendations for policy	give priortiy to HEP based on small scale community involvement and investment, as well as in water supply and irrigation	conlicts must be minimised, some policies are conflicting, need integration of policies

Key policy recommendations from the Pokhara workshop

- Build awareness of the impacts of climate change
- More participation in development of climate response policy
- Better monitoring and data collection about conditions in upper mountain areas
- Participatory survey on selected indicators of climate change implemented in key areas
- Develop mechanisms to support and promote adaptation strategies
- Investigate potential for water saving techniques
- Encourage the development of experimental cropping (in conjunction with the Ministry of Agriculture)

Appendix 4: Dissemination Outputs

A4.1	Project Leaflet: 'Mountain Livelihoods and Climate Change'
A4.2	Posters (presented and distributed at India and Nepal Workshops 2004)
A4.2.1	'Climate Change, Water Resources and Livelihoods in the Himalaya: case studies from across the region'
A4.2.2	'Climate Change and Water Resources in Nepal'
A4.2.3	'Mountain Livelihoods and Climate Change: a case study from Nepal'
A4.3	Press Coverage: Nepal Workshop
A4.4	Press Coverage: India Workshop
A4.5	Policy Briefing Note 1
A4.6	Policy Briefing Note 2
A4.7	Conference Paper: *'Mountain livelihoods and climate change: A case study from central Nepal'* (presented at The University of Bergen Workshop: 'Fragile Mountains – Fragile People? Understanding "fragility" in the Himalayas'), Bergen, Norway, November 2003.

Appendix 4.1
Project Leaflet: 'Mountain Livelihoods and Climate Change'

(Side 1)

Mountain livelihoods and climate change

Global climate change

- People everywhere are noticing changes in their weather and climate.
- The IPCC (1996) estimates suggests that global glacier mass will be reduced by some 25% by 2050.
- Between 1991 and 1996, the annual mean temperature change in Nepal has been 0.07°C.

Potential impacts of climate change

Global temperatures will rise, with changing average levels of rainfall, and increasing variability. This means that both worse droughts *and* worse floods can be expected.

How water influences livelihoods

- Water is a factor of production in agriculture and industry;
- Water availability influences people's health, especially for women and children;
- When people have to spend a lot of time collecting water, it means they have less time to be involved in productive work;
- A healthy aquatic environment provides ecosystem services to communities (eg fish).
- Pollution, and demand from large scale users can cause conflicts

Group Discussion at Landruk

Research Approach

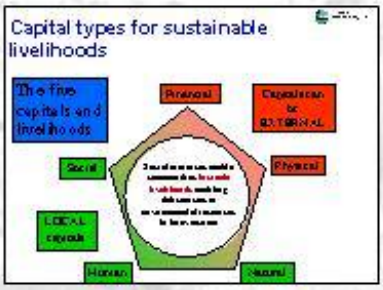
Household surveys 12 settlements were randomly selected (from all settlements in the catchment), representing different eco-zones in the Modi Khola watershed, on the basis of altitude. A total of 360 households were surveyed.

Group discussions Informal discussions were carried out in a total of 12 groups representing different occupational groups, elected persons, social workers and farmers in each selected community. Community level information about distribution of assets and present utilization pattern of these were collected using standard PRA approaches. In addition, perception regarding climate change and its relation to livelihoods of local people were examined.

Inventory of water uses and mapping An inventory of different water uses was made through consultation with local people and field observation. These were mapped using GPS and recent topographic maps. The water uses included water mills, irrigation canals, power plants, woodcarving workshops, piped water supply, hot Springs, and religious and culturally important places.

Field observation Extensive field observation was made as a supplementary method to techniques mentioned above.

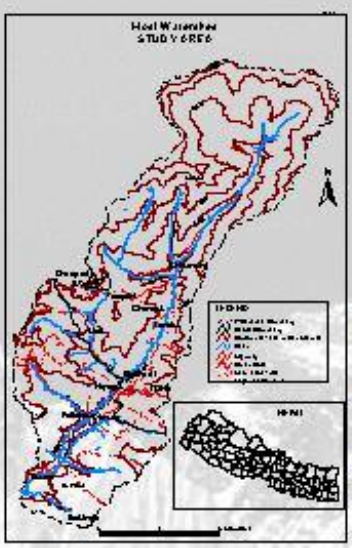
Group Discussion at Chhomrong



Livelihood options in the Modi Khola

Agriculture
Remittances
Tourism
Services
Forest utilisation
Fishing
Wage labour
Brewing
Weaving and other

Note: in spite of these various options, about 56% of households produce insufficient food supplies, and they have to buy food from other sources, requiring a cash income



People in the Modi Khola

- In 2001, the population of the Modi Khola watershed was estimated to be about 75,000 in 17,000 households. The average family size of 4.6 varied between 4.1 persons in Sankhar Pokhari to 5.7 in Ghandruk.
- Average literacy rate in the watershed was 64.8 percent, ranging from 51.7% in Arther Dandakharka and highest in Mudikuwa (80.7%)

Land size (ha)	Downstream sub-region			Upstream sub-region		Total
	Lower zone	Middle zone	Upper zone	Middle zone	Upper zone	
	%	%	%	%	%	%
No land	1.7	0.0	0.0	1.1	**6.7**	2.2
Below 0.5	36.7	20.0	**41.7**	28.9	33.3	31.9
0.5-2.0	48.3	51.7	51.7	60.0	54.4	**53.9**
Above 2.0	13.3	**28.3**	6.7	10.0	5.5	11.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

Household incomes

Many of the households in this area do not have much access to financial capital, although a significant proportion do receive money from outside.

Income sources	Lower zone Rs	%	Middle zone Rs	%	Upper zone Rs	%	Total Rs	%
Agriculture	34,896	24.1	22,995	20.6	18,272	13.0	23,407	18.0
Business	29,673	20.5	7,280	6.5	5,320	3.8	10,557	8.1
Tourism	484	0.3	3,091	2.8	29,393	20.8	13,646	10.5
Wage	2,619	1.8	7,253	6.5	5,261	3.7	5,799	4.4
Service	40,148	27.7	29,711	26.6	5,849	4.1	20,918	16.0
Remittance	18,,564	12.8	29,007	25.9	58,977	41.8	40,679	31.2
Pension	3036	2.1	7,772	7.0	17,232	12.2	10,820	8.3
Other	15,264	10.6	4,679	4.2	749	0.5	4,528	3.5
Total	**144,685**	**100**	**111,787**	**100**	**141,053**	**100.**	**130,354**	**100**

Only 18 % of household income comes from agriculture/crops, 10% from tourism, 16% from services

Livelihood vulnerability

Vulnerability exists when resources are limited and access to them is tenuous;
Human vulnerability to climate change is influenced by poverty, capacity and geographical conditions;
Poor and politically weak groups are likely to be more vulnerable than others;
Changes in ecological conditions arising from climate change (eg changes in river water temperatures and chemistry) are likely to influence fish spawning activities and influence fisheries in other ways;
Livelihoods which are dependent on water inputs as a power source, or as another factor of production will be particularly vulnerable, especially in times of low flows.

Some perceptions of climate change

Over 58% of hhs reported losing crops due to hailstorms over the last 10 years
20% reported losing crops due to landslides
16.9% lost crops due to drought
13.6 % lost crops due to floods

Potential adaptation strategies

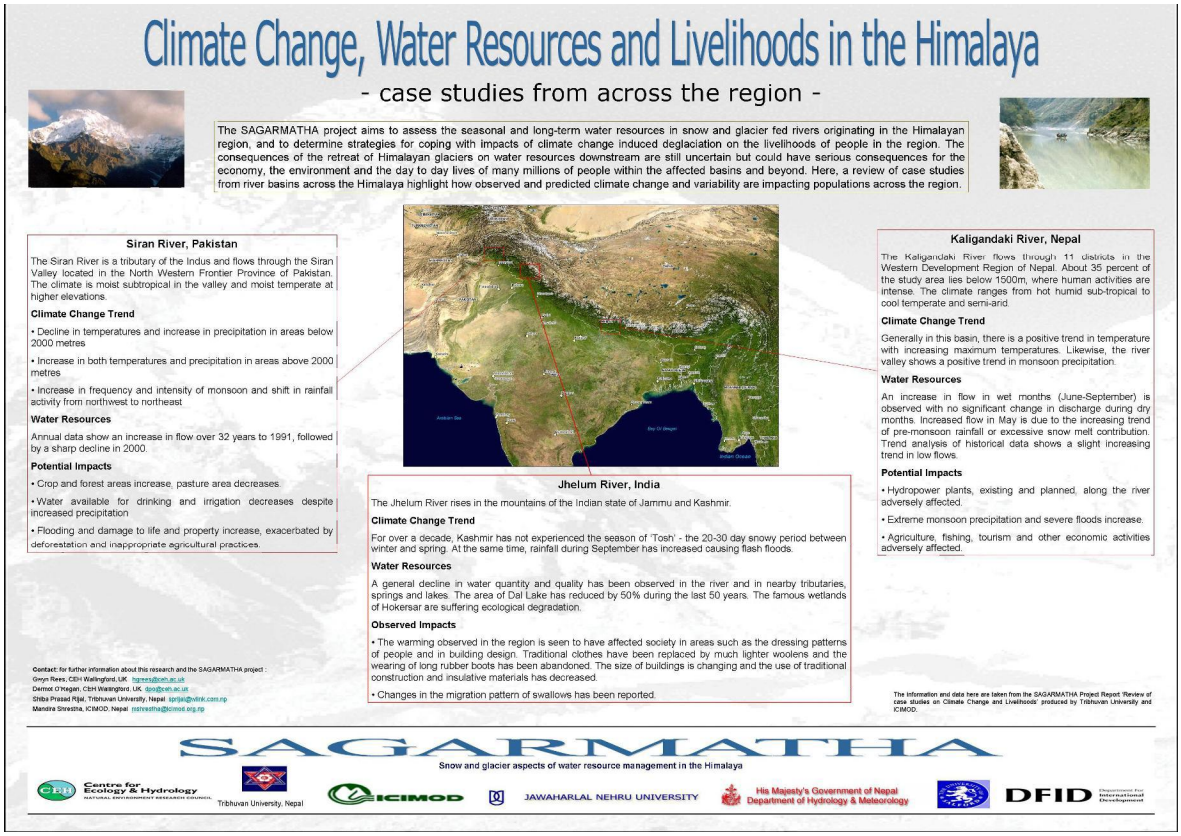
- Changes in cropping patterns, substitution of crop varieties and species;
- Changes in the location of fishing activities, promotion of fish breeding and river stocking;
- Changes in the appropriate location of certain tourism activities such as rafting;
- Changes in animal husbandry techniques;
- Human migration;
- Changes to design specifications for water and other infrastructures, and modification of existing structures;
- Development of management strategies to cope with reduced water availability in an equitable way to prevent conflicts.
- Promotion of social networks

The funding for this work has been provided by the UK Department for International Development. The views here do not necessarily represent those of DFID.

For More information, please contact:
Shiba Prasad Rijal, Tribhuvan University, Kathmandu, Nepal.
Email: sprijal@wlink.com.np

Appendix 4.2.1

Poster: 'Climate Change, Water Resources and Livelihoods in the Himalaya: case studies from across the region'



Appendix 4.2.2

Poster: 'Climate Change and Water Resources in Nepal'

Climate Change and Water Resources in Nepal

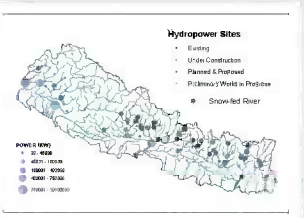
Nepal has over 6000 snow-fed and rain-fed rivers, many originating in the Himalaya. Important economic activities and livelihoods in the country will be affected by climate change and its effect on water resources. Different scenarios of climate change and deglaciation show that impacts would be felt in varying degrees in many sectors: hydropower, industry, domestic water supply, food production, and other activities such as tourism and fisheries. River flows could be affected along the entire length of major river basins, such as that from the headwaters of the Modi Khola to its confluence with the Kaligandaki river and downstream to the Nepal - India border.

Water Use in the Rivers of Nepal

Water Uses in Nepal in 2003

Water Use and Features		Snow-fed River	Rain-fed River	Total
Consumptive	Irrigation Area (ha.)	265,280	273,370	538,650
	Water Supply (m³/day)	450,111	583,226	1,033,337
	Melamchi Water Supply Project (Proposed) for 1,000,000 population in Kathmandu Valley	170,000,000 litres/day		
Non-Consumptive	Hydropower (MW)			
	- In use	438	119	557
	- Under Construction	74	0	74
	- Proposed and Planned	22,830	310	23,479
	Water Mills (total number)			
	- Improved	395	47	442
	- Traditional	281	796	1,077
	Recreational: Rafting			
	- Number of Whitewater rafting rivers	12	-	12
	- Total Number of Rafting Tourists	13,762	-	13,762

The use of water is divided into consumptive and non-consumptive. It is estimated that 13,880 million m^3/yr water are consumed for domestic, irrigation and industrial use, and 1,000 million m^3/yr water is used in hydropower generation and whitewater rafting on a non-consumptive basis.

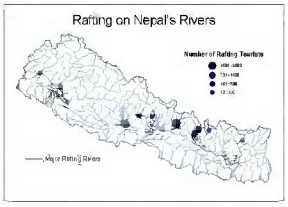


Hydropower

Estimates put Nepal's total potential hydropower output at 83,000 MW with 42,000 MW economically viable from snow-fed rivers. This includes major and small (1 MW or greater) hydropower generation sites. Planned sites could provide a further 22,407 MW of energy in the future, including the Melamchi Diversion Scheme (25 MW)

Tourism

Rafting is a popular and growing activity among tourists in Nepal, where Himalayan white waters offer a variety of grades. It is estimated that up to 14,000 tourists participated in this activity during 2003 on some 10 rivers. Whitewater rafting activities were recently initiated on five more Nepal rivers.



Water Mills

It is estimated that 15 to 20 thousand traditional water mills (*ghattas*) are in operation across Nepal. The Center for Rural Technology has improved more than 632 traditional water mills through donor support.

Water mill (Ghatta) at Syaulibazar

Potential Impacts along the Modi/Kaligandaki River Corridor

Hydropower

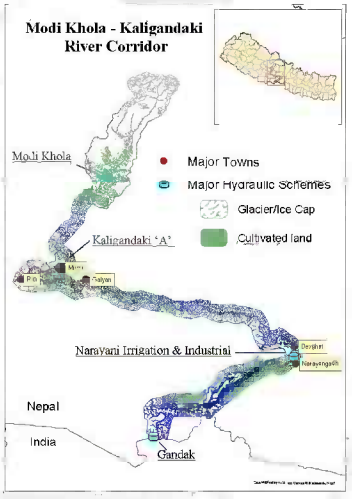
There are three existing major hydroelectricity projects in the corridor: *Modi Khola*, *Kaligandaki A* and *Gandak*. The power generated at these sites is used locally and transmitted to the national grid. Gandak also supplies electricity to India. Another three hydroelectric projects have been proposed – two upstream and one downstream. It is important to consider the impact of changes in river flow while designing these projects, as well as the impacts of potential increases in extreme rainfall events and floods.

Industrial use

Water is extracted from rivers for major industry in the lower part of the corridor, such as Bhrikuti Pulp and Paper Industry where approximately 450 cubic metres per hour is lifted from the Narayani River. In the Modi basin only cottage industries extract water.

Irrigation

A number of formal and traditional (*kulos*) irrigation schemes provide irrigation facilities in the Modi Khola, where water is diverted from tributaries and natural springs. In Kaligandaki, a number of larger schemes are the *Narayani Lift Irrigation Project* and the *Gandak Irrigation Canal*, which irrigates 8700 ha in Nepal and 1600 ha in India.



Water Mills

In some areas, local people use water mills for grinding food grains. An estimated 3,320 households directly benefit from water mills in the upper area of the corridor. It is likely that these ghats will need to be relocated or reconstructed.

Tourism

The region is a popular destination for tourists, particularly for white water rafting, with 1500 visitors per year taking part. The change in runoff may affect rafting activities and impact on the employment opportunities of local people.

Fishing

Fishing is another important economic activity, especially amongst the region's ethnic groups. Climate change is expected to enhance the current negative impacts of major hydraulic schemes on important aquatic habitats.

Other Water Uses

Water from rivers of the corridor is also important for domestic use and for recreational and religious purposes. Since the volume of water used for these is relatively small, impacts should not be significant. However, if reduced quality of water occurs there may be negative effects on human and animal health.

Contact for further information about this research and the SAGARMATHA project :
Gwyn Rees, CEH Wallingford, UK hgrees@ceh.ac.uk
Dermot O'Regan CEH Wallingford, UK dpo@ceh.ac.uk
Shiba Prasad Rijal, Tribhuvan University, Nepal sprijal@wlink.com.np
Mandira Shrestha, ICIMOD, Nepal mshrestha@icimod.org.np

The information and data here are taken from the **SAGARMATHA Project Reports** 'Inventory of Water Use in the Rivers of Nepal' produced by the Water, Hazard and Environment Management (WHEM) Division of the International Center for Integrated Mountain Development (ICIMOD) and 'Livelihood Impact analysis of deglaciation in corridor of modi/kaligandaki river' produced by Narendra Raj Khanal, Shiba Prasad Rijal and Mandira Shrestha.

SAGARMATHA

Snow and glacier aspects of water resource management in the Himalaya

Centre for Ecology & Hydrology NATURAL ENVIRONMENT RESEARCH COUNCIL | Tribhuvan University | ICIMOD | JAWAHARLAL NEHRU UNIVERSITY | His Majesty's Government of Nepal Department of Hydrology & Meteorology | DFID Department for International Development

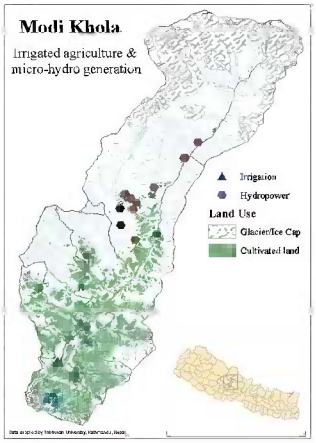
Appendix 4.2.3

Poster: 'Mountain Livelihoods and Climate Change: a case study from Nepal'

Mountain Livelihoods and Climate Change

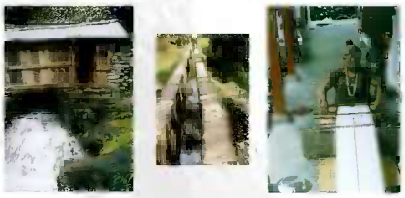
- a case study from Nepal -

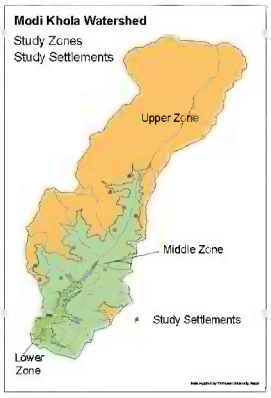
Changes in water availability in Himalayan rivers as caused by deglaciation can have direct and indirect impacts on people's livelihoods. Reduced water availability creates water shortages for water-dependant activities such as industry, hydropower, irrigation, drinking water facilities, and water transportation. Increase in river flows can affect human activities in many ways through flooding, landslides, bank cutting and the destruction of water delivery infrastructure. To cope with changes in water resources, adaptation strategies need to be developed which must be achieved in consultation with different stakeholders and consider the ideas, experience and knowledge of local people, scientists, and governmental and non-governmental organisations



Water and Livelihoods

- Water is a factor of production in agriculture and industry
- Water availability influences people's health, especially for women and children
- When people have to spend a lot of time collecting water, it means they have less time to be involved in productive work
- A healthy aquatic environment provides ecosystem services to communities (e.g. fish)
- Pollution and demand from large scale users can cause conflicts





Participatory Research Approach

Across the watershed, 12 settlements were selected with communities represented over 3 zones based on altitude

- Household Survey & Key Informants
- Community Workshop & Group Discussion
- Inventory and Mapping of Water Uses
- Field Visit & Observation

Landscape and People

The Modi is a perennial river with its main source the Annapurna glacier and is one of the main tributaries of the Kaligandaki river. The river drains an area of 660 square kilometres. The watershed is characterized by rugged topography with elevation up to 8000 metres. The climate varies with elevation from warm to cool temperate. Around 75,000 people live in the area in 17,000 households. The distribution of ethnic groups varies spatially within the Modi Khola watershed, with mostly Gurung in the upper part of the watershed and Chhetri and Brahmin downstream. Many of the households in this area do not have much access to financial capital, although a significant proportion do receive money from outside

Potential Adaptation Strategies

- Change cropping pattern and crop varieties
- Adjust animal husbandry techniques
- Diversify fishing activities
- Relocate tourism activities, e.g. rafting
- Change animal husbandry techniques
- Human migration
- Redesign water facilities
- Develop equitable water management
- Promote social networks

Perceptions of Climate Change

- Over 58% of households reported losing crops due to hailstorms over the last 10 years
- 20% reported losing crops due to landslides
- 16.9% lost crops due to drought
- 13.6 % lost crops due to floods

Contact for further information about this research and the SAGARMATHA project :
Gwyn Rees, CEH Wallingford, UK hgrees@ceh.ac.uk
Dermot O'Regan, CEH Wallingford UK dpo@ceh.ac.uk
Shiba Prasad Rijal, Tribhuvan University, Nepal sprijal@wlink.com.np
Mandira Shrestha, ICIMOD, Nepal mshrestha@icimod.org.np

The information and data here are taken from the SAGARMATHA Project Reports: 'Water and Livelihoods in Mountain Areas. A Case of Modi Watershed, Nepal' and 'Report on Local Stakeholder Consultation in Modi Khola Watershed' both by Shiba Prasad Rijal.

SAGARMATHA

Snow and glacier aspects of water resource management in the Himalaya

Centre for Ecology & Hydrology NATURAL ENVIRONMENT RESEARCH COUNCIL · Tribhuvan University · ICIMOD · JAWAHARLAL NEHRU UNIVERSITY · His Majesty's Government of Nepal Department of Hydrology & Meteorology · DFID Department for International Development

Appendix 4.3
Press Coverage: Nepal Workshop

Press cuttings from:

The Rising Nepal (26 April 2004)

The Kathmandu Post (26 April 2004)

The Himalayan (24 April 2004)

PRESS RELEASES ON WORKSHOP FOR KALI GANDAKI STAKEHOLDERS

27TH APRIL 2004

Workshop for Kali Gandaki stakeholders

By A Staff Reporter

KATHMANDU, April 26: International Centre for Integrated Mountain Development (ICIMOD) organised the Kali Gandaki stakeholders consultation workshop on April 21 in Pokhara, ICIMOD press release stated today.

The workshop was organised to disseminate the findings of a three-year study on 'Snow and Glacier Aspects of Water Resources Management in the Himalayas' (SAGARMATHA) to various stakeholders and to develop adaptation strategies to help communities to cope with the impact of deglaciation caused by climate change.

Supported by the UK Department of International Development (DFID), the study is being carried out in collaboration with the Centre for Ecology and Hydrology (EH), UK, Jawaharlal Nehru University, India, Department of Hydrology and Metrology, Nepal, and the University of Salford, UK.

As part of the project, case studies are being conducted on the use of water along the Modi Khola Basin and the Kali Gandaki Corridor, it stated.

THE RISING NEPAL

Workshop on impacts of climate change held

KATHMANDU, April 26 (PR)- The participants of workshop organized in Pokhara by the International Center for Integrated Mountain Development (ICIMOD) stressed the need for better monitoring and data collection on conditions affecting mountain areas and for building awareness about the impact of climate change. This was stated in a press release issued by ICIMOD here today. The recommendations from the participants at the workshop, which concluded on April 21, will be incorporated in the final report during a follow-up workshop to be held in New Delhi, India from April 27 -28, 2004, the statement said.

THE KATHMANDU POST

· ONCE-OVER

ICIMOD workshop

KATHMANDU: The Centre for Integrated Mountain Development (ICIMOD) had organised a 'Kali Gandaki Stakeholder Consultation Workshop' on Wednesday at Pokhara to disseminate the findings of the three-year study related to melting of glaciers in the Himalayas. About 40 participants attended the workshop, said Mandira Shrestha, the water resource specialist at ICIMOD. The aim of the workshop was to assess the seasonal and long-term water resources in snow and glacier-fed rivers originating in the Himalayan region, and to determine strategies to cope with impacts of climate change induced deglaciation on the livelihoods of people in the region. Another workshop will be held on April 27-28, 2004, in New Delhi, India, to disseminate the findings of the study at the international level. – HNS

The Himalayan (24 April 2004)

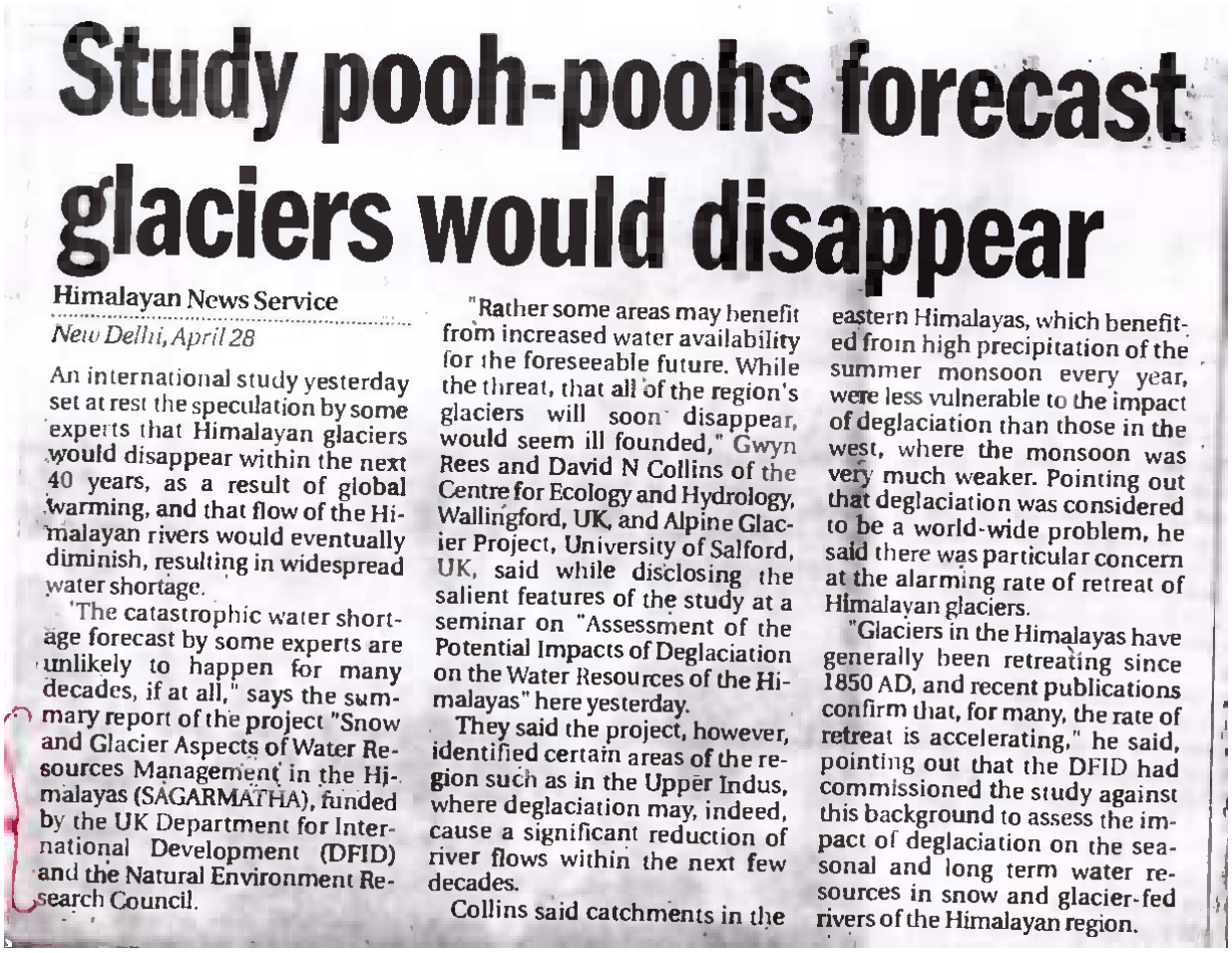
Appendix 4.4
Press Coverage: India Workshop

Press cuttings from:

The Himalayan (28 April 2004)

The Times of India (29 April 2004)

The Tribune (3 April 2004)



Study pooh-poohs forecast glaciers would disappear

Himalayan News Service

New Delhi, April 28

An international study yesterday set at rest the speculation by some experts that Himalayan glaciers would disappear within the next 40 years, as a result of global warming, and that flow of the Himalayan rivers would eventually diminish, resulting in widespread water shortage.

"The catastrophic water shortage forecast by some experts are unlikely to happen for many decades, if at all," says the summary report of the project "Snow and Glacier Aspects of Water Resources Management in the Himalayas (SAGARMATHA), funded by the UK Department for International Development (DFID) and the Natural Environment Research Council.

"Rather some areas may benefit from increased water availability for the foreseeable future. While the threat, that all of the region's glaciers will soon disappear, would seem ill founded," Gwyn Rees and David N Collins of the Centre for Ecology and Hydrology, Wallingford, UK, and Alpine Glacier Project, University of Salford, UK, said while disclosing the salient features of the study at a seminar on "Assessment of the Potential Impacts of Deglaciation on the Water Resources of the Himalayas" here yesterday.

They said the project, however, identified certain areas of the region such as in the Upper Indus, where deglaciation may, indeed, cause a significant reduction of river flows within the next few decades.

Collins said catchments in the eastern Himalayas, which benefited from high precipitation of the summer monsoon every year, were less vulnerable to the impact of deglaciation than those in the west, where the monsoon was very much weaker. Pointing out that deglaciation was considered to be a world-wide problem, he said there was particular concern at the alarming rate of retreat of Himalayan glaciers.

"Glaciers in the Himalayas have generally been retreating since 1850 AD, and recent publications confirm that, for many, the rate of retreat is accelerating," he said, pointing out that the DFID had commissioned the study against this background to assess the impact of deglaciation on the seasonal and long term water resources in snow and glacier-fed rivers of the Himalayan region.

The Himalayan (28 April 2004)

Melting threat worst for Indus

TIMES NEWS NETWORK

New Delhi: Here is something India and Pakistan can chew on together: A hydrological model indicates that if scenarios play out as assumed, the effects of melting glaciers in the Indus region will be much worse than the Ganga or Brahmputra.

In about a hundred years or so.

All this comes hedged with many words of caution on how inexact the science is and how many assumptions are being made. With alarmist suggestions on the region's glaciers disappearing "soon" being described as ill-founded.

But when a group of experts from England, India and Nepal met here over two days, ending Wednesday, their basic conclusion was that in catchments where rainfall contributes its share of river flows, the effects will be less severe. Which is why the Indus would be in trouble, in the long term, and the eastern Himalayas, which get the monsoon, would be "less vulnerable".

In the Upper Indus, deglaciation, as they call it, could cause a "significant" reduction in river flows within the next few decades. This would have "serious consequences" for water availability and use throughout the basin. Pakistan would be worst hit.

The Times of India (29 April 2004)

Glaciers feeding rivers may be wiped out

by Shruti Rajan

GLACIERS feeding the Ganga, Yamuna, Indus and the Brahmaputra rivers may be wiped out in 40 years, impacting the economic, cultural and spiritual life of India, warn scientists.

The warning bells were sounded in the first report on melting glaciers and their impact by Sagarmatha — the Snow and Glacier Aspects of Water Resources Management in the Himalaya — presented in Delhi on Tuesday.

Sagarmatha, commissioned by Britain's Department for International Development (DFID), gives a decade-by-decade analysis for Indian rivers over the next 100 years. The study warns that global warming will result in increased glacial waters in the next 40 years — and then the shortfall of the precious resource will begin.

It also urges timely water management activities.

Syed Iqbal Hasnain, Vice-Chancellor of Calicut University, told IANS: "In today's times, the rivers have shown 3 to 4 per cent surplus due to the 10 per cent increase in the melting of the glaciers of the western Himalayas, and the 30 per cent increase in the eastern Himalayan glaciers.

"But after 40 years, most of these glaciers will be wiped out and then we will have severe water problems.

"In order to lighten our fall, we should start taking water management steps, like water harvesting, water recharging."

According to the study, the upper Indus over the first few decades will have plus 14 per cent to plus 90 per cent increase, after which there will be a drastic fall to as low as 30-90 per cent below the baseline level by decade 10.

The Kaligandaki basin in the East, however, contrasts in behaviour. The decadal mean flow shows an increase throughout the next 100 years; the most extreme temperature scenario attaining a peak mean flow of between plus 30 per cent and plus 90 per cent.

For the Ganga, near its headwaters in Uttarkashi, the flow is predicted to peak at plus 25 to plus 33 per cent of baseline level within the first two decades and then recede to as low as minus 50 per cent of the baseline by the sixth decade.

Further downstream, de-glaciation impacts are barely noticeable. David Collins, Professor of Salford University, is quoted as saying: "I had been studying the effect of de-glaciation in Switzerland for the past 30 years. The rivers there today have double the expected water amount due to melted snow.

"But in another half century, these rivers will be reduced to half their expected quantity.

"In the subcontinent too, while the Indus basin spreading over Jammu and Kashmir in Pakistan will be terribly affected by glacial activity, the Brahmaputra delta in West Bengal and Bangladesh will have increased water flow due to heavy rainfalls caused by the melting of glaciers.

"The level of sea water is expected to rise by 35 cm. Imagine the highest of tides and the biggest of floods to be taller by 35 cm. The issue is very serious.

"This could in fact submerge the whole of India's gradually sloping eastern coastal region."

But the water imbalance is just the tip of the iceberg, says the study. *IANS*

The Tribune (3 April 2004)

Appendix 4.5
Policy Briefing Note 1

Mountain Livelihoods, Water Resources and Climate Change in Nepal

POLICY BRIEFING NOTE

The nature of mountain livelihoods

In Asia, 65% of the rural population live in upland areas, depending on farming, small scale industry, handicrafts, tourism and external remittances. While there is considerable cultural and social diversity in such regions, people often face the same kinds of threats and challenges. The topography and ecology of the region is also highly diverse, giving rise to many different microclimates and geographical conditions impacting on how people live, but in spite of adversity, people generally tend to be resilient and resourceful. In the upland areas of Nepal, livelihoods depend predominantly on animal husbandry, cultivation of medicinal plants, and the utilisation of non-timber forest products. Small scale hydropower and water mills are used to support communities within these mountain catchments, and domestic water supplies are almost always taken from springs, small tributaries or wells, rather than from the main rivers themselves, due to the fact that communities are usually located on steep valley slopes away from the river. Irrigation is important in some areas, and rivers originating in these upland zones provide water for people and the economy for hundreds of miles downstream.

Current problems in mountain communities

Poverty is a major problem for upland communities, and rural depopulation is a direct consequence of that, as young people leave the area in search of work. Because of the high levels of unemployment, non-cash income is important, and there is much dependence on the utilisation of open-access natural resources. Forests and water play an important role, but concern has been raised about environmental degradation, often characterised by landslides and floods. Unpredictability of seasons creates a problem for farmers, and people feel that outdated and inappropriate agricultural techniques currently in use should be revised. Lack of infrastructure such as irrigation schemes and transport, and poor educational facilities are considered a problem for these communities, along with lack of markets and political instability. In the mountain communities of Nepal, and other countries in the HKH region, people have considerable ecological knowledge, and from experience, have good understanding of how climate variation can influence local livelihoods. There is much scope for drawing on this local and indigenous knowledge, to support the development of more integrated and holistic resource management policies, in which communities are keen to be involved.

Research findings

1. Integrated hydrological modelling has suggested possible changes in water availability across the Himalayan region, as a result of climate change. Rising global temperatures are bringing about a process of deglaciation, directly impacting on river flows, initially causing an increase in flow rates in many areas, followed later by a reduction, as glacier melting rates decrease.

2. In the east of the region, increased volumes of water flowing out of mountain areas are likely to increase flows downstream, where precipitation is high during monsoon seasons. In western areas of the region, however, where rainfall contributes much less to local conditions, impacts of changes in snow melting rates will be more severe, resulting in significant reductions in water availability in the longer term.

3. Across Nepal, both immediate and longer term impacts may be felt, but not with the severity felt in other parts of the region. This is mainly due to the volume of snow and ice available at high elevations in Nepal.

4. These changes in water availability are likely to impact more on communities in upper parts of river basins, and this will have both regional and global implications. As a result, there is a need for the development of suitable and acceptable adaptation strategies, to address issues which may impact on the health and welfare of diverse human populations across the region.

5. Participatory consultation with a range of stakeholders highlighted the need for better, more equitable water allocation and management strategies, along with more public and professional awareness-raising campaigns.

POTENTIAL ADAPTATION STRATEGIES

Following extensive consultation at the local, national and regional levels, a number of adaptation strategies have been identified for further investigation:

- Develop management strategies to cope with changes in water availability
- Review approaches to techniques in the design of infrastructure, dams, irrigation schemes etc.
- Investigate change in cropping patterns, identify new, less climate-sensitive varieties
- Promote social networks of knowledge transfer and support
- Evaluate changes in location of fishing activities, development of community fish ponds
- Investigate appropriate alternative locations of tourism activities and options
- Review animal husbandry techniques, and development of new breeds
- Migration – need to prevent further rural depopulation

POLICY RECOMMENDATIONS[1]

- Build awareness of the impacts of climate change
- Encourage more participation in the development of climate response policy
- Promote better monitoring and data collection about conditions in upper mountain areas
- In key areas, introduce participatory surveys on selected indicators of climate change
- Develop mechanisms to support and promote adaptation strategies
- Investigate potential for water saving techniques
- Encourage the development of experimental cropping (in conjunction with the Ministry of Agriculture)
- Investigate potential for early warning
- Investigate scale of impacts on infrastructure in key basins
- Assess appropriate infrastructure responses
- Investigate potential need for water storage facilities
- Facilitate the introduction of a comprehensive (environmentally friendly, participatory, equitable) water use act by the government
- Support more integration and coordination between government departments, NGOs, etc., and development of a comprehensive mountain database
- Encourage the implement of participatory catchment conservation projects, and afforestation programmes near glaciers
- Promote and foster existing social heritage in tourism development
- Identification of risk levels associated with hydrological accidents and other natural disasters, in specific geographical locations
- Enable more participation by women and marginalized people, including lower caste groups, and encourage their empowerment and support
- Research findings should be disseminated widely to people at all levels of society, not just policy makers. Children are important recipients of knowledge about climate change impacts and adaptation strategies

[1] These are based on consultation outputs from local and national stakeholders. Full details can be found in Sullivan et al. (2004), *An assessment of the potential impacts of climate-induced deglaciation on communities in the Hindu Kush Himalaya*. CEH, Wallingford, UK.

This publication is an output from the SAGARMATHA research project (R7980), funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID.
Full details of this work can be found in the SAGARMATHA Final Technical Report, Rees et al, 2004, CEH. Wallingford, UK.

Appendix 4.6
Policy Briefing Note 2

Climate Change, Water Resources and Livelihoods in the Himalayas

POLICY BRIEFING NOTE

Water resources and mountain systems

There is compelling evidence that climate change is a widespread problem with serious consequences for water resources around the world, and more than half of humanity relies on the freshwater that accumulates in mountains. The Hindu Kush-Himalayan (HKH) mountain region stretches across eight countries, is home to more than 140 million people, and influences the lives of three times as many in the plains and river basins below. The snow and glaciers of the HKH provide up to 90% of the lowland dry-season flows of the Indus, Ganges and Brahmaputra rivers and their vast irrigation networks. Scientists are studying the retreat of Himalayan glaciers and, although uncertainty exists, the consequences of deglaciation on water resources in the region could have serious consequences for the environment, national and regional economies, and for the day to day lives of many millions of people. To cope with these predicted and potential changes, and in the face of the increasing demands on water resources from growing populations and economic development, the effective management of mountain water resources is essential. Policies and adaptation strategies need to be developed and achieved in consultation with different stakeholders, considering the ideas, experience and knowledge of local people and scientists, as well as government and non-government organisations.

Current issues in mountain communities

Communities in mountain regions face many problems such as poverty and inequity, depopulation, unemployment, a lack of healthcare and educational facilities, and poor infrastructure. People across the HKH region share these problems which are exacerbated by environmental issues such as the unpredictability of seasons, extreme events (e.g. floods, storms, droughts), deforestation, soil erosion, and a lack of capacity in natural resource management. Water is vital for all kinds of economic and livelihood activities and any changes in the quantity, availability and quality of water resources would add to the current social, economic, and environmental problems faced by populations across the region.

Research findings

The SAGARMATHA project[1] has made an assessment of the potential impacts of deglaciation on the water resources of the Himalaya and on the livelihoods of people in the region. This has been achieved through the development of hydrological modelling and livelihood assessment and with the involvement of many stakeholders across the region. The studies have found that:

1. Changes in water availability in Himalayan Rivers as caused by deglaciation can have direct and indirect impacts. An increase in river flows can affect human activities in many ways through flooding, landslides and the destruction of water delivery systems. Reduced water availability creates water shortages for water-dependant activities such as agriculture, fisheries, hydropower, industry, domestic water supply and water transportation.

2. For many areas, the catastrophic water shortages forecast by some experts are unlikely to happen for many decades, if at all. Rather, some areas may benefit from increased water availability in the medium-term. Areas where glacial meltwater contributes significantly to river flow, such as in the upper Indus, however, appear to be vulnerable to deglaciation and this could have serious consequences for water availability and use throughout the basin. Eastern Himalayan areas, benefiting from high summer monsoon rainfall, are less susceptible to droughts, but more likely to experience flooding.

3. In the longer term, a reduction in water supply from the mountains could affect the economy of the region by limiting the energy from hydropower plants and hampering industrial productivity. However, while deglaciation may hinder economic development nationally, the impacts are likely to be hardest felt at the local level by the most vulnerable in society, particularly the women and children of poor families, and the communities most vulnerable are those living at higher and middle altitudes and dependent on their crops, livestock, and small-scale industry.

4. The impacts of deglaciation, and other effects of climate change, will vary considerably with time and specific location across the HKH region. The research has also highlighted the uncertainty associated with climate research and emphasises that care must be taken when interpreting the results.

[1]Rees *et al*., *SAGARMATHA: Snow and Glacier Aspects of Water Resources Management in the Himalayas*, CEH Research Report 2004.

POTENTIAL ADAPTATION STRATEGIES

Following extensive consultation at the local, national and regional levels, a number of adaptation strategies have been identified for further investigation:

- Improve long-term monitoring, data collection, and modelling of the links between climate impacts and hydrological regimes
- Carry out research into alternative cropping patterns and crop varieties
- Increase water storage capacity
- Promote water saving techniques in all sectors
- Develop early warning systems to give longer warning of forthcoming events, hail storms etc.
- Diversify employment opportunities in upland areas
- Improve and expand planning of communications & infrastructure to take account of potential impacts of changes in river flows
- Develop integrated, equitable & sustainable water resource management strategies
- Promote institutional networking and development
- Empower women and marginalized communities to have more inputs into water policies

POLICY RECOMMENDATIONS[2]

It is considered that deglaciation could impact on all sectors of the regional economy and on many people's livelihoods and that mechanisms to support and promote appropriate adaptation strategies need to be developed to face these challenges. These strategies will need to be site-specific and aimed at creating sustainable livelihoods for all people across the HKH region, particularly the poorest.

- There is a need to improve systems of data collection and modelling to reduce uncertainty
- In key areas, introduce a survey on selected indicators of climate change, to improve monitoring of conditions in upper mountain areas
- Investigations should be carried out to assess the potential for the introduction of water saving techniques, and to identify the need for water storage facilities
- Assessments of the scale of impacts on infrastructure in key basins is needed
- Development of experimental cropping and new crop types are recommended
- General awareness-raising of climate change impacts is needed, and specific training about climate change mitigation should be given to key persons and institutions
- Alongside scientific and technical approaches, it is particularly important to take a more participatory approach in the development of climate response policy
- There is a need for an assessment of the potential benefits of early warning systems for extreme events, and providing better communication of forthcoming hailstorms etc.
- Long-term and appropriate strategies are required that will build stronger institutions and improve water management to take account of competing needs

[2] These are based on consultation outputs from local and national stakeholders. Full details can be found in Sullivan et al. (2004) *An assessment of the potential impacts of climate-induced deglaciation on communities in the Hindu Kush Himalaya*. CEH, Wallingford, UK.

This publication is an output from the SAGARMATHA research project (R7980), funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID.

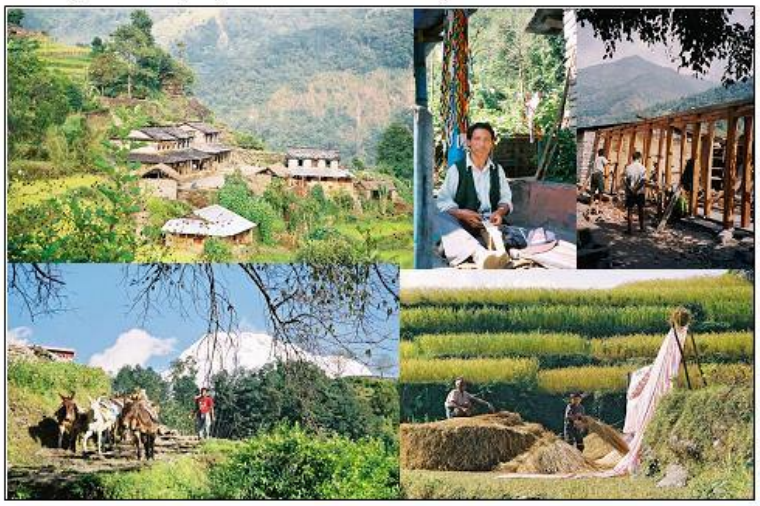
Appendix 4.7

Conference Paper: 'Mountain livelihoods and climate change: A case study from central Nepal'

(Powerpoint Presentation from the University of Bergen Workshop: 'Fragile Mountains – Fragile People? Understanding "fragility" in the Himalayas', Bergen, Norway, November 2003)

Mountain livelihoods and climate change:
A case study from central Nepal

Caroline Sullivan[1,4], Shiba Rijal[2], Mandira Shreshtra[3] , Narendra Khanal[2] and Dermot O'Regan[1]

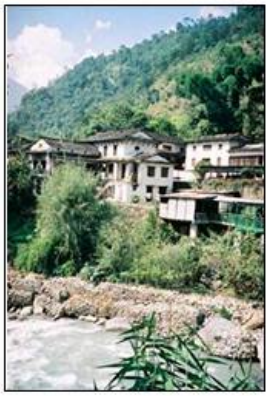


1. Centre for Ecology and Hydrology, Wallingford, UK
2. Tribhuvan University, Kathmandu, Nepal
3. International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal
4. Corresponding author, Email csu@ceh.ac.uk

Paper presented at The University of Bergen Workshop 'Fragile Mountains – Fragile People? Understanding "fragility" in the Himalayas', November 2003

Climate change and mountain systems: some observations

- Data analysed by The World Glacier Monitoring Service (WGMS, 2001) indicates that a significant degree of glacial shrinkage has been occurring over the last 100 years, with evidence that this rate of shrinkage has been increasing over the last 30 years
- The IPCC (1996) estimates suggests that global glacier mass will be reduced by some 25% by 2050
- The International Commission on Snow and Ice (ICSI, 1999) suggests that this reduction is likely to be most marked in the Himalayas
- Data collected by the Sagamartha Project (Rees et al, 2003) suggests that the annual mean temperature change in Nepal between 1991 and 1996 has been 0.07°C
- On the basis of data from a subset of gauging stations at higher altitudes (between 1800m and 4100m), the mean increase in surface temperature has been as much as 0.1°C per year over the 35 year period



Potential impacts of climate change on water availability – 'scientific' evidence

- According to the IPCC, (2001, a and b), the impacts of climate change will mean that global temperatures will rise, with changing mean levels of rainfall, and increasing variability.
- This is likely to bring about two types of change in water availability:
  - shifts in mean conditions,
  - changes in the amount of variability around these new conditions.
- the IPCC predicts that: "Flood magnitude and frequency are likely to increase in most regions, and low flows are likely to decrease in many regions." In other words, both worse droughts *and* worse floods can be expected.

How water influences livelihoods

- The time spent in collecting water for domestic needs can be enormous. To give just one example, in places where people do not have water piped into their homes in Tanzania, the average time per household for domestic water collection was recorded at 7 hours per day (Sullivan et al., 2003).
- Both the loss of time, which might have been used for other productive purposes, and the expenditure of physical energy collecting water from a distant source, have major impacts on people's livelihoods. Queuing for access or unreliable supply systems mean that people may sometimes have to travel to more distance sources or wait until late at night to get domestic water supplies
- These issues tend to affect women and children disproportionately, and are often reasons why poorer children are unable to attend school.
- clean water within a distance of not more than 1 km from the house tends to lead to improved health status since people start to use substantially more water for cleaning and washing
- The health impacts related to water access are well known
- The availability of water for growing food and other productive purposes (eg small-scale irrigation and livestock watering) are key components of livelihood strategies.
- Small-scale and cottage industries (for instance, brick making, beer brewing, and textiles) can help to lift people out of poverty, and require an adequate water supply.
- Since the amounts of water required for purposes other than domestic needs are often larger, especially for irrigation, this can lead to competition between uses;
- pollution of domestic water sources by agricultural and industrial use causes conflict.
- The integrity of the aquatic environment is relevant because of the goods and services they provide, being the life support systems of poor people in rural areas.

Climate change impacts on water resources

- Increased mean temperatures and changes in the transient snow line are likely to bring about a rise in the rate of snow melt
- Higher mean temperatures may lead to higher levels of evapotranspiration from both natural vegetation and from crops
- Surface water run-off rates likely to increase
- River flows likely to increase and river levels to rise
- Probable difference in impacts over short, medium and long time periods
- Many more extreme events and greater variability

Irrigation canal, Gyandi

Water mill (Ghatta) at Syaulibazar

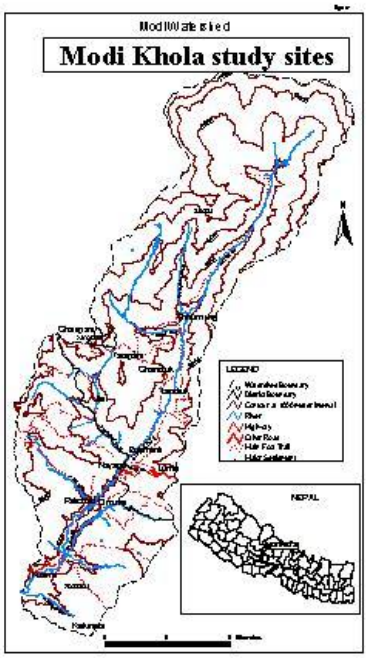
Water in the Himalayan region: management issues and potential sources of conflict

- Huge dependent populations
- Spatial scale of impacts
- Irrigation and food security
- Livestock water provision
- Fishing
- Risk of extreme events
- Infrastructure
- Erosion and sedimentation of dams
- Hydropower
- Tourist water demand
- Ecological degradation of river systems and loss of biodiversity

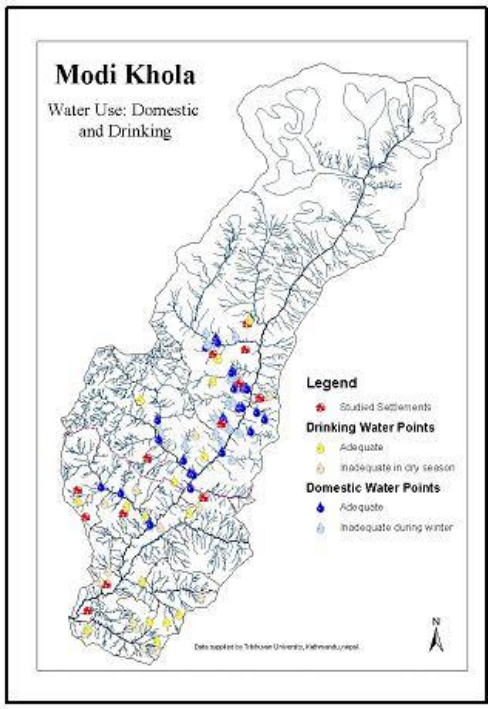
Research approach

- **Household surveys** For the purpose of study the Modi Khola watershed was divided into two sub-regions the upstream sub-region and downstream sub-region on the basis of the water regime. The dam site of the Lower Modi Hydropower Project was considered as the dividing line. Each sub-region was further sub-divided into different ecological zones on the basis of altitude at a range of 1000 meters interval. Altogether 12 settlements were randomly selected (from all settlements in the catchment)to represent different eco-zones of the sub-regions. 30 household units were taken as the sample size of individual settlements. A total of 360 households were selected for the whole watershed
- **Group discussions** Community level information about distribution of assets and present utilization pattern of these were collected using standard PRA approaches. In addition, perception regarding climate change and its relation to livelihoods of the local people were examined. For this purpose, a group consisting 5-10 persons representing different occupational groups, elected persons, social workers and farmers were formed at each selected community. A total of 12 groups were organized, and in addition, a number of informal discussions were carried out.
- **Inventory of water uses and mapping** An inventory of different water uses was made through consultation with local people and field observation. These were mapped using GPS and recent topographic maps. The water uses included water mills, irrigation canals, power plants, woodcarving workshops, piped water supply, hot Springs, and religious and culturally important places.
- **Field observation** Extensive field observation was made as a supplementary method to techniques mentioned above. Information on the physical environment, settlement pattern and resource base was recorded. Spatial data were checked and updated in the field.

Profile of a catchment: The Modi Khola



- Longitudinal transect ranging from upper catchment and glacier mouth to the Indian border
- 12 villages surveyed in Modi Khola
- Large scale Water uses examined in the Kaligandaki corridor



Demographic characteristics of the Modi Khola people

• In 2001, the population of the Modi Khola watershed was estimated to be about 75,000 in 17,000 households. The average family size of 4.6 varied between 4.1 persons in Sankhar Pokhari to 5.7 in Ghandruk.

• Average literacy rate in the watershed was 64.8 percent, ranging from 51.7% in Arther Dandakharka and highest in Mudikuwa (80.7%)

• Bramin/Chhetri people make up 51.1 percent of the total sample population followed by Gurung (22.7 percent), Magar (16.3 percent) and others (8 percent). In the upper part of the watershed, Gurung and magars are the dominant group, while Chhetri and Brahmin are dominant in the lower parts.

	Downstream sub-region						Upstream sub-region				Total	
	Lower		Middle		Upper		Middle		Upper			
Ethnic groups	No	%	No	%	No	%	No	%	No	%	No	%
Brahmin/Chhetri	379	85.6	379	92.7	19	5.4	301	51.4	112	20.8	1190	51.1
Gurung	0	0.0	9	2.2	8	2.3	127	21.7	384	71.2	528	22.7
Magar	0	0.0	3	0.7	308	87.0	57	9.7	13	2.4	381	16.3
Kami/Damai	55	12.4	0	0.0	19	5.4	54	9.2	25	4.6	153	6.6
Sarki	5	1.1	10	2.4	0	0.0	47	8.0	0	0.0	62	2.7
Newar	4	0.9	8	2.0	0	0.0	0	0.0	0	0.0	12	0.5
Thakali	0	0.0	0	0.0	0	0.0	0	0.0	5	0.9	5	0.2
Total	443	100.0	409	100.0	354	100.0	586	100.0	539	100.0	2331	100.0

Livelihood options in the Modi Khola

- Agriculture
- Brewing
- Fishing
- Brick making
- Tourism
- Transportation
- Weaving and other crafts
- Forest utilisation

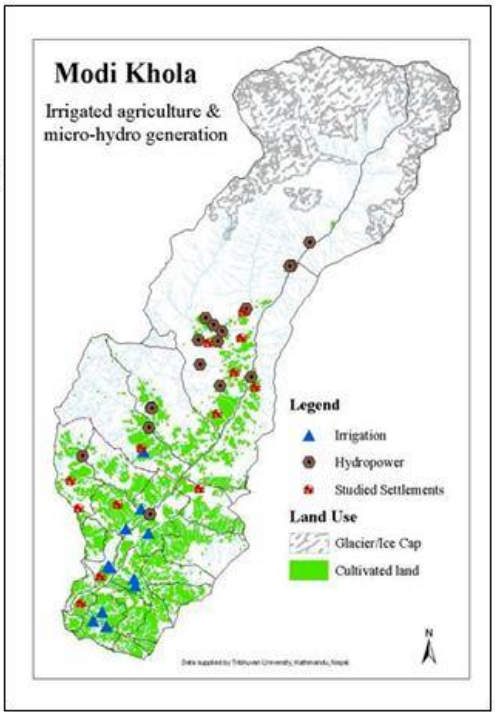
Capital types for sustainable livelihoods

Note: in spite of these various options, about 56% of hhs produce insufficient food supplies, and they have to buy food from other sources, requiring a cash income

Vegetation and water resources

The vegetation of the Modi Khola basin can be grouped into four major types. These include:

- semi-evergreen hill and riverine forest in subtropical zones,
- *Quercus Lamellas* and mixed broad-leaved forest in lower temperate zone,
- Birch- Rhododendron and mixed broad leaved forest in upper temperate/ sub-alpine zone, and
- pure grassland and pasture in alpine zones
- The long term average flow of the Modi Khola is 44.75 m3/sec at Nayapul (NEA, 2001). Downstream from the confluence of Kimrung Khola, the average annual discharge is currently 30.48 m3 /sec and at Syauli bazaar it is 33.592 m3/sec
- Large areas of irrigation are mainly found in the downstream areas, with most hydropower plants being found upstream



Land holdings in the Modi Khola valley

Land size (ha)	Downstream sub-region			Upstream sub-region		Total
	Lower zone	Middle zone	Upper zone	Middle zone	Upper zone	
	%	%	%	%	%	%
No land	1.7	0.0	0.0	1.1	**6.7**	2.2
Below 0.5	36.7	20.0	**41.7**	28.9	33.3	31.9
0.5-2.0	48.3	51.7	51.7	60.0	54.4	**53.9**
Above 2.0	13.3	**28.3**	6.7	10.0	5.5	11.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

- Land is an important natural asset as agriculture is the main source of subsistence of the people in the Modi watershed. The average size of the landholding of the study area both cropped and other lands is 1.1 ha.
- 53% of hh hold between 0.5 and 2 ha of land
- Most large land holdings >2 ha are in the middle zone of the downstream subregion

Land type	Downstream sub-region			Upstream sub-region		Total	
	Lower zone	Middle zone	Upper zone	Middle zone	Upper zone	Area	%
Khet	**60.7**	54.5	11.7	**48.5**	19.5	156.0	**41.3**
Bari	21.7	19.2	**58.6**	34.0	**52.2**	132.6	35.1
Grassland	10.4	**18.3**	20.2	12.0	16.4	57.9	15.3
Forest	6.9	**7.0**	4.2	3.4	5.0	20.3	5.4
Abandoned	0.4	1.0	5.4	2.1	**7.0**	11.3	3.0
Total	100.0	100.0	100.0	100.0	100.0	378.0	100.0

- Most land is used as Khet, (ir) with Bari (rf) being found in upper areas of both down and upstream areas
- Most abandoned land is in the upper zone of the upstream sub region
- Most grassland and forest is in the middle downstream zone

Household 'wealth' holdings and money

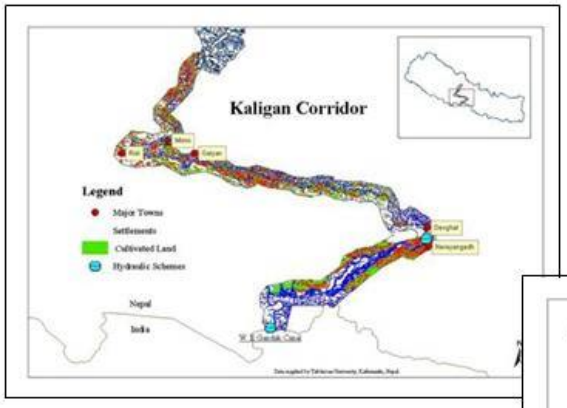
Types	Downstream sub-region			Upstream sub-region		Total
	Lower	Middle	Upper	Middle	Upper	
Radio	88.3	88.3	83.3	87.8	98.9	90.0
TV	25.0	28.3	3.3	13.3	17.8	68.9
Watch	53.3	33.3	16.7	24.4	35.6	21.3
Bio-gas plant	8.3	6.7	0.0	0.0	1.1	2.8
Solar power	0.0	0.0	5.0	1.1	4.4	2.2
Improved stove	23.3	11.7	0.0	3.3	13.3	10.0
Piped water	63.3	71.7	58.3	82.2	88.9	75.0
Improved latrine	65.0	71.7	73.3	57.8	75.6	68.3
Refrigerator	3.3	0.0	0.0	0.0	8.9	2.8
Swing machine	8.3	1.7	0.0	4.4	6.7	4.4
Furniture	70.0	45.0	18.3	41.1	54.4	46.1

Many of the households in this area do not have much access to financial capital, although a significant proportion do receive money from outside. This makes some of them relatively rich, and illustrates how results from one place cannot be generalised

Working place	Downstream sub-region						Upstream sub-region				Total	
	Lower		Middle		Upper		Middle		Upper			
	No	%	No	%	No	%	No	%	No	%	No	%
Outside VDC within district	8	13.3	2	3.3	1	1.7	3	3.3	4	4.4	18	5.0
Outside district within country	9	15.0	14	23.3	2	3.3	6	6.7	0	0.0	31	8.6
Other countries	16	26.7	15	25.0	21	35.0	27	30.0	33	36.7	112	31.1
Total	33	55.0	31	51.7	24	40.0	36	40.0	37	41.1	161	44.7

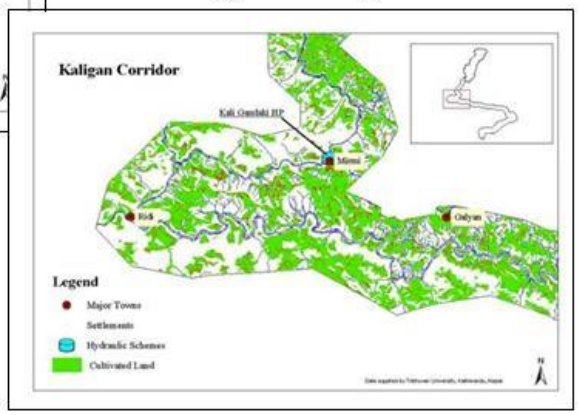
Only 16 % of hh income comes from agriculture/crops, 10% from tourism, 16% from services

Downstream of the Modi Khola: The Kaligandaki Corridor



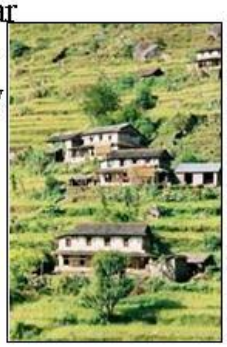
The Kaligandaki River basin is a tributary of Narayani River. This river basin is bordered in the north by Tibetan plateau, in the south by Narayani basin, in the east by Seti basin, and in the west by Jhimruk and Thuli Bheri basin. The total length of the river is approximately 300 km.

The relief of the basin ranges from 200 m to over 7000m. About 35 percent of the area lies below 1500 m where human activities are intense, and about 40 percent of the area lies above 3000 m. The climate ranges from hot humid sub-tropical to cool temperate and semi-arid.



Climate impacts in the Kaligandaki corridor

• Over the last 30 years, monthly water availability in Kaligandaki River has changed. In dry months there is a clear indication of a decreasing trend of discharge rates. Since the river is described as as a 'surplus basin', impacts of this may not be felt immediately, but potential hydropower plants within the river may be affected in future.



• In recent decades, extreme precipitation in the monsoon together with the basin topography has given rise to severe floods, but other problems associated with cloud cover have had the effect of reducing winter crop yield by as much as 38% between 1988 and 1998

• Recent research (Shrestha et al. ,2002) suggests that there has been an increase in monsoon precipitation ranging between 1.6 to 31mm/ year. At the same time, mean temperature increases have been recorded at rates between 0.026 and 0.029°C per year.

Livelihood vulnerability

- Vulnerability exists when resources are limited and access to them is tenuous;
- Human vulnerability to climate change is influenced by poverty, capacity and geographical conditions;
- Poor and politically weak groups are likely to be more vulnerable to shocks than others;
- Changes in ecological conditions arising from climate change (eg changes in river water temperatures and chemistry) are likely to influence fish spawning activities and influence fisheries in other ways;
- Livelihoods which are dependent on water inputs as a power source, or as another factor of production will be particularly vulnerable, especially in times of low flows.

Potential strategies for adaptation

- Changes in cropping patterns, substitution of crop varieties and species;
- Changes in the location of fishing activities, promotion of fish breeding and river stocking;
- Changes in the appropriate location of certain tourism activities such as rafting;
- Changes in animal husbandry techniques;
- Human migration;
- Changes to design specifications for water and other infrastructures, and modification of existing structures;
- Development of management strategies to cope with reduced water availability in an equitable way to prevent conflicts.

Conclusions

- Climate change is likely to impact on water resources
- Local communities are aware of changes already
- Impacts will vary with both spatial and temporal scales
- Different adaptation strategies are available
- Community responses to these strategies may be influenced by social and economic factors
- Attempts to understand these potential changes are important in we are to develop appropriate mitigation strategies.
- In this context, 'appropriate' means what is relevant and suitable for the very diverse communities dependent on the water resources flowing from the Himalayas
- Preliminary results suggest that the people in the higher altitudes will be most effected by climate change, but there is significant differences in these effects ranging from east to west across the region.
- Millions of very poor people may be effected both by more extreme events, and by significant changes in water availability, both in the medium and longer terms.