iied

January 2013

Economics of climate change in the water sector in Nepal

A stakeholder-focused approach

A case study of the Rupa Watershed, Kaski, Nepal

© Arjun Dhakal

Arjun Dhakal and Ajaya Dixit
Institute for Social and Environmental Transition – Nepal (ISET Nepal)

www.iied.org

Economics of climate change in the water sector in Nepal
A stakeholder-focused approach

A case study of the Rupa Watershed, Kaski, Nepal

Arjun Dhakal and Ajaya Dixit
Institute for Social and Environmental Transition – Nepal (ISET Nepal)

January 2013

Authors:
Arjun Dhakal and Ajaya Dixit work at ISET Nepal.
Email: arjun.dhakal@gmail.com

This country report is submitted as part of the Economics of Climate Change in the Water Sector project funded by the International Development Research Centre (IDRC) and coordinated by the International Institute for Environment and Development (IIED). For further information please visit http://www.iied.org/economics-climate-change-adaptation-water-sector

First published as grey literature by the International Institute for Environment and Development (UK) in 2012

For a full list of publications please contact:
International Institute for Environment and Development (IIED)
80-86 Gray's Inn Road, London, WC1X 8NH
Tel: +44 (0)20 3463 7399
Fax: +44 (0)20 3514 9055
newpubs@iied.org
www.iied.org/pubs

Acknowledgements:
We are grateful to ISET staff and the IIED study team for their valuable input in this study and input during the report's final preparation. We thank Muyeye Chambwera (Team Leader) and Denise Loga (Consultant) of IIED for their constructive input to refine the study and report. Our sincere gratitude goes to his regular backstopping and technical input during study and editing. Ram Chandra Sapkota and Lekh Nath Dhakal of Rupa Lake Protection Cooperatives, Mahendra Baniya, Engineer DDC Kaski, Ram Chandra Dhakal, Under Secretary Ministry of Tourism Kathmandu, without their support, it was not possible to complete this study timely. Last but not least, we are thankful to the local community of the Rupa watershed for their local efforts to successfully complete this study and achieve the results.

Contents

Abbreviations and acronyms

AMC	Action in Mountain Community Nepal
CBA	Cost-benefit analysis
CFUG	Community Forestry User Groups
DDC	District Development Committee
FGD	Focus group discussion
GCM	Global climate models
GDP	Gross domestic product
INGO	International nongovernmental organisation
IRR	Internal rate of return
NAPA	National Adaptation Plan of Action
NPV	Net present value
PRA	Participatory rural appraisal
SLD	Shared learning dialogues
VDC	Village Development Committee
WTP	Willingness to pay

Executive summary

Economics of Climate Adaptation in the Water Sector is an ISET study under the Economics of Climate Change in the Water Sector supported by International Development Research Center (IDRC) and the International Institute for Environment and Development (IIED). The main objective was to explore the options for managing Rupa Lake even under the extreme conditions of climate change through implementing adaptation measures as chosen by local stakeholders.

Nepal's National Adaptation Programme of Action (NAPA) shows the area is vulnerable to climate change, with landslides a particular concern. The region in general has experienced increased temperatures and erratic and intense rainfall over the past 10 years. The key indicators local people have experienced related to climate change and the weather include changing flowering and fruiting behaviours (phenological behaviour), decreasing agricultural productivity, increased incidence of crop pests, and increased soil erosion and sedimentation due to intermittent rainfall and dry spells.

The pilot followed stakeholder-focused approaches and tools for community consultations, orientations, community awareness workshops, to scope out climate change cost benefit analyses of adaptation measures at a watershed level. Initially, the watershed territory and its boundary actors were defined. Consultation workshops, individual interviews, shared learning dialogues (SLD), focus group discussions (FGD) were held with representatives of stakeholders both upstream and downstream of the lake. Transect visits were made, and a final stakeholders' negotiation meeting over their willingness to pay (WTP) was organised.

Initially, individual interviews were used to collect stakeholders' perceptions of potential climate risk and adaptation measures. Stakeholder workshops identified the criteria for ranking those options, depending on whether the cost was shared by external actors or not. After identifying the options, monetary and non-monetary costs and benefits were calculated on the basis of a technical analysis using engineering tools, market prices and stakeholders' perceptions. All the cost items were calculated using government guidelines and rates where available. Where unavailable, costs were based on stakeholders' estimates.

During the consultation, two options; construction of gabion check dams in the river, and construction of an earth-fill dam in the lake, were analysed individually, using different discount rates. The cost-benefit analysis (CBA) found that gabion check dams construction was more economically feasible and environmentally sound than an earth-fill dam. The third option, to construct both types of dam, was found to be more effective for lake conservation and improving adaptation capacity. These three options were then considered in the stakeholders' workshop based on their social, economic and environmental basis. Using decision criteria developed within the workshop, the stakeholders decided the most effective option was the construction of both the gabion check dams in the river and the earth-fill dam in the lake. This provides a win-win situation among the stakeholders, reduces investment cost, creates economic opportunity and increases the resilience capacity of the local community. Environmentally, this also promotes sustainable lake ecosystem management and helps to control soil erosion.

Stakeholders vary in their WTP for the project and in their perception of who should pay. Most of them thought that climate change is due to international factors so international actors should contribute a greater share of the project, followed by government agencies but nearly 92 per cent of the benefits of the project do go to the local community. Stakeholder-focused CBA gave all the stakeholders an opportunity to negotiate over the project implementation.

1. Introduction

1.1 Background

Climate change particularly affects people living in developing countries like Nepal whose livelihoods are highly dependent on natural resources and the local ecosystem. Of these, the poor and marginalised possess fewer livelihood options and are often the most vulnerable to climate hazards such as water runoff. Non-climate related factors may also play an important role locally (Pachauri, 2002; IPCC, 2007).

The costs of the local impact of climate change have not been assessed. Most of the research on this issue has focused on assessing the global costs of adaptation (Chambwera and Stage, 2010) to inform global financing policy, or on the impacts in developing country sectors like water and agriculture, for example Strzepek and McCluskey (2007). These studies do not consider local-level issues such as who bears the cost and who makes the decisions. The local-level economic issues of climate change need to be considered to facilitate developing countries taking action, particularly in relation to adaptation.

Taking the watershed as the unit of analysis makes the challenge even greater. The watershed is the normal unit for analysing the stock and flow of water, sedimentation and other natural processes. This approach can be extended to bring in the diverse stakeholders who live within in a watershed: the upstream, middle and downstream users. Despite the challenges, MoE (2010) has identified stakeholder-focused approaches to watershed management as a means to adapt to the effects of climate change.

Most of the literature on climate change recognises adaptation as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects. Adaptation can be carried out in response to or in anticipation of changes in climatic conditions. It consist of the process by which measures and behaviours to prevent, moderate, cope with and take advantage of the consequences of climate events are planned, enhanced, developed and implemented (UNDP, 2005; UKCIP, 2003; IPCC, 2001). While these definitions have been widely used and provide intellectual stimulation, we find it more useful to take more practical definitions of adaptation. Mechler *et al.* (2008), for example, start by making a distinction between coping and adaptation arguing that adaptation is more than just coping. It defines adaptation as the capacity to change strategies when faced with stress, including stress due to climate change.

In order to enhance adaptive capacity at a watershed level, local communities need to be involved and upstream-downstream linkages strengthened by providing strategic incentives. Such an approach can also contribute to the sustainable management of natural resources and ensure livelihood security (Regmi *et al.*, 2009; Pradhan and Providoli, 2010). The Rupa Lake watershed of Kaski district provides an insight into a stakeholder-focused approach to adaptation by looking at it within the ambit of watershed management. Such an approach will initiate long-term environmental management such as protection of the lake, control of soil erosion, water regulation, forest management, local employment opportunities and income generation. At the same time such an approach will protect the habitats of aquatic flora and fauna, medicinal plants birds and wildlife.

The National Adaptation Plan of Action (NAPA) document (MOE 2010) prepared by the government of Nepal has identified and prioritised adaptation measures to meet urgent and immediate needs for vulnerable districts based on hazards such as drought, flood, landslides and flooding from glacial lake outbursts. The government of Nepal has prioritised various adaptation options for Nepal (MoE, 2010) and estimated that their implementation would cost US$350 million. However, this cost is estimated at a national level and there is no site-specific, stakeholder-focused cost-benefit analysis (CBA) to assess the benefits that would accrue from making such an investment.

Cost-benefit analysis is an established tool for determining the economic efficiency of interventions comparing the costs and benefits in net present value. In disaster risk management the benefits are mostly the avoided or reduced potential damages and losses, including the benefits of the primary development interventions (Mechler *et al.*, 2008). Additionally, CBA takes a broader perspective. It aims to estimate the overall "profit" for society rather than mere financial gains accruing to an individual business. But it has some limitations, such as the societal distribution of benefits and costs (Dasgupta and Pearce, 1978). Perceptions of stakeholders regarding who is losing or winning can be subjective but it is quite important to calculate the costs and benefits for negotiation and contribution among affected stakeholders.

This stakeholder-based CBA is driven by estimating the monetary and non-monetary values of benefits and cost to find the optimum option for climate adaptations. It is designed to identify a simple stakeholder-focused cost-benefit method to generate experiences of designing potential local adaptation strategies. It explores the processes, institutions and mechanisms needed to involve local communities, and to integrate this approach to adaptation planning at the watershed level. This study also contributes to a better understanding of the climate change adaptation process and identifies needs and benefits, including a mechanism for the sharing of costs and benefits among different stakeholders.

Rupa Lake is the third largest lake in the Pokhara valley of Nepal. The Nepal's National Adaptation Programme of Action (NAPA) also shows the area is vulnerable to climate change, with landslides a particular concern. The region in general has experienced increased temperature, erratic and intense rainfall over the past 10 years (Thapa *et al.*, 2011). Livelihoods in the region are predominantly based on agriculture and fisheries. Rupa Lake and its watershed is also a popular tourist destination and has high potential for developing agro-ecotourism. Impacts of climate change are clearly observed in the lake ecosystem through increased siltation. Livelihoods are also affected by climate change as drought is prolonged and rainfall becomes erratic. This causes declined productivity.

1.2 Purpose of the study

This study aims to identify the stakeholders' involvement in lake watershed management and improve the livelihoods of the poor and marginalised communities living around it.

The study will help local communities adapt to climate change, and will promote informed decision-making among national governments of developing countries and the international community on the basis of sound scientific, technical and socio-economic criteria (IPCC, 2007).
Local community and authorities will use this report for local-level planning.

1.3 Specific objectives

Develop a stakeholder-focused CBA methodology applicable to water dependent/heavy regions in developing countries under extreme weather conditions – in this case the Rupa watershed, which is likely to suffer from heavy rainfall, landslides, and increased siltation due to climate change.

Develop a scenario of potential cost and benefits and recommend specific investment projects and the sharing of costs and responsibility.

1.4 Limitations of the study

The study was done in the absence of an elected local government during a political transitional phase, when there was no responsible and functional institution to answer questions although local community and environment agencies did provide information. The major limitation of the study was around cost and benefits. Local stakeholders had never been involved in the calculation of uncertainty before and the data available were not sufficient so estimates were used for most of the issues.

2 Study area

2.1 Geography and socio-economic overview

The Rupa Tal watershed is located between the latitudes of 28˚07'30"N to 28˚18'00"N latitudes and the longitudes of 84˚00'00"E to 84˚20'00"E. Its watershed is an area of 27.6 km², and is fed by streams that descend from the mountain regions of the Annapurna Himalayan Range. Rupa Lake lies east of Begnas Lake, separated by a single mountain ridge connecting Sundari Danda with Pachabhaiya. Dobhan Khola, also called Talbeshi Khola, is the major perennial river flowing into Rupa Lake. The elevation of the watershed ranges from 600m to 1420m and is a habitat to many sub-tropical types of vegetation.

The watershed is typical of mountain ecosystems. The majority is covered by forest and cultivated land. The mean annual precipitation ranges from 2700mm to 4150mm, of which 90 per cent comes between May and September (Banjara *et al.,* 2011). The maximum temperature recorded in Pokhara station was 37.4^{0}C (8 April, 1975) and the minimum temperature was 1.8^{0}C (13 January, 1970) (Koirala, 2010).

The watershed shares its boundary with Lekhnath Municipality (wards no. 10, 11 and 14) and three Village Development Committees (VDCs): Rupakot (wards no. 1, 3, 6, 7, 8 and 9), Hansapur (ward no. 6, 7, 8 and 9), and Majhthana (wards no. 4 and 5). But this study covers three wards of Lekhnath Municipality (no. 10, 11 and 14), four wards of Rupakot VDC (wards no. 1, 3, 6 and 8), one ward of Hansapur VDC (ward no. 6), and two wards of Majhthana VDC (wards no. 4 and 5). The watershed can be classified into two parts: the upstream and the downstream area. Upstream is largely rural while downstream is gradually urbanising although it could be conceived as a desakota[1] region.

2.2 Potential climate envelopes

The nearest meteorological station to Rupa Lake is Pokhara airport. Pokhara is located at a fairly high altitude (827m above sea level) in mountainous terrain and as such its climate is largely dominated by the local topography as well as the Asian monsoon. It is always important to consider current climate inter-annual variability when investigating the climate of a region. This gives an indication of the range of variability currently being experienced, which is critical when considering future changes. It is often the case that the current inter-annual variability of precipitation is very large compared to future projected changes, particularly for the near future (50 years). This is an important consideration for end users depending on the sector and the type of vulnerability under question.

The wet months are July to September while October to December are dry. From January the rain starts and the maximum precipitation is received in the month of July. The monsoon starts in mid-June and reaches its maximum intensity in July, falling away gradually in October.

While global climate models (GCMs) simulate the entire Earth with a relatively coarse spatial resolution (e.g., they can capture features with scales of a few hundred km or larger), in this study, GCMs show rising temperatures and uncertainty in precipitation but the lake has its own microclimate (for details see Annex 1).

2.3 Biodiversity and ecosystem

The Rupa Tal watershed contains aquatic, wetland and terrestrial ecosystems. Rupa Tal is the third largest lake in the Pokhara valley with an area of 1.07 km^2 and an average depth of

[1] Desakota, a term defined by the Canadian geographer Terry McGee, comes from Indonesia (desa means "village", while kota means "city") It means peripheral rural areas with high population densities and labour-intensive activities.

1.97m (ISET 2011). The most common gregarious natural vegetation types under tropical to subtropical monsoon climates are *Schima wallichii, Castonopsis indica, Alnus nepalensis* and *Shorea robusta* (Department of Forest, 2002). However, the natural vegetation is interspersed with patches of rural settlement and agricultural fields. The ecosystem of the region has deteriorated over the past few decades as a result of human encroachment into the watershed to extract forest resources, followed by conversion of forest into agricultural land and settlements (Pradhan and Providoli, 2010).

The region in general has experienced increased temperatures and more erratic and intense rainfall over the past 10 years. Local communities also perceive such changes (Thapa *et al*., 2011). The trend, however, varies. Pre-monsoon rainfall in some pockets of Western Nepal is decreasing (MoE, 2010), whereas monsoon rainfall is increasing. Post-monsoon rainfall on southern slopes of hills in western Nepal shows an increasing trend (MoE, 2010). The NAPA also shows that Kaski district is moderately vulnerable to climate change. The district is highly vulnerable to landslides because of the erratic and intense rainfall (MoE, 2010). These findings are also endorsed by GCM analyses which suggest that while temperature is likely to increase, precipitation in Nepal is likely to become more erratic (see Annex 1 for details).

2.4 Land use

Land use in the watershed can be characterised as semi agricultural, typical of the mid-hill belt (600-1420m) of the mountain system. The main land use categories of the watershed are forest, agriculture, open forest and barren land. Cultivation depends upon prevailing local climatic conditions. Livestock is an important economic activity in the watershed (Regmi *et al.*, 2009).

Table 1. Land use in the Rupa watershed

	Land use description	**Total area (km^2)**	**Per cent of watershed area**
1	Forest	8.718	33.55
2	Cultivated land	9.444	35.27
3	Suburban	0.744	2.77
4	Urban	0.646	2.41
5	Barren soil	5.805	21.68
6	Bodies of water	1.424	5.32

Source: Banjara et al., 2011.

2.5 Livelihoods

The land use of the watershed has been categorised into natural (agriculture, water and forest) and non-natural (industries, service, business and remittance). The residents of the watershed mainly base their livelihoods on agriculture. Local communities also earn income from fishery activities in the lake through co-operatives. Rupa Lake has a high potential for developing ecotourism.

Impacts of climate change are observed in the lake ecosystem, which is beginning to affect the livelihoods of the communities (Thapa *et al*., 2011). A clear indicator of climate change is increased siltation, decreased agriculture productivity and declined productivity indicates that drought is prolonged and rainfall is erratic. These are changing the local weather patterns which include erratic rainfall of short duration high intensity rainfall, less number of cold days (shortened winter), increased days with fogs while there is no rainfall for rest of the year. Increased temperatures and prolonged dry spells and intense precipitation (Thapa *et al*., 2011) are major climatic hazards in the area.

Table 2. Comparative study of the morphological characteristics of Rupa Lake

Parameter	Study				
	Ferro and Sar 1978	Rai *et al.*1995	Fishery Center 2005	Banjra *et al.* 2011,/KU	ISET Nepal Dec 2011
Surface area Km^2	1.17	1.15	1.35	1.04	1.07
Water volume MCM	2.7	3.25	3.25	2.56	2.08
Maximum depth M	4.5	6.0	3	4.1	3.52
Average depth M	2.3	2.4	2.3	2.44	1.95

The land use of the watershed has been categorised into natural (agriculture, water and forest) and non-natural (industries, service, business and remittance-based). The majority of those living in the watershed depend on natural resources for their livelihood, and mostly depend on agricultural activities. Remittances are another major income source. Due to economic, social and ecological pressures, local people are forced to leave their villages for short- and long-term employment. The poor often work as seasonally-paid labourers in the nearest employment markets, such as Gagangauda, Shishuwa, Begnas Lake and Pokhara (Regmi *et al.*, 2009). Households in some wards in the VDC are engaged in off-farm activities as an additional source of livelihood.

2.6 Landholding and food security

The average landholding of households in the upstream region is less than 0.5ha. Downstream areas have better productivity and food security because of the availability of irrigation water (Pant *et al.,* 2007). More than half of the households of the plains grow sufficient crops for the whole year whereas upstream a little less than 30 per cent of households produce enough food for the whole year (Pant *et al.,* 2007).

2.7 Drinking water

Upstream, drinking water comes from rivulets, ponds and springs. The drinking water systems used in the villages have been categorised into engineered types, such as pipe systems, tube wells and rain water harvesting (RWH) and non-engineered types such as stone spouts, river/rivulets and springs. The majority of people use rain water harvesting systems as an alternative source of drinking water. The use of RWH is common especially in ward no. 1, 2 and 3 of Rupakot VDC, where systems were installed with help of Helvetas, a Swiss international nongovernmental organisation (INGO). Altogether there are 196 engineered and 66 non-engineered drinking water systems in the area, benefitting almost an equal number of households (Field visit, 2011).

2.8 Upstream-downstream linkage

In the past, major floods and landslides have deposited large amounts of sediment in the lake and its surrounding wetlands. This process has been exacerbated by a high rate of deforestation in the lower reaches of the watershed which also has resulted in overall degradation of forest and soil (Pradhan & Providoli, 2010). New private agricultural areas have been developed in the wetlands and forests have been cleared to build settlements, while streams and tributaries have been diverted to irrigate farm land (Poudel and Buckles, 2007). These processes have not only threatened the livelihoods of fishermen who earn a living from the lake but also engendered changes in the surrounding landscape.

Upstream community:
Get no direct benefits from the lake and the economic activities of the co-operative, but have the potential to contribute to the lake's conservation and environmental protection and to minimise siltation.

Downstream community:
Get direct benefits from the lake in terms of water provision, transport and fisheries. They have a high interest in conservation of the lake and its biodiversity.

Recognising that the conservation of the forest and management of the watershed are crucial for sustaining the lake systems and enhancing its productivity, the Rupa Lake Restoration and Fishery Cooperative was established in 2001. The co-operative provides direct benefits to Community Forestry User Groups (CFUGs) and incorporates an effective local benefit-sharing mechanism to provide support in schools and micro-infrastructure to the upstream communities. These incentives are expected to conserve the lake catchment. The co-operative members are beneficiaries of the services provided by upstream farmers. Various CFUGs receive significant economic benefits from the lake, and these benefits are shared with upstream communities to provide incentives for the protection of the lake and its wetlands.

2.9 Use of energy

The main energy sources for cooking and lighting in the watershed can be divided into traditional energy (firewood), clean energy (solar, electricity and biogas) and commercial energy (LPG and kerosene). The primary source of energy for cooking purposes is traditional energy and for lighting is electricity.

3 Conceptual framework

Climate change is expected to impact on most parts of society in most countries, but particularly in developing countries. Some studies have already tried to analyse the costs and benefits of climate change and of various adaptation strategies, focusing on impacts on gross domestic product (GDP) and national economies (Stage, 2010).While these measures can be useful as indicators of the capacity of developing countries to adapt, they provide an incomplete picture, ignoring local community and sectoral vulnerability.

Research on the impact of climate change in developing countries is currently very limited, although there are studies in progress in different areas and sectors. Some of the studies in developing countries are focused on autonomous adaptation, particularly in the water and agriculture sector (Stern, 2007), and externally imposed planned adaptation (Stage, 2010). Stern (2007) estimates the cost of adaptation at a global level, including the impact of sea-level rise for the world's economies, but offers few local-level insights (Stage, 2010). Other studies state the economics of planned adaptation focus on the impact on a specific sector using the equivalent variation measures (willingness to pay (WTP)) rather than compensating variation measures (willingness to accept) (Juana *et al.*, 2008 Mechler *et al.*, 2008; Stage, 2010; Reid *et al.,* 2008).

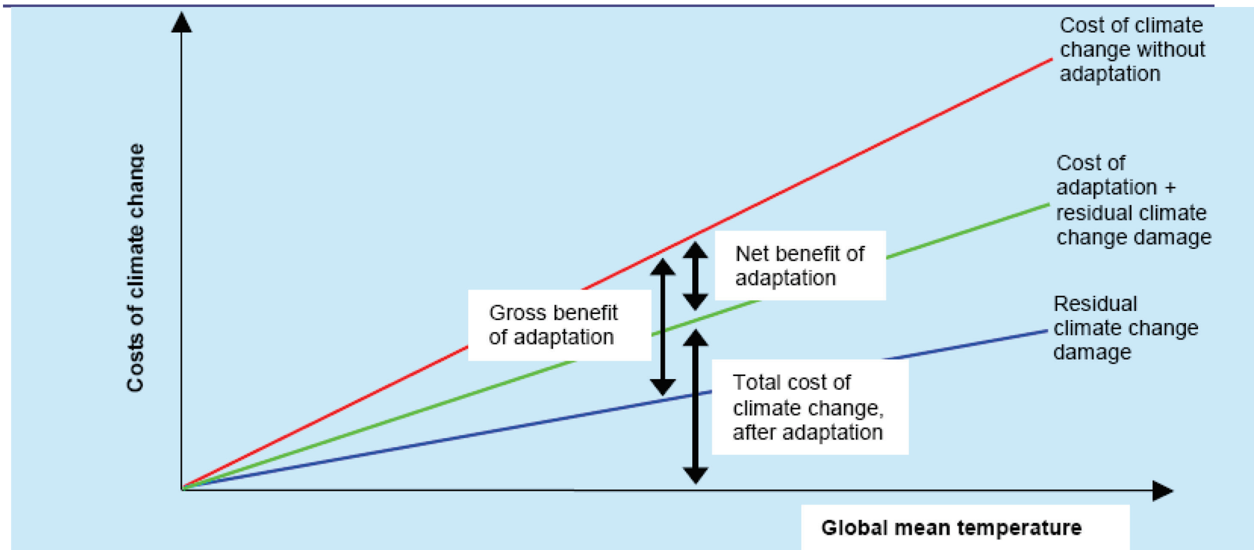
If climate change leads to extreme weather conditions people automatically adapt, a process known as autonomous adaptation (Stage, 2010). Some of the studies including Mendelsohn and Dinar (1999) have used Ricardian functions to estimate impacts of a range of different temperature increases in the agricultural sector but these are not suitable for predicting future uncertainty (Stage, 2010). Mendelsohn and Dinar 1999 assume that farmers automatically move to adopt adaptation measures to deal with uncertainty but most farmers in developing countries are not profit maximising rational actors (Stage, 2010). However, the discourse on Ricardian methods and economics of climate change adaptations through the Mendelsohn and Dinar 1999 method gives a good starting point for policy interventions.

Climate change will affect the basic elements of life for people around the world. Hundreds of millions of people could suffer from hunger, water shortages and coastal flooding as the world warms (Stern, 2007). Climate change also creates additional pressure on the development budgets of developing countries, which are already suffering from resource scarcity.

Before the cost of adapting to climate change can be calculated, a clear estimate of the potential physical impact is needed, which is still limited or ignored (Gambarelli and Goria, 2004).

"Adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change. (p. 642)" [Source: IPCC, 2007)

Figure 1. The economics of climate change



Source: Stern, 2007.

Soft adaptation[2] is more complicated because the benefits, to a great extent, must be inferred from resulting changes in private sector behaviour and prices (World Bank, 2010). Increasingly, countries are coming to realise that, in the long-term, climate change

[2] According to the World Bank definition: "Hard" adaptation measures usually imply the use of specific technologies and actions involving capital goods, such as dikes, seawalls and reinforced buildings, whereas "soft" adaptation measures focus on information, capacity building, policy and strategy development, and institutional arrangements (source: http://climatechange.worldbank.org/content/adaptation-guidance-notes-key-words-and-definitions)

adaptation needs to be supported by an integrated, cross-cutting policy approach; in other words, mainstreamed into national development planning. Specifically, sustainable management of watershed areas in mountainous countries like Nepal has become increasingly important.

3.1 Monetary and non-monetary evaluations

This study used multiple criteria analysis to identify and prioritise adaptation needs before applying a CBA. After the CBA, environmental sensitivity criteria was applied and addressed to poor and vulnerable communities. Both a non-economic evaluation approach and an economic approach were used to estimate the costs and benefits of adaptation measures. Cost-benefit analysis is a well-known tool in project planning and investment decision-making. In the case of adaptation, benefits include the cost of damage avoided and the value of benefits accrued following the adoption and implementation of adaptation measures. Adaptation costs include the planning, preparing for, facilitating and implementing adaptation measures, including transition costs (IPCC, 2007). Simply put, assessing the costs and benefits of adaptation help policymakers decide which options for adapting to climate change to adopt. There is a conceptual question as to whether costs should be considered as part of the project costs or estimated as additional project costs. The benefits of both hard and soft adaptation measures should also be estimated in both non-monetary and monetary terms.

Once the optimal adaptation strategy has been identified, its economic merit can be evaluated based on qualitative and quantitative methods. The most popular method of quantitatively evaluating the net worth of projects is the net present value (NPV) method. Other non-market benefits such as social and environmental benefits and costs are evaluated qualitatively.

3.1.1 Qualitative evaluation

Net present value is the difference between the discounted values at a required discount rate of future benefits and costs associated with a project. The higher the net present value the more economically viable the project. If the net present value is negative, the project is not economically viable. Cost-benefit ratio is the ratio of the present value of project benefits to the present value of project costs. It is the discount rate at which the present value of the benefits from a project equals the present value of the costs of the project. The higher the internal rate of return, the more economically attractive is the project. Hence, an economically worthwhile project is one for which the discounted value of the benefits exceeds the discounted value of the costs; i.e., the net benefits are positive. This is equivalent to the net present value being greater than zero and the internal rate of return being greater than the cost of capital.

The net present value is given by the formula:

$$NPV = \sum_{i=1}^{n} \frac{net\ benefit}{(1 + discount\ rate)^i} \qquad (1)$$

Where n= the life time of the project
i= any given year

The internal rate of return (IRR) is iteratively calculated by setting the NPV value equal to zero. Hence for the calculation of IRR, equation (1) is modified to:

$$NPV = \sum_{i=1}^{n} \frac{net\ benefit}{(1 + IRR)^i} = 0 \qquad (2)$$

A spreadsheet can be used to calculate the internal rate of return using arbitrary starting values. The CBA of a planned climate change adaptation project could be done using discounted cash flow analysis at a discount rate of 6 per cent (market interest rate) and 50 per cent (average rate of time preference generated using experimental field surveys in many developing countries (Yesuf and Bluffstone, 2009). The project life time could depend on many factors but a figure of 30 years could be used as a starting point.

The financial evaluation of a commercial project with the objective of maximising profits, requires the analysis of its annual revenue cash flows and costs. The financial capital cost of any given adaptation project represents the stream of investment made during its lifetime. A project's investment expenditures might include the purchase of capital goods, cost of acquisition of land, the cost of payments to skilled and unskilled workers and the material inputs for construction. The annual operation and maintenance costs of the project include expenditure on energy, and material inputs and payments made to skilled and unskilled labour for maintenance. The investment goods and material inputs used by the project are evaluated at market prices, where the market price of a commodity is defined as producer price plus commodity tax minus commodity subsidy.

A sensitivity analysis could be conducted to assess the sensitivity of the NPV values to changes in the discount rate.

3.1.2 Non-monetary evaluations

The importance of examining the non-market benefits over and above the economic worth of a project stems from the fact that a project is bound to bring about costs and benefits to stakeholders other than those who primarily carry out the project. These might add to or reduce the positive and negative impacts of a project on areas such as the ecosystem.

The indirect costs or non-market benefits including the environmental costs have been estimated for each activity. Included are environmental benefits, local peoples' income, merchandise for businesses, opportunity, improved recreational value, incremental income from agricultural products, and improved fisheries. Financial analysis of each investment has been calculated using market prices and procurement guideline of government.

Traditional CBA has focused on market values, but stakeholder-based cost-benefit frameworks consider the stakeholders' perception of cost and benefit and their expectations and interests. Contribution from stakeholders can be gathered by methods such as shared learning dialogues (interaction between science and society) and participatory rural appraisals (PRA), which apply a series of qualitative multidisciplinary approaches to participatory learning about local-level conditions and local peoples' perspectives.

Stakeholder-focused CBA provides stakeholders with the opportunity to identify and evaluate/audit adaptation options which are not considered in traditional CBA. In traditional CBA, most of the cost and benefits are decided by expert evaluation or authorities' judgment. Broadly defined, stakeholder-focused CBA is an approach that gives stakeholders (community, private sector, local government and environmental groups) control over planning decisions and investment resources. Stakeholders participate in identifying and evaluating options for adapting to climate change. Stakeholder-focused CBA empowers the communities by allowing them to play a stronger role in the direct provision of basic services, and to hold government more accountable for its performance in assisting communities to address their needs. It thus addresses some of the weaknesses of traditional CBA.

4 Major stakeholders and their interests

The Rupa Lake watershed community is diverse in terms of language, profession, culture and livelihood. For this study, it can be divided into two broad categories: upstream and downstream. Within these two categories, there are four further sub-categories of stakeholders each.

Table 3. Major stakeholders

Upstream	Downstream
Household/community institutions - Community organisations / co-operatives - Farmers - Community forestry representatives - Women's groups	Household /community institutions - Co-operative employees - Co-operative board members - Farmers around the lake
Private sector - Hotel upstream of the lake - Travel agencies	Private sector - Hotels around the Lake - Travel agencies
Environmental groups or experts - Libird - AMC - NGOs	Environmental groups or experts - Libird - AMC - NGOs - Environment expert from Pokhara University, Prithivi Narayan Campus etc
Local government - VDC secretaries - DDC Kaski	Local government - Lekh Nath municipality - DDC

4.1 Household/community institutions
In the case of Rupa Lake, most of the farmers and local people are involved in different community organisations such as co-operatives, women's groups or community forestry user groups. It is difficult to segregate their involvement in different groups from their membership of an individual household.

Additionally, individual members and community groups whose experiences, values and/or interests may be shared may interact with each other and be concerned about mutual and collective well-being. However, this set of individuals may include diverse groups that could act collectively (as an organised community) or individually in order to increase climate resilience at the household level.

4.2 Farmers
- **Upstream farmers:** do not get any direct benefit from the lake but their activities could be responsible for siltation. They have the potential to contribute to environmental protection and have some interest in conservation for maintaining tourist activities related to the lake.
- **Downstream farmers:** downstream farmers get water for irrigation out of lake. They will not be negatively affected by any dam construction but will be affected by water scarcity and drought since they do need lake water.
- **Downstream farmers around the lake:** these farmers live on land surrounding the lake. Land ownership is an issue for them. They are responsible for lake conservation and siltation and use the lake as a means of transportation, bringing the hay from field to home. Any dam irrigation will flood agricultural land.

4.3 Private sector
These mostly consist of small hotels, guesthouses and restaurants, making money from visitors to the lake and thus are dependent on the lake landscape and its conservation.

4.4 Local and government agencies
- **Village development committee (VDC) secretary**: the implementation agency for the upstream area with responsibilities including agriculture, health, planning and budget allocation.

- **Municipality**: government agency for the downstream side, bigger than the VDC but carrying out the same tasks. Lake issues are distributed between two municipalities.
- **District Development Committee (DDC)**: the DDC has greater powers than the municipalities and VDCs and is responsible for all development co-ordination, and for energy, roads, agriculture, and the vegetation surrounding the lake.
- **Lake conservation committee:** the national body responsible for maintaining the ecosystem of the lake.

4.5 Environmental groups

This group includes environmental NGOs, researchers and experts.

5 Study methods

The study used stakeholder-focused approaches and tools for community consultations. Initially, the watershed territory was defined and its boundaries identified in a consultation workshop representing individual upstream and downstream area stakeholders including: households (poor and non-poor), businesses (co-operatives, small shopkeepers, etc.), institutions (local government, community, and national departments), and environmental NGOS and groups. During the study individual interviews and focus group discussions were organised to identify community perceptions on climate change and local response measures. One broad consultative workshop was organised at a watershed level also. Community responses were collected to understand the ways in which the community was responding to climate change and their coping strategies.

Desk review: Relevant documents were reviewed including national and international studies, project reports, and local-level data collected by government agencies and NGOs.

Visit: In the initial stage of the study, a transect visit was conducted along the upstream section and the downstream region that surrounds the lakeside. The case study was selected in consultation with officials from the DDC, VDC municipality and other institutions as well as knowledgeable individuals in the respective village level and district. Rupa Lake was selected for fieldwork because it already has some local income generation activities and a benefit-sharing mechanism like payments for ecological services. Second, it has potential opportunities for fisheries and tourism with rural-urban linkages. The third, but most important, reason for selection is the siltation of Rupa Lake. Extreme weather conditions influenced by climate change could make siltation a much greater problem that could exert a serious blow to the lake system.

Individual interviews: Individual interviews were held with key informants such as community leaders, co-operative leaders, VDC/municipality officials, hotel entrepreneurs, and local NGOs working on environment and conservation issues.

The members of the co-operatives and local fisherman were also interviewed. Where possible the approach was to solicit their experiences and opinion. Attempts were also made to estimate the cost of materials, labour and other intangibles that would be necessary to invest for adaptation. A checklist was prepared to assess the perception of the stakeholders about climate change, the challenges it poses and options for adaptation. These consultations also helped assess monetary and non-monetary costs and benefits of climate change risk as well as adaptation measures. The estimates also used indirect assessment of environmental variables such as siltation control, biodiversity protection, drinking water sources protection etc.

Shared learning dialogues: A number of climate change adaptation options are available to stakeholders, each of which will be differently suited to the needs of the different stakeholders. Identifying a suitable adaptation strategy or strategies requires the stakeholders to make a joint evaluation of the available options. While there are several ways of carrying out this exercise, the rapid rural appraisal (RRA) method is the most popular. The key methods used were shared learning dialogues (SLDs) with different stakeholders to collect community, perception, and system data. Community SLDs collected watershed-level information in co-operation with the Action in Mountain Community Nepal (AMC), an NGO based in Pokhara.

Focus group discussion: The focus group discussion (FGD) methodology tries to gain knowledge about a particular topic. It was developed to collect many opinions such as community costs and benefits, evaluation of projects and needs assessment. Using this methodology to choose stakeholder-based climate change adaptation strategies relies on FGDs with stakeholders. Focus group discussions were organised among the stakeholders using a semi-structured checklist of questions. They were held with communities to identify the costs, benefits and their WTP including their attitudes, feelings and preferences. Eight focus group discussion were conducted, four in the upstream area and four in the downstream area, with farmers, NGO staff, local private sector companies, local officials, the DDC and academics. The individuals attending the FGD were asked to read the checklist before making their points if any issues were not clear. They were also asked to identify the most important adaptation options upstream and downstream separately based on their response and its costs and benefits. In the FGD, communities scored the economic, social, and environmental costs and benefits of the potential adaptation options from zero to five (with 0 being no cost or no benefit, 1-2 low cost or low benefit, 3 medium cost or medium benefit, and 4-5 high cost or high benefit). They were also asked which agencies could contribute to or support their implementation.

Stakeholders' workshop (negotiation meeting): At the end of the study, a stakeholders' workshop was organised to share the analysis and outcomes of the study. Stakeholders discussed and negotiated to identify the beneficiaries and their WTP. The project options were also presented with their estimated costs and benefits and rate of return. The workshop discussed and compared the options and proposed to implement the third option (construction of both earth-fill dam and gabion check dam) based on socially-accepted, economically-viable and environmentally-sustainable grounds. A trade-off point was also sought, to negotiate among the stakeholders, including their WTP.

6 Local perceptions of climate change impacts on water

(See check list of focus group discussions Annex 4)

6.1 Water-related stress

Local communities have been already facing some water-related stress in their livelihoods and economy. Upstream, those who live in the watershed areas of the lake but get limited benefits from lake activities, are facing difficulties such as lack of access to drinking water, landslide and soil erosion while downstream communities are also facing water scarcity for both irrigation and drinking water. The private sector, local government agencies and environment groups are all observing similar kinds of problem - lack of drinking water and siltation in the lake.

Table 4. Local perception of climate change

Stakeholders	Downstream	Upstream
Community	Scarcity of drinking water Siltation No water for irrigation Decreased fish productivity	Problem of drinking water Soil erosion Land slide
Private sector	Scarcity of drinking water Soil erosion Siltation Lack of water for irrigation	Lack of drinking water Soil erosion Landslides Siltation Low water for irrigation Loss of local fish species
Government agencies	Drinking water Siltation	Lack of irrigation Siltation
Environmental groups	Siltation Drinking water	Aqua biodiversity Lake Soil erosion

Source: ISET field visit 2011.

Upstream communities and their activities are mainly responsible for soil erosion and siltation in the lake while getting very limited benefits from it. Meanwhile downstream communities are getting benefits from the fisheries and the private sector is also making some profit from the tourism in the lake.

6.2 Local perceptions of climate change: now and the future

Local stakeholders have been observing that the climate is changing and that it has had some local impacts. In the focus group discussion, most participants commented that temperatures have been higher than before, rainfall has been decreasing, winter has been longer, and rains have been unpredictable and heavy. They think that due to these changes they are losing agricultural productivity and seeing an increasing numbers of landslides and siltation. Having these experiences, they think their livelihood will be more difficult after 30 years if there are no adaptation measures.

Table 5. Local perceptions of the situation after 30 years without any adaptation measures

Bishnu Maya Adhikari, 45, a farmer in Rupakot (upstream of the lake), shared her experience in a personal communication that she has been facing water scarcity in winter. Her agricultural productivity was 30 per cent higher in the past when the monsoon season was longer but the rainy and cold climate of the early winter this year meant her rice lost quality. Her urgent requirement is the construction of water storage facilities and a drinking water facility during the summer.

Gopal Gurung, a farmer near the lake, faced similar problems in the November rains. His rice became black due to the erratic rainfall and the prices of rice and hay are falling comparing other years due to the low quality.

Dipesh Kanta Adhikari, a tourism entrepreneur of Sundhare Danda, said he had to spend NRs1.25- 2.50 (US$1.5- 3) for a litre of water in winter as the wage for a labourer is NRs250 (US$3.15) per day, who can only bring 100-120 litre each. He operates a tourist hotel at his own house, built 30 years ago. At that time, water was available near his home even in winter but in the last few years it is not possible to get water near his home. He has to provide at least 100 litres of water per tourist to provide sufficient water for the toilet, bath and drinking and has no alternative to reduce the consumption (such as efficient appliances). Because he earns just NRs500 (US$6.25) per stay, half of his income goes on water provision alone.

Stakeholders	Downstream	Upstream
Community	Low productivity of agriculture, horticulture and livestock More landslides Lake and fisheries collapsed Lack of drinking water Reduction in number of tourists	Low productivity of agriculture Scarcity of grass and fodder for livestock Increased chance of landslide Water sources disappearing
Private sector	Decreased agricultural productivity More landslide and soil erosion Forced migration and no tourism Reduction of lake area and disappearance of indigenous fish species	Low agricultural production Loss of sources of drinking water Massive landslides Loss of lake and fish Population migration starts
Government agencies	Increase livelihood challenges Loss of production Food insecurity	More water stress Higher temperatures Increased landslide and erosion
Environmental group	Significant impact on the livelihoods of the poor New diseases will appear To little water for use but too much water causing flooding	Loss of biodiversity Lack of water Significant impact on the livelihoods of the poor

Step 1: Ranking proposed adaptions

6.3 List of adaptation options collected

During the field study, people shared their observations on water and climate which affect their livelihoods (see the list of people visited during field visits in Annex 3).

Table 6. List of adaptation options

Upstream	Downstream
Individuals (farmers, community organisations) Drinking water Rainwater collection ponds for irrigation Drinking water supply Building gabion check dams (a kind of retaining wall in the hillside to prevent landslides and control water flow)	Individuals (farmers, community organisations) Plantations upstream Terraces upstream Earth-fill dam to increase water volume (farmers whose land is not near the lake) lake water for irrigation Fisheries Proper management of development activities Terrace implementation Transportation Cleaning lake by building pipe to bypass siltation
Private sector Rainwater collection ponds	Private sector Bridge over the stream
Government agencies Rainwater harvesting for every household	Government agencies Earth fill dam construction
Environment agencies Horticulture Livelihood diversification Rainwater harvesting for every household	Environment agencies Biodiversity protection of the lake Planting vegetation

6.4 Options if the communities make the investment for adaptation themselves

During the shared learning dialogues, local stakeholders prepared a list of potential adaptations if the cost was to be borne by local stakeholders such as the community and local government. These options included;

- Building gabion check dams (a kind of upward retaining wall in the hillside to prevent landslides and control water flow).
- Proper management of development activities.
- Terrace implementation.
- Awareness raising of communities on erosion control and conservation of forested areas.
- Planting vegetation.
- Earth fill dam construction at one end of lake to increase water volume.
- Building a pipe to bypass siltation.

6.4.1 Prioritising and evaluating the top three strategies

During the SLD, participants also identified the top three strategies/activities for adaptation.

Table 7. Proposed adaptation options and their ranking (only top three)

Six criteria	Dam construction	Terrace improvement	Awareness raising
Technically feasible	1	3	3
Economically efficient	1	2	2
Politically correct	2	3	1.5
Socially acceptable	1	2	2
Legally permitted	1	3	3
Organisationally capable	1	3	3
Total	7	16	14.5

Ranking: 1=difficult; 3=easy. Source of ranking criteria: Based on Benson/Twigg, 2004 cited in Mechler *et al.,* 2008 and revised during the SLDs in consultation with stakeholders.

Selection: Terrace improvement to minimise siltation.

This is a scenario of selection of adaptation options assuming the cost of the adaption measures covered by local stakeholders themselves (without external funding). If the cost is shared by external actors, stakeholders had different adaptation options which were bigger scale and more expensive.

6.5 Adaptation options if cost shared by external actors

During the focus group discussions, upstream and downstream stakeholders identified the potential options based on their needs. The downstream community stakeholders were more interested in river control activities through building constricting gabion check dams in the Talbesi River. This would reduce siltation, and control river cutting while also protecting agricultural lands. The following table gives the top two options for each group of stakeholders (for the full list of options please see Annex 2)

Table 8. Adaptation options if cost shared by external actors

	Stakeholders	Top two options	Ranking (high=5 and low=1)			
			Environ-mentally	Economic-ally	Social/ culturally	Total
Upstream	Community	Gabion check dam in the river	5	4	3	12
		Terraces	5	2	3	10
	Private sector	Earth-fill dam[3]	5	4	4	13
		Control digging in upstream	4	3	2	9
	Government	Earth-fill dam	5	4	3	12
		Terraces	5	2	3	10
	Environmental groups	Earth-fill dam and bio-fencing in the border of the lake	5	4	3	12
		Gabion check dam in the river	5	3	3	11
Downstream	Community	Earth-fill dam	5	3	5	13
		Plantation	5	4	2	11
	Private sector	Earth-fill dam	5	5	4	14
		Plantation	5	3	3	11
	Government agencies	Earth-fill dam	5	3	5	13
		Plantation	5	4	2	11
	Environmental groups	Earth-fill dam	5	3	5	13
		Plantation	5	4	2	11

In the above table, communities and government agencies of both the upstream and downstream areas expressed their needs. The private sector's stakeholders are more

[3] Earth-fill dams/earthen dams are constructed as a simple embankment of well compacted earth. This dam is entirely constructed of one type of material but may contain a drain layer to collect seep water.

interested in the protection of the lake to expand their tourism business. Interestingly, environmental agencies also prioritised the conservation of the lake and the economic opportunities it brings. Therefore, they argued for the packages of interventions to address both the upstream and downstream communities' means of controlling siltation and the expansion of the lake through construing the earth fill dam. During the multi stakeholder meetings, the eight stakeholders group agreed on combining the earth-fill dam in the lake and gabion check dams in the river. These became the focus of the economic analysis.

7 Step 2: Financial analysis of adaption options

Identification of the monetary and non-monetary costs and benefits: technical analysis based on engineering tools and stakeholders.

7.1 Preferred adaptation options

If the cost of the project was to be shared by external actors, the stakeholders identified two activities as their preferred adaption options.
a) Construction of an earth-fill dam in the Rupa Lake (dam made by massive use of local material like stone and soil).
b) Gabion wire check dams in Talbesi Khola.

7.1.1 Salient features of the selected project

1. Location			
District	:	Kaski	
VDC/Municipality	:	Rupakot VDC / Lekhnath Municipality	
2. Adopted design criteria:			
2.1. Earth-fill dam			
Type of dam	:	Earth-fill dam	
Top width of dam	:	4.5 m	
U/S Slope	:	1.5:1	
D/S Slope	:	2:01	
Core width	:	2 m	
Bridge	:	Box type sluice Bridge	
Gate	:	Iron Gate for Irrigation water regulation	
Filter	:	Toe Filter	
2.2 Gabion check dams			
Gabion check dams in Talbesi Khola			
Number of gabion check dams		100	
Size of gabion check dams		60 M3	

Source: DDC Kaski (Unpublished Document) 2008.

Location of earth fill dam

Gabion check dam in 100 locations of Talbesi Khola

7.2 Cost benefit analysis of the two options individually

There are two major components to the project; constructing an earth-fill dam in the lakeside and constructing a check dam in the Talbesi River. In the CBA, the construction of the gabion check dam is more feasible economically compared to the earth-fill dam alone or along with gabion check dams. However, the CBA shows that all three components (gabion check dam, earth fill dam, and both) are acceptable. See the calculation table in Annex 5 for details.

The dam engineering survey and estimate was completed in 2008 by the technical team of the District Development Office with the special request from National Lake Conservation Committee. All of the costs were calculated based on the materials and labour rates decided by District Development Council(DDC) Kaski for the fiscal year 2011/12 (Annex 6, 7, 8, 9 and 10). Similarly, rates for equipment are based on Ministry of Physical Planning for the year of 2011/12 (Annex 11).

Table 9. Earth-fill dam cost

S. N.	Description of work	Unit	Quantity	Rate US$	Amount US$
1	Excavation for dam foundation in hard soil including removal and satisfactory disposal of all materials up to a lead of 50m along the lead route as per specification.	m^3	12,441.44	3.42	42,553
2	Construction of dam in embankments and miscellaneous backfilling areas with approved material in layer of 15 cm. Including spreading, sprinkling of water and compaction by labour, with initial lead of 50m as per specification	m^3	33,213.27	8.44	280,353
3	Construction of non-porous clay core with proper compaction	m^3	3250.02	5.63	18,281
4	Construction of toe-filter on downstream slope of the dam with graded material	m^3	1989.81	7.88	15,670
5	Construction and installation of iron gate with accessories for regulation of irrigation water	Job	1.00	12500	12,500
6	Construction of 20m span box-type sluice bridge	m^3	20.00	3750	75,000
7	Dry stone pitching (soling) work on upper slope of dam embankment with trimming and levelling of existing surface including collection and supply of rubble stone as per specification.	m^3	1591.85	22.93	36,498
8	Carrying out the construction operations of granular sub-base work with naturally found riverbed material including loading, unloading & transporting material, levelling surface with compaction by 8-10 ton roller all complete.				
8.1	On the top of dam	m^3	447.71	20.45	9157
8.2	Approach road	m^3	1350.00	20.45	27,611
9	Bio-engineering works with small civil structures (turfing, check dams, plantation, slope protection) around lake area	Job	1.00	18,750	18,750
10	Construction and improvement of approach road up to dam site	m^3	10,000	3.42	42,553
11	Environmental cost Land acquisition and productivity loss	Hectare	25.5		

USUS 1=NRs 80[4]

Source: DDC Kaski, 2064 (unpublished official document). Prepared for National Lake Conservation Committee to submit to the Ministry of Tourism.

[4] Exchange rate as per decided by Nepal Rastra Bank (Central Bank of Nepal) on March 16, 2012. http://nrb.org.np/fxmexchangerate1.php?YY=2012&MM=03&DD=16&B1=Go

Table 10. Gabion check dam

S. N.	Description of work	Unit	Quantity	Rate in US$	Amount US$
1	Gabion wire	m^3	6000	12.50	75,000
2	Labour for filling	Person day	6000	4.81	28,875
3	Stone	m^3	6000	0.63	3750

Source: DDC Kaski Rate list 2011 and discussion with local people.

7.3 Benefits of the earth-fill dam and gabion wire check dam

The first priority of the local community was the earth-fill dam, especially for stakeholders from downstream areas and surrounding the lake. They thought it would bring much economic activity particularly from fishing, irrigation and tourism. They have seen a similar type of dam constructed in Begnas Tal, the closest lake to Rupa Lake.

In the stakeholders consultation workshop 2012 (for details see Annex 5), participants listed the positional benefits from the earth-fill dam and gabion wire check dams e.g. increment in net profile by fisheries irrigation in downstream, local tourism, selling stone and sand from the rover and protection of local agricultural land in upstream over the next 30 years.

7.4 Cost and benefits of both projects with environment costs (in NPV)

All the cost items were calculated based on the technical survey of DDC Kaski, the district wage rate and the price list approved by DDC Kaski for the year 2011/12 and the procurement guidelines and rates issued by Ministry of Physical Planning, Government of Nepal. Costs not found in those documents were calculated based on stakeholders' estimations. To estimate the benefits, stakeholder's estimations and local market prices were used.

Nepal Rastra Bank, Nepal's central bank, estimated the discount rate at 6 per cent in December 2011 but normally infrastructure related projects use a discount rate of 8 per cent in general. Even using this discount rate either the whole project or the individual components would still be acceptable since the minimum IRR is 10 per cent. Transactional costs were calculated at 10 per cent of the project cost.

7.5 Summary sheet of the project

The following table shows that the incremental benefits from the project for the period of 30 years is around US$2,394,200US$ in net present value. Other opportunities for investment and their benefits are not calculated in the CBA process but it opens the new opportunities of investment and alternative options to the private sector.

Table 11. Summary of CBA

A. Cost items	NPV in USUS
A.1 Construction of 664 m earth-fill dam with materials	3,675,000
A.2 Construction of gabion Check dam in Talbesi Khola	114,312
A.3 Transaction Cost (10% of the total Cost)	378,925
Total cost of the project	4,168,237
B. Benefits	
B.1 Direct benefits	7,069,887
B.2 Loss in agricultural productivity due to the dam construction	509,650
Net benefit from the project in 30 years(B.1 – B.2)	6,562,437
Incremental benefit US$ (B-A)	2,394,200

7.6 Options analyses

During the study period, the different options (earth-fill only, gabion check dams only and both) were compared using the different discount rates.

Table 12. Comparison between different discount rates

(see Annex 5, Annex 12 and Annex 13 details cost calculation)

Comparative Analysis of Different Adaptation Options									
	Total cost in NPV (US$)		Total benefits in NPV (US$)		Net benefits in NPV (US$)		Cost-benefit Ratio		IRR
Discount rate→	6%	8%	6%	8%	6%	8%	6%	8%	
CBA of both (earth-fill dam and gabion check dam)	4168237	4158962	6298925	4988575	2130688	829625	1.57	1.25	10%
CBA of earth-fill dam only	5395650	5037987	6562438	5204850	1166788	166875	1.17	0.99	8%
CBA of gabion check dam only	125750	124350	266687	218125	140950	93775	2.12	1.75	16%

These scenarios were presented in the workshop after which the three options were discussed. Workshop participants identified the benefits and losses to the community and environment. The result was also shared in negotiation meetings.

Table 13. Comparative analyses of the project components: monetary and non-monetary costs and benefits

Project option	Costs/negatives	Benefits / positives
Construction of earth-fill dam only	- Environmentally unacceptable, (does not control the siltation and erosion) - High risk of disaster -Excludes the upstream community - High investment low return (lower CBA and IRR value) Issues of land acquisition	-Creates economic opportunity by increasing fish production, tourism and irrigation and agriculture
Construction of Talbesi gabion check dam only	- Long unresolved conflict among the upstream community about gabion check dam construction Socially not accepted and difficult to implement now	Economically acceptable (highest CBA and IRR) Environmentally acceptable
Construction of both earth-fill dam and Talbesi check dam	- Require comparatively huge resources - Loss of upstream agricultural land - High risk of disaster	- Creates economic opportunities and employment -high opportunity of tourism promotion - Economically viable -Protection of lake - Addresses both development and adaption -Socially acceptable due to the economic opportunity and employment -Could invite (interested) private sector companies to invest -Local community and government also interested in investing and implement -increases the productivity of both downstream and upstream agriculture.

Table 14. Environmental cost-benefit analysis

Option	Cost	Benefits
Gabion check dams only	Low	Reduced siltation
Earth-fill dam only	500 *ropani (25.5 hectare)* land lost due to water logging Additional investments needed for protecting of lake	
Both	Loss of 500 *ropani (25.5 hectare)* land due to water logging	Increased adaptive capacity and resilience Increased flow from lake may help downstream ecosystem

8 Step 3: Consensus building on options

Method: Shared Learning Dialogue.
Stakeholder evaluation of the two options: individually and combined.

8.1 Stakeholders' workshop

A stakeholders' workshop was organised in March 13, 2012, at the Wetland Academy to discuss these three options based on their social, economic and environmental impact. The workshop included representatives from the upstream and downstream communities, the private sector and government agencies including the executive officer of Lekhnath Municipality. The decision criteria were developed by the stakeholders themselves. Table 15 shows that constructing both (he earth-fill dam and the gabion check dam in Talbesi Khola ranked highest.

Table 15. Decision matrix

Project options	Gabion Check dam only	Earth-fill dam only	Both
Local demand	Low:2	High :4	Excellent : 5
Ecological contribution	Excellent: 5	Very low :1	Excellent :5
Land acquisition, resettlement	Low :2	Low : 2	High : 4
Monetary benefits	Excellent : 5	Medium : 3	High :4
Return to investment	Excellent : 5	Medium : 3	High :4
Livelihood diversification	Very low :1	High: 4	Excellent : 5
Capital requirement	Excellent 5	Medium :3	Medium: 3
Total score	25 points	20 points	30 points
Preference: Combined earth-fill dam and gabion check dam in Talbesi Khola			

8.2 Discussion and decision

Option 1: Construction of earth-fill dam only

- This option serves only to increase the water level and increase economic opportunities but scores poorly socially (due to land acquisition) and environmentally (as it doesn't control the siltation). According to the local government representatives, some donor agencies were interested in implementing this project if they found it economically socially and environmental viable. So the stakeholders' workshop did not reject the option outright but looked at wider options.

- Environmental issues might include higher siltation and the fact that the limit of adaption will be quickly reached, floods bigger and the high environmental cost.

Option 2: Construction of gabion check dam only

- This option is important in terms of the environmental benefits (controlling siltation) and economics (low cost and high return) but is difficult to implement due to conflict over land ownership among the local communities. The river changes course every year and some local people have been using the old route of the river for farming without any land ownership certificates. If gabion check dams were to be built in the river, some people would become landless, affecting their livelihood. In the stakeholders' workshop, some participants mentioned that Care Nepal, an INGO which has worked in this area for 12 years (1988-2000), had tried to implement a similar project but due to the social conflict, it was never implemented.
- Low environmental cost.
- Doesn't maximise economic opportunities but it would increase the resilience capacity of local people.

Option 3: Construction of earth-fill dam and gabion check dam

- In both consultation (stakeholder workshop and negotiation meeting), the participants agreed to accept this project even though it needs high investment. It addresses the issues of both communities and therefore it seems socially viable, economically acceptable and environmentally friendly. It protects the lake, increases economic opportunities and solves local conflict if it is implemented openly. Donors are also interested. Regarding the social issue, the stakeholders identified a solution to solve the social problem of land acquisition.
- If the project were to be implemented, the owners of nearly 500 ropani (nearly 25 hectares) of land upstream would need compensation. Similarly, this project would provide irrigation for some hundreds of ropani of government-owned land downstream. If the upstream farmers affected were provided land in compensation downstream (new irrigated public land), they would easily accept this option.. This option reduces the cost of project and resolves the conflict among upstream stakeholders.
- Most importantly the possibility of needing to increase the dam size later due to the deposition of soil in lake will be very low.

8.3 Investment decision

- There have been several attempts to construct gabion check dams upstream but they have never been implemented due to conflict among the stakeholders. After heated discussion in the negotiation meeting, the upstream community were willing to give up the land for gabion check dams and the earth-fill dam, provided they were given newly irrigated land from public land downstream in compensation by the government.

- This is the win-win situation for the stakeholders as it reduces the investment cost by reducing the compensation cost of land, creates economic opportunities and increases the resilience of the local community. For the environment, it promotes sustainable lake ecosystem management and helps to control soil erosion.

9 Step 4: Willingness to pay (WTP) analysis

Benefits from the project (stakeholders' perception).

Willingness to pay (WTP) analysis assesses stakeholders' actual behaviour and perception. As a result, it helps in negotiation among the stakeholders based on benefits distribution and contribution in the project. In climate adaptation, this also provide attitude of stakeholders on who have to be publish for climate change and in which level. In the other, it also helps to analysis the potential contribution from the stakeholders if the project implemented.

Methodology: Individual stakeholders group meetings followed by combined stakeholders groups discussion and discussion.

9.1 Perception of benefit sharing among different stakeholders

In the focus group discussion, different stakeholders expressed their perception of how the benefits of proposed adaption measures will be shared.

Table 15. Perception of benefit sharing among different stakeholders

Perception	Stakeholders	Monetary	Non-monetary
Community	Community	Irrigation of 2000 Ropani land downstream	Price increase of land Employment opportunities
	Government	Tax from tourism activities	
	Private		Recreational business opportunity
	Environment		Protection of lake
	Poor and vulnerable		New employment and labour market
Government agencies	Community	Livelihood improvement	Production of more fish
	Government		
	Private		Make more profit
	Environment		Protection of lake and soil
	Poor and vulnerable		
Private sector	Community	Employment and agricultural productivity	Increase the value of land Community development
	Government	Revenue	
	Private	Increased business by NR 10,000 per day	Expansion of tourism
	Environment		Conservation of lake and biodiversity
	Poor and vulnerable		Employment

Environment agencies	Community		Protection of their livelihood
	Government		
	Private		Make more business and profit
	Environment		Protection of lake, soil and biodiversity
	Poor and vulnerable		Employment

9.2 Benefit sharing scenario in monetary terms

Looking at the perception of benefit sharing among the stakeholders in monetary terms (Table 16), higher benefits go to the local community following the private sector.

Table 16: Benefit-sharing scenario in monetary terms

CBA of stakeholders in NPV USUS				
	Cost	**Benefits**	**Net benefits**	**Benefit sharing %**
Community	509,650	6,553,287.5	6,043,638	92
Local government	0	94,637.5	94,637.5	1.4
Private	0	421,962.5	421,962.5	6.43
Environment	nearly 25 hectares land will be waterlogged.	Proper conservation of lake		

9.3 Expectation and willingness to share costs

In the focal group discussion, each group shared their expectations of monetary and non-monetary contributions from the other stakeholders in percentage along with their own contribution. The following table shows each groups perception and expectation.

Table 17. Expectation and willingness to share costs

Perception	Stakeholders	Monetary	Non-monetary
Community proposal	community	Voluntarily according to capacity to pay; community 5% of total	20% of labour cost
	Local government	15%	
	National government	40%	
	Private sector	5%	
	International Community	40%	
Government agencies' proposal	Individual/ community	5%	Labour
	Local government	15%	
	National government	50%	
	Private sector	At least 20%	
	International Community	50%	
Private sector proposal	Individual/ community	Voluntarily according to capacity to pay	Labour contribution
	Local government	Budget allocation	
	National government	Budget allocation	Expenditures for tourism promotion
	Private sector	3%	
	Global	Lake is a global resources they should contribute significant amount	
Environment agencies' Proposal	Individual/ community	10%	
	Local government	10%	
	National government	10%	
	Private sector	10%	
	Global	60	

Stakeholders have different perceptions of who should pay and vary in their WTP for the project. Most of them think that climate change is happening due to international actions so they feel that international actors should contribute a higher share of the project, after government agencies. This translates into the following matrix of monetary costs for each stakeholder groups (Table 18).

Table 18. Matrix of who should pay

	Community	Private sector	Government	International community
Community	5%	5%	50%	40%
Private sector	10%	3%	36%	51%
Government agencies	5%	20%	25%	50%
Environment sector	10%	10%	20%	60%
Average %	7.5%	9.5%	32.8%	50.3%

9.4 Stakeholders' proposal for cost sharing

Table 19 averages the individual stakeholder groups' WTP, and the proportion they expected other stakeholders to contribute and translates them into monetary terms using the total monetary cost of the combined project.

Table 19. Stakeholders' proposal for cost sharing

	Community	Private sector	Government	International community
Average %	7.5%	9.5%	32.8%	50.3%
Total in USUS	312,612	395,987	1,365,100	2,094,538
Total project cost USUS				4,168,237

10 Analysis

10.1 Stakeholder participation and ownership

Climate change affects all people but the poor and vulnerable will suffer most due to their lack of capacity to adapt. This stakeholder-focused CBA considered all of the stakeholders, including the poor and vulnerable, analysing how and to what level they will be affected. This also provides an opportunity to understand the issue, analysing the potential options and measures, including costs and benefits, which is an important basis for informed decision-making and planning.

Linking with NAPA

The rise in temperatures is drying up the water sources of Rupa Lake. In addition, the lake is gradually turning into degraded area with swamp on the side. Sediments and nutrients are being deposited every year reducing the depth of the lake. The problem of eutrophication is severe and threatens the recharging of water sources. This situation is further aggravated by the impacts of climate change. Hence, immediate actions are needed to ameliorate the situation through the construction of a dam and a landscaping scheme around the lake.

Source: National adaptation programme of action (NAPA) to climate change. Ministry of Environment, Government of Nepal, Kathmandu, Nepal page 39.

The National Adaption Plan of Action (NAPA), the official plan to address climate change, has also covered the issue of Rupa Lake and made the case to build a dam to protect the lake (see box) although we found that the stakeholders in the Rupa Lake area knew nothing about this plan. Following this policy, last year the government conducted a detailed study of the dam and allocated some budget for it but when the political situation changed, the budget was transferred to another sector. The government interest in building the dam seems to be for hydropower generation too, making the dam is necessary to increase the capacity of the lake. This is a clear example of how an informed decision-making process helps in process and negotiation.

This assessment method is transparent and can be iteratively used for local-level decision-making on adaptation planning. It also can help with prioritising adaptation funding and can help meet distributional needs. It reflects local socio-economic and environmental dimensions for building adaptive capacity.

10.2 Facilitating stakeholder negotiation

SF-CBA also provided an opportunity to all the stakeholders to come into a negotiation meeting about the project implementation. Sharing the outcomes of the process in the meeting helped with the negotiation. This was only possible because stakeholders were involved in the whole process of option selection, and cost and benefit calculation. Table 20 shows the comparative table that demonstrates how the benefit to the local community compares to their costs against other stakeholders.

Table 20. Comparison of benefit and cost sharing

Direct benefit	Costs (based on willingness and expectations)
Community: 92%	Community: 7.5% -Labour, stone, awareness (in kind and labour contribution)
Private sector: 6.43%	Private sector: 9.5% -Making gabion check dam surrounding lake (calculated in earth-fill dam construction)
Local government: 1.4%	Government: 32.8% -Land acquisition and gabion construction and transaction costs
Environment: proper conservation of lake	International community: 50.2% -Contribution to earth-fill dam construction

10.3 New opportunities for development

This project not only provides measures for climate adaptation, it also provides the opportunity for new kinds of local development. There are several co-benefits of the adaptation measure which have not been considered in the CBA calculation process such as reduced deforestation, protection of the lake ecosystem and biodiversity, diversified livelihoods through the promotion of fishery ponds in private land etc. It also offers investment opportunities for the private sector such as developing small-scale hydropower, constructing viewing towers for tourism, promoting bungee jumping, and developing hotels. These measures will also facilitate green growth and will improve the resilience capacity of local community in the long term.

10.4 Issues to be addressed

There are still some issues that were not considered during the analysis and negotiation. Local government road expansion and construction upstream has often occurred without any environmental impact assessment or soil erosion control measures. These types of development activities are a popular demand of local communities but in the long run they affect the local ecosystem and increase soil erosion, landslides and siltation in lake.

The study process did not discuss the issue of equitable benefit sharing among local communities. How the benefits of the adaptation measures will reach to the most vulnerable and marginalised people within the community itself in an important issue. Addressing it needs a clear mechanism and further studies.

Considering local issues and local capacity, stakeholders would need to be involved in developing institutions and mechanisms for the implementation and operational management of the project.

10.5 11.5 Shared responsibility: divided interests

As the local community themselves have said, based on their experience, the major problems of climate change in the watershed area are soil erosion and siltation through its deposition in the lake. Heavy and erratic precipitation may accelerate the siltation process in the lake, particularly from degraded forests and pasturelands. Both communities, upstream and downstream, are agreed on their interest in conserving the lake, controlling soil erosion and implementing some measures such as vegetation planting through community forestry and user groups and co-operatives. But when discussing specific development projects at a personal or group level, they are interested in those projects which give direct benefits to them rather than the community as a whole.

Farmer groups in the downstream community with land on the shore of the lake demand proper compensation if their land is taken over by the government. They are not able to use this land properly due to the possibility of dam construction.

10.6 Communication with larger stakeholders and dissemination

A stakeholders' workshop was organised in the study site to share the outcomes which also facilitated cost and benefit sharing and negotiation for project implementation and trade-off among the different stakeholders. Similarly, a workshop was organised in Kathmandu to share the outcomes and methodology of stakeholder-based CBA among policymakers and the donor community.

11 Conclusion

Stakeholder-focused CBA can be used to contribute to effective and informed decision-making and bridge co-ordination gaps across agencies and stakeholders when designing climate adaptation measures. Traditional CBA alone can't resolve strong differences in value judgments and controversial issues such as the distribution of benefits and assessment of non-market impacts. The stakeholder-focused CBA process engages stakeholders to analyse the present and potential future climatic risks, potential adaptation measures and compare the costs and benefits of those measures.

Stakeholder-focused CBA also brings out stakeholders' perceptions of the benefits and their willingness to share costs. This informed decision-making process helps to bring the stakeholders into negotiation over effective implementation of projects. This method is useful not only for climate adaptation but for other development project which have serious issues of conflict and distribution. Identifying the stakeholders is a crucial part of this process, however. It is very important to incorporate vulnerable communities and ensure their active involvement. Indeed it defines the success and effectiveness of this method.

Time and scale of projects are important considerations when carrying out a stakeholder-focused CBA. A team of facilitators who are familiar with climate change and its adaptation are needed to conduct the individual interviews, focus group discussions, stakeholders' workshops and negotiation meetings. Stakeholders may present one thing in the workshop but share different interests in the groups and individual meetings. Therefore, it is important to investigate individuals' interests and community interests separately.

The main strength of stakeholder-focused-CBA is its explicit and rigorous accounting of gains and losses, monetary and non-monetary benefits, enabling transparent and informed decision-making. It can be part of the larger decision-making framework incorporating social, economic and environmental considerations in local-level planning.

12 References

Banjara B., Thapa, M. and Shrestha, S. 2011. *Lake Morphometry and Hydrological Modeling of Begnas Lake and Rupa Lake.* Watersheds Department of Civil and Geomatics Engineering, School of Engineering, Kathmandu University, Nepal.

Chambwera M. and Stage J. 2010. Climate change adaptation in developing countries: issues and perspectives for economic analysis. International Institute for Environment and Development (IIED). London. Available at http://pubs.iied.org/pdfs/15517IIED.pdf

Darwin, C. 1859. *On the Origin of the Species by Natural Selection*. John Murray, London.

Dasgupta, A.K. and Pearce, D.W. 1978. *Cost-Benefit Analysis: Theory and Practice*. Macmillan, London.

DDC (District Development Committee) 2008. Earth Fill Dam Survey Report 2008. Report prepared by the District Development Committee Kathamndu for the National Lake Conservation Committee (unpublished government document).

Gambarelli, G. and Goria, A. 2004. *Economic Evaluation of Climate Change Impacts and Adaptation in Italy*. Working Paper Series, Fondazione Eni Enrico Mattei, Milan, Italy.

IPCC (Intergovernmental Panel on Climate Change) 2007. *Climate Change 2007: Synthesis Report.* Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.

Juana, J.S., Strzepek, K.M., Kirsten, J.F. 2008. Households' welfare analyses of the impact of global change on water resources in South Africa. Agrekon 47: 309–326.

Kafle, G., *et al*. 2008. Status of and threats to waterbirds of Rupa Lake, Pokhara, Nepal. *Journal of Wetlands Ecology*. 1(1/2):9-12.

Koirala, Saroj, 2010. Land Use/Land Cover Change and Its Impact On Soil Erosion Process in Begnas Tal Rupa Tal Watershed Using Geospatial Tools, Kaski District, Nepal.Dissertation Submitted in Master Degree In Science In Geospacial Technology. ISEGI/ University of NOVA ,UJI, and IFGI http://run.unl.pt/bitstream/10362/2732/4/TGEO0030.pdf

Mechler, R. and the Risk to Resilience Study Team 2008. *The Cost-Benefit Analysis Methodology: From risk to resilience.* Working Paper No. 1, ISET-Nepal and ProVention, Kathmandu, Nepal.

Mendelsohn, Robert, and Ariel Dinar. 1999."Climate Change, Agriculture, and Developing Countries: Does Adaptation Matter?" The World Bank Research Observer. 14(2): 277-93.

MoE (Ministry of Environment) 2010. *National Adaptation Programme of Action (NAPA) to Climate Change*. Ministry of Environment, Government of Nepal, Kathmandu, Nepal.

Oli, K.P. 1996. Forests and Rivers. In *Environmental Study of Nepal's Begnas and Rupa Lakes* (p. 10). National Conservation Strategy Implementation Project, Kathmandu, Nepal.

Pachauri, R. 2002. Intergovernmental Panel on Climate Change (IPCC): keynote address. 26 August-4 September 2002. UN World Summit on Sustainable Development in Johannesburg, South Africa. *Environmental Science and Pollution Research*

International, *9*(6), 436-8. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12515354

Pant, D., Bhatta, B. and Shrestha P. 2007. *Multi-stakeholder Perspective in Catchment Management: Case from Nepal*. International Water Management Institute (IWMI-Nepal), Jawalakhel, NEPAL

PCC 2001. 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., Ding, Y., Griggs, D.J., Noguer, M., van der Linden, P.J., Dai, X., Maskell, K., Johnson, C.A. (eds). Cambridge University Press, Cambridge.

Poudel D. and D Buckles (2007). A History of Events and Actions that have Degraded or Protected Rupa Lake in the Pokhara Valley of Nepal. Social Analysis Systems2 1.0, http://sas-pm.com, Technique Report #5.

Pradhan, N., and Providoli, I. 2010. Valuing water and its ecological services in rural landscapes : A case study from Nepal. Mountain Forum Bulletin, January 2010.

Rai AK, BC Shrestha, PL Joshi, TB Gurung, M Nakanishi. 1995. Bathymetric maps of lakes Phewa, Begnas and Rupa in Pokhara Valley, Nepal. Memoirs Faculty of Science Kyoto University. 16 pRegmi, B.R., *et al.* 2009. Towards an innovative approach to integrated wetland management in Rupa Lake Area of Nepal. *Journal of Geography and Regional Planning*, Vol. 2(4), pp. 080-085. http://www.academicjournals.org/jgrp/PDF/PDF%202009/Apr/Regmi%20et%20al.pdf

Reid, H., Sahlén, L., Stage, J., MacGregor, J. 2008. Climate change impacts on Namibia's natural resources and economy. Climate Policy 8: 452–466.

Stage, J. 2010. Economic valuation of climate change adaptation in developing countries. *Annals of the New York Academy of Sciences*, *1185*, 150-63. doi:10.1111/j.1749-6632.2009.05168.x

Stern, Nicholas. 2007. *The Economics of Climate Change: The Stern Review.* Cambridge University Press, Cambridge, UK, available at http://webarchive.nationalarchives.gov.uk/+/http:/www.hm-treasury.gov.uk/sternreview_index.htm.

Strzepek, Kenneth and McCluskey, Alyssa, The Impacts of Climate Change on Regional Water Resources and Agriculture in Africa (July 1, 2007). World Bank Policy Research Working Paper No. 4290. Available at SSRN: http://ssrn.com/abstract=1004404

Thapa, Keshav and LIBIRD Team 2011. *Exploring Climate Adaptation Mechanisms for Watershed Management*, Climate Adaptation Design and Piloting Project, Nepal. 2011.

UKCIP 2003. Climate adaptation: Risk, uncertainty and decision-making. Willows, R.I., Connell, R.K. (eds). UKCIP Technical Report. UKCIP, Oxford, Available from: http://www.ukcip.org.uk/images/stories/Pub_pdfs/Risk.pdf

UNDP (United Nations Develoment Programme) 2011. *Economic Analysis of Local Government Investment in Rural Roads in Nepal*. UNDP, Kathmandu, Nepal.

UNDP 2005. Adaptation policy frameworks for climate change: Developing strategies, policies and measures. Lim, B., Spanger-Siegfried, E., Burton, I., Malone, E., Huq, S. (eds). Cambridge University Press, Cambridge and New York

World Bank 2010. The costs to developing countries of adapting to climate change: New methods and estimates. Consultation Draft. The Global Report of the Economics of Adaptation to Climate Change Study. World Bank

Yesuf, Mahmud and Bluffstone, Randall A., Poverty, Risk Aversion, and Path Dependence in Low-Income Countries: Experimental Evidence from Ethiopia (2009-01). American Journal of Agricultural Economics, Vol. 91, Issue 4, pp. 1022-1037, November 2009. Available at SSRN: http://ssrn.com/abstract=1483970 or http://dx.doi.org/10.1111/j.1467-8276.2009.01307.x

For related annexes see online version at http://www.iied.org/economics-climate-change-adaptation-water-sector