National Issues Report on Key Sector of Water and Glacial Lake Outburst Floods (Adaptation)

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List of Acronyms

ADB	Asian Development Bank
DHM	Department of Hydrology and Meteorology
DoI	Department of Irrigation
DWIDP	Department of Water Induced Disaster Prevention
DWSS	Department of Water Supply and Sewerage
GEF	Global Environmental Facilities
GLOF	Glacial Lake Outburst Flood
ICIMOD	International Centre for Integrated Mountain Development
IPCC	Intergovernmental Panel for Climate Change
KUKL	Kathmandu Upatyaka Khanepani Limited
MoEST	Ministry of Environment, Science and Technology
MOPE	Ministry of Population and Environment
MoWR	Ministry of Water Resources
NPC	National Planning Commission
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WECS	Water and Energy Commission Secretariat

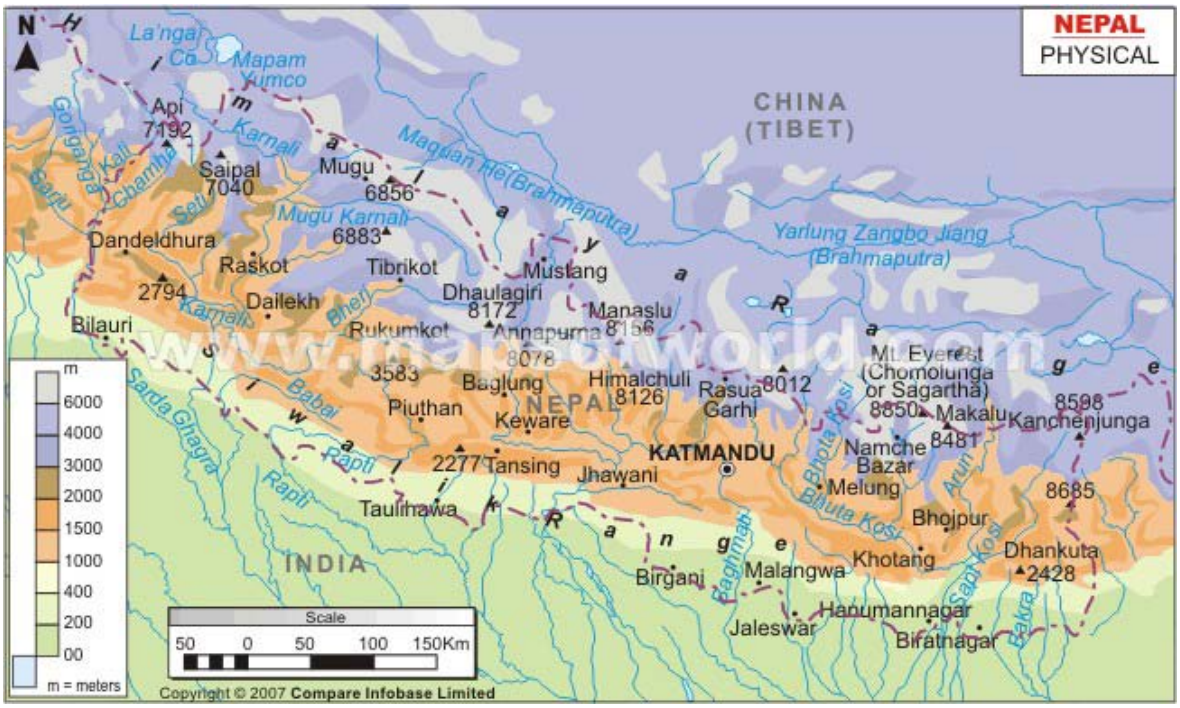
Why water, including GLOFs, is a key sector for the country?

Water resources play an important role in the overall development of Nepal. Nepal has a theoretical hydropower potential of about 83,000 MW. The source of livelihoods of majority of the population is agriculture. Both of these sectors are heavily dependent on water resources. In such a context, Nepal has very little alternative to water resources development for food security, people's livelihoods, industrial growth, environmental sustainability and by and large the economic prosperity of the country. However, owing to sharp altitudinal variation: 65 – 8848 m in 160 km (see Figure 1), uneven annual distribution of rainfall (75% in 4 months) make water sector of Nepal as one of the most vulnerable sectors; the impact of climate change has put an additional stress to it. Climate cycle and water cycle are closely linked, so that any change in one of these systems induces a change in another one. Climate change impact ranks high on water resources and hydropower of Nepal in terms of certainty, timing, severity and importance. [1]Observational records and climate projections have revealed that water resources are highly vulnerable to climate change with wide-ranging consequences on human societies and ecosystems.[2] Water related disasters such as floods, landslides; reduced low flows are all associated with climate change. Likewise, increasing temperature enhances the likelihoods of Glacial Lake Outburst Floods (GLOFs) in the Nepal Himalayas. Major infrastructure including fertile agriculture fields, as well as settlements and forests are located along the major river banks susceptible to floods including GLOFs. Potential GLOFs may damage lives, property and environment along the river valley hundreds of kilometres downstream from the GLOF source.

[1] Agrawala et al., 2003.

[2] IPCC, 2008.

Figure 1: Physical Map of Nepal



Source: http://www.mapsofworld.com/physical-map/nepal-physical-map.html

Nepal does not have any proven reserves of fossil fuels. A large portion of Nepal's foreign earning goes for the import of petroleum products. Therefore, development of hydropower is one of the potential options in order to reduce the dependency on imported fossil fuels and to save the foreign earning for other development works. Furthermore, because of the growing global concern of climate change, Nepal's hydropower sector could play a significant role in the emission trading as a source of clean energy. Nepal's electricity is predominantly a hydro-based and most of hydropower plants are the run-off-river types, which are generally designed for low flows.[3] Studies show that there will be decreasing low flows during non-monsoon seasons in the river as a result of climate change, which might have direct adverse impacts on Nepal's hydropower generation. Besides, Nepal's economy is largely dominated by subsistent agriculture, which in turn very much depends on availability of water for irrigation. Increasing temperature may result in decreased river flows on the one hand and increased irrigation water requirement on the other, which may adversely affect the agriculture production.

Predicted water stresses as a result of climate change will create additional conflicts within the society. Extreme events like floods and landslides will generate forced migration as well as adverse environmental impacts like loss of biodiversity. The water

[3] Chaulagain, 2007.

stresses will have greater burden on the poorer sections of the society living already under more vulnerable social and economic conditions. Climate change through its impact on water resources will bring additional stresses to the societies already having other social, economic and political stresses. Adaptation technologies being used so far in the water resources sector are mostly of conventional type such as open water storage ponds. Adoption of new technologies like sprinkler, drip irrigation system requires financial and skilled human resources as well as strong political will.

DESCRIPTION OF THE WATER SECTOR INCLUDING GLOFS

Nepal has more than 6000 major rivers, majority of them are fed by snow and glacier melts. Nepal's annual average rainfall is about 1700 mm, about 75% of which occurs during the summer monsoon season (June-September). Nepal has around 660 lakes of more than 1 hectare.[4] Groundwater remains an important source of water, particularly in the Terai and Kathmandu Valley.

Nepal has about 224 km³ of renewable water. The annual per capita water supply in 2001 was 9,600 m³ and whereas per capita annual withdrawal in the same year was 800 m³. Out of the total withdrawal, around 96% was in agriculture, 3.6% in domestic use and 0.3% in industry.[5] The amount of average dry season flow in Nepal is about 12 % of the annual total flow.[6] Out of the total available surface water 170 km³ (76%) is collected within Nepal and the rest from the catchment areas outside Nepal. Out of Nepal's total precipitation of 267 km³, about 10% is estimated as snowfall.[7] Similarly, about 3.5% of annual river runoff is contributed by the glacier melt.[8] About 70% of annual river discharge is contributed by the major rivers fed by snow and glacier melt and the rest by the rain-fed ones.[9] Nepal's groundwater, which is largely in Terai areas, is estimated to be about 12 km³.[10]

The Himalayan region is considered as the greatest source of global ocean-ward sediment flux. Since Nepal shares one of the wettest and steepest areas of the Himalayan region, it contributes significant sediment to the Gangetic plain and to the Bay of Bengal. As water is the main agent of erosion and sediment transport, the pattern of sediment transport is directly influenced by the pattern of changes in precipitation and runoff.[11] Increase in the intensity of rainfall generates floods of high magnitudes, enhances landslides and land degradation resulting in mass wasting and thus significant increase in sediment delivery rate of the basin.

In Nepal Himalayas, there are 3252 glaciers with a surface area of 5323 km² (which is about 3.7% of Nepal's total surface area) and an ice reserve of 481 km³.[12] Similarly, there are 2323 glacial lakes identified so far, out of which 20 are identified as the most dangerous ones with potential risks of GLOFs (ibid). Increasing temperature may result in the accelerated melting of snow and glaciers and reduction in the surface albedo

[4] Based on ADB/ICIMOD, 2006.
[5] Based on ADB/ICIMOD, 2006.
[6] Based on MOPE, 2004.
[7] Based on UNEP, 2001.
[8] Chaulagain, 2007.
[9] See WECS, 2005.
[10] ADB/ICIMOD, 2006.
[11] MOPE, 2004.
[12] Mool et al., 2001.

which may lead to more absorption of solar radiation.[13] Therefore, increased melting of snow and glaciers as a result of temperature rise may have amplified effect on warming. Furthermore, accelerated melting of glaciers in the Himalayas has resulted in creation of new glacial lakes and expansion of existing ones in the mountain valley of Nepal.[14] Increased temperature in the water body results in quality degradation of water leading to possible causes of water-borne diseases needing further studies to determine the extent of its influence.

As mentioned earlier, water resources sector is one of the most vulnerable sectors to climate change. Already a large gap exists between supply and demand on municipal water even during rainy season. There will be widening gaps between water demand and water availability due to climate change.[15] Increasing temperatures may lead to decreased glacier-ice reserve in the Nepal Himalayas, increased likelihoods of GLOFs and reduced soil moisture. Analysis of observed precipitation data in Nepal has revealed changed precipitation patterns i.e. decreasing number of annual rainy days, increasing number of extreme precipitation events and increasing days with higher precipitation amount[16], which intensifies the likelihoods of landslides, floods and droughts.

Proposed Adaptation Options for the Sector

In line with the Initial National Communication[17] National Capacity Needs Self Assessment (MoEST, 2008a) and Stocktaking Report for the Second National Communication (MoEST, 2008b), the followings are some of adaptation options (see Table 1):

Table 1: Proposed Adaptation Options and Responsible Agencies

Adaptation Options	Responsible Agency	Region	Duration
Water Resources Assessment	WECS	Nationwide	3 years
Establishment of operational water resources data base	WECS/ DHM	Central Level	Regular
Establishment of an optimal operational hydrological and meteorological observation network	DHM	Nationwide	3 years
Strengthening DHM on real time data monitoring	MoEST	Nationwide	2 years
Identification and regular monitoring of glaciers	DHM	Himalayan	3 years

[13] Ageta and Kadota, 1992.
[14] Mool et al, 2001.
[15] Chaulagain, 2007.
[16] Baidya et al., 2008.
[17] Based on MOPE, 2004.

and glacial lakes with potential GLOF risks		Region	
Establishment of Operational Early Warning System for floods and droughts including GLOFs	DHM	Major Rivers & Himalayan region	5 years
Preparation of Water Induced Disaster Preparedness Plans: • Flood hazard mapping including GLOF • Pre- and post-flood preparedness such as raising the plinth level of house, elevating hand-pumps, safety boat arrangement, food storage	MoWR/ DWIDP	Central Level	2 years
Revision of Engineering Design Parameters in the context of climate risk: • Hydraulic structures (hydropower plants, flood control structures, irrigation schemes, drinking water) • Demand and supply management	WECS	Central Level	3 years
Promotion of Indigenous Practices for Sustainable Water Resources Management : • Rehabilitation, improvement & construction of water storage ponds • Conservation of springs/spouts	WECS/ DoI	Nationwide	3 years
Regular maintenance of infrastructures related to water supply; better instrumentation, improvement and control of water leakages.	DWSS/ KUKL	Nationwide	3 years
River Bank Protection	MoWR/ DWIDP	Nationwide	5 years
Rain water and fog-water harvesting	MoWR/ WECS	Water stressed area	Regular
Enhancing public awareness on climate risks and adaptation options through: • workshops, seminars, • electronic and print materials	MOWR/ WECS/MoEST/ NPC	Nationwide	Regular

KEY ISSUES IN ASSESSING INVESTMENT AND FINANCIAL FLOWS TO ADDRESS CLIMATE CHANGE ADAPTATION IN THE SECTOR

Data Availability

There are very limited scientific studies on assessing investment and financial flows to address climate change adaptation in the sector. The methods and tools for this purpose are either poorly developed or not developed at all. There are very limited observed data in terms of data length, and geographical coverage regarding the impacts of climate change on water resources.

The quality of available data and information is generally not satisfactory. The methods and tools whatsoever available for quantifying climate change impacts are poorly developed, not adequately transparent and not very robust. Likewise, there is a poor coordination among the agencies, actors and organizations working in the different sub-sectors of water and at the different levels. Sharing of information is not very common.

Financial Constraints

Due to financial constraints, there are limitations on improving institutional and project implementation capacities. The policy makers and media people have not been adequately trained on this issue.

Political Instability and Policy Uncertainties

Nepal is currently under a crucial transition period from a constitutional monarchy to a federal republic leading to policy uncertainties and lingering bureaucratic processes.

PROPOSED APPROACHES / RECOMMENDATION FOR CONDUCTING THE ASSESSMENT OF INVESTMENT AND FINANCIAL FLOWS TO ADDRESS CLIMATE CHANGE ADAPTATION IN THE SECTOR

The following approaches for conducting the assessment of investment and financial flows have been proposed:

Institutional Setup

The approach should be made through different agencies in which Water and Energy Commission Secretariat (WECS) will work as a lead agency in assessing I&FF. The following arrangement has been proposed (see Table 2) for the assessment of I&FF:

Table 2: Proposed Institutional Set-up for I&FF

Agency	Responsibility/ Areas
Water and Energy Commission Secretariat	Overall coordination
Department of Electricity Development	Hydropower
Department of Irrigation	Irrigation
Department Hydrology and Meteorology	Regional climate modelling, hydrological and meteorological data, snow and glaciers including GLOF
Department of Water Supply and Sewerage	Drinking water and sanitation
Department of Water Induced Disaster Prevention	Floods, landslides, river control
Environment Division, Ministry of Environment, Science and Technology	Assessment of climate risks, UNFCCC/GEF coordination, international relationship and funding issues

Collection of Data and Information: Data and information in the water resources sector including snow and glaciers are to be collected.

Organization of Workshops and Seminars: Assessment existing adaptation options, level of public awareness and further required adaptive measures through workshops, seminars and interaction programmes coordinated by the Environment Division of the MoEST.

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