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## REDUCING CLIMATE CHANGE-INDUCED RISKS AND VULNERABILITIES FROM GLACIAL LAKE OUTBURST FLOODS IN THE PUNAKHA-WANGDI AND CHAMKHAR VALLEYS

<b>Country</b>	Bhutan [ <a href="http://www.adaptationlearning.net/country-profiles/bt">http://www.adaptationlearning.net/country-profiles/bt</a> ]
<b>Region</b>	Southern Asia
<b>Key Result Area</b>	Disaster Risk Management, Natural Resource Management, Water Resources <i>Keywords: Glacial Lake Outburst Flood (GLOF), Glaciers, Glacier Lakes, Flash Floods, Early Warning Systems (EWS), Lake Management, Disaster Preparedness</i>
<b>UNDP Project ID</b>	3722
<b>Project Activity Dates</b>	Start: Project Preparatory Phase (Jan-Dec 2007) End: Implementation Phase (2008-2012)
<b>Primary Partners</b>	Government of Bhutan: Department of Geology and Mines, Department of Disaster Management, Department of Energy, Gross National Happiness Commission, <i>Dzongkhag</i> (district level) administrations
<b>Donor Agencies</b>	United Nations Development Programme, GEF - Least Developed Countries Fund (LDCF), Austrian Development Agency, and World Wildlife Fund Bhutan

## ABSTRACT

Unprecedented glacier melting in the Bhutan Himalayas is posing imminent risks in the form of Glacial Lake Outburst Floods (GLOF). GLOF events can release millions of cubic meters of water and debris into narrow mountain valleys and thereby cause catastrophic loss of lives, livelihoods and critical infrastructure. The risks are mounting as water levels in several glacier lakes approach critical geostatic thresholds. In direct response this project is working to reduce climate change-induced GLOF risk in the Punakha-Wangdi and Chamkhar Valleys in Bhutan. The project is undertaking a controlled, artificial drainage effort at Lake Thorthomi, one of Bhutan's most dangerous glacier lakes. An early warning system is being established in the downstream Punakha-Wangdue valley. 21 hazard-prone communities are being trained in GLOF preparedness. The project is also integrating climate change-related risk management into Disaster Management legislation. The project has lowered Lake Thorthomi by more than 3.63 meters, averting a predicted GLOF event. 17 siren towers along the Punakha-Wangdue valley are providing GLOF early warning signals to 21 vulnerable communities. 67% of households in the target area of the project are aware of GLOF hazard zonation and evacuation routes. Findings from Bhutan are informing GLOF projects throughout the region. Key lessons learned from the project include recognizing the importance of involving stakeholders from different government departments to create appropriate adaptation measures and ensuring that there is on-going cooperation and consistent support between the stakeholders and the government.

## BRIEF DESCRIPTION OF ISSUES

### Background

Bhutan is a landlocked, mountainous country located in the Eastern Himalaya. Perpetual snow and glaciers cover 7.5 per cent of the country's territory. The entire northern mountain reaches are speckled with 677 glaciers and 2,674 glacial lakes. Of the range of hazards that Bhutan is vulnerable to, none is more significant than the formation of supra-glacial lakes due to the accelerated retreat of glaciers. Rising mean temperatures, attributed to climate change, are the main cause of glacial retreat and are correlated with faster rates of glacier melt, receding at a rate of 30-60 meters per decade. The melting ice from these receding glaciers is increasing the volume of water in glacial lakes, and the melting of ice-cored dams is destabilizing them, pushing the hazard risk for GLOFs to critical levels.

### Problem

With a majority of Bhutan's population, economic activities and infrastructure development concentrated in large river valleys, climate-induced GLOFs could cause colossal human and economic devastations. Furthermore, numerous hydropower projects – existing, under construction and planned – are located downstream in these sub-basins. GLOF events would, therefore, take a huge toll on hydropower investments and revenue. Other economic sectors, such as the agricultural sector, are also threatened by climate change-induced GLOFs which would have significant secondary impacts considering that agriculture in Bhutan provides livelihoods and employment to 79% of the population. The majority of the population practices subsistence farming with average land holdings ranging from 1-4 acres. This agricultural land is extremely vulnerable to flood impacts.

Two sub-basins in north central Bhutan — Punakha-Wangdi and Chamkhar valleys — represent the two most GLOF-vulnerable areas in the country. In these regions, people tend to settle in areas at high risk of GLOF— areas with steep slopes or flood-prone riverbeds. Approximately 10% of the Bhutanese population lives in these two valleys which accounts for about 8.1% of total agricultural land. Considering that only 7.8% of Bhutan's land area is suitable for farming, the risk of decreased agricultural output due to GLOFs is high.

While Bhutan has been able to respond to small-scale disasters in the past through informal institutional arrangements, meeting the challenges of climate change requires more robust mechanisms. There are three main barriers to effectively addressing the additional risks posed by GLOFs. 1. Disaster management policy: Stakeholders implementing the National Disaster Risk Management Framework (NDRMF) have not yet been able to fully project the dynamic, growing vulnerabilities from GLOFs and integrate these longer-term climate change considerations into their planning. Existing planning and management frameworks also need to be adjusted in light of new climate risks. 2. Disaster mitigation technology and practices: Support is necessary to demonstrate a specific model of vulnerability reduction through effective input/output management of glacier lake levels that can be replicated in other disaster-prone areas. 3. Disaster preparedness: Current flood Early Warning Systems (EWS) are not able to effectively manage the risks posed by rising water levels in glacier lakes, nor to trigger and deliver early warning messages to downstream areas at risk of GLOFs.

## BRIEF DESCRIPTION OF PROJECT

### *Solution: Adaptation Approach, Components and Description*

The main goal of the Reducing Climate Change-induced Risks and Vulnerabilities from Glacial Lake Outburst Floods in the Punakha-Wangdi and Chamkhar Valleys project is to enhance adaptive capacity in order to prevent climate change-induced GLOF disasters in Bhutan. With the main objective being to reduce GLOF risks in the Punakha-Wangdi and Chamkhar Valleys. In doing so, the project aims to support the Royal Government of Bhutan to integrate long-term climate change-induced risk reduction planning and management into the existing disaster management framework and practices.

Addressing urgent priorities from Bhutan's NAPA formulated in 2006, this project integrates climate risk projections into existing Disaster Risk Management (DRM) practices and implements corresponding capacity development measures at the national, district, and community levels. To meet its objective, the project aims to demonstrate a practical approach to reduce GLOF risks from Thorthormi Glacier Lake, one of Bhutan's most dangerous glacier lakes with a worst-case-scenario outburst projection as early as 2010. The project also seeks to ensure that the existing Early Warning System (EWS) in the Punakha-Wangdi Valley, which is not currently equipped to handle the full extent of GLOF risks, is upgraded to take sufficient account of this growing risk of climate change-induced GLOFs in the area. Lessons learned from this initiative will enable improvement of EWS in other areas vulnerable to GLOFs.

## SUCCESSFUL PRACTICES

<b>Key Successes</b>	The project has lowered Lake Thorthomi by 3.63 meters (72 % of the overall target of 5 meters), to decrease the hydro-static pressure on the thinning moraine dam and thereby avoiding the earlier prediction of a GLOF event as early as 2010.
<b>What Factors Supported Success</b>	Facing challenges related to a harsh, high-altitude working environment above 4,200 m. the multi-disciplinary team responsible for planning and carrying out the artificial lowering has established a strong partnership between various government agencies (Department of Geology and Mines, Ministry of Health, Departments of Forest and Park Services, and Department of Roads), the Royal Bhutan Army and district authorities. This partnership contributes not only to the national capacity building in artificial drainage design but also to effective planning, conduct and monitoring of the workforce as well as with regard to environmental, health and safety aspects
<b>Relevant Information</b>	At the national level, 41 technical professionals are actively involved in GLOF preparedness and mitigation including Early Warning Systems (8 from Department of Disaster Management, 15 from Department of Energy and 18 from Department of Geology and Mines).
<b>Key Successes</b>	One of the key successes of the project is the progress made in raising awareness on GLOF risks and building capacities in the vulnerable areas on disaster management and disaster risk reduction in particular to GLOF. In order to strengthen the community preparedness, more than 500 officials and community-representatives were trained in Community Based Disaster Management Plans at district, sub-district and village-levels since the beginning of the project.
<b>What Factors Supported Success</b>	Strong outreach, solid collaboration, and media savvy knowledge products have helped raise awareness. For example high quality TV-productions, such as the Discovery Channel's "Himalayan Meltdown" and UNDP Bhutan's feature in "One Day on Earth", have presented the project and risk related GLOF to a wider audience both at the national and international levels.
<b>Relevant Information</b>	Formulation of Community Based Disaster Management Plans were started and completed at 40 out of 55 Chiwogs (cluster of villages) in Punakha, 40 out of 75 Chiwogs in Wangdue, and 20 Chiwogs out of 20 in Bumthang.  A Qualitative Based Survey (QBS) was conducted between April-July 2011 to assess the project's impact on awareness- and capacity-levels related to climate change-induced disasters. At the local level, according to the survey, 39% of community members interviewed feel that they are better prepared to respond to GLOF threats than before the project.

# PROJECT CHALLENGES AND SOLUTIONS

## Major Challenges

The main barrier encountered relates to the health and safety risks of the remote project site at Thorthormi Lake. Project activities pertaining to the artificial lowering of the water level of Thorthormi Lake entail environmental and health risks due to high altitude, harsh climate, difficult accessibility, and fragile terrain. Despite preventive measures such as medical screening and briefing on altitude sickness and other health risks, as well as the presence of medical staff during the trek and at the work site, there have been three casualties (all in the 2010 working season), two of which were related to altitude sickness. The medical as well as police reports certify that there has been no fault on the part of the project, and that these casualties are related to a confluence of factors in extreme environmental conditions. The project management and UNDP initiated an independent review to examine the fatal incidents. Following this review, health and safety aspects of the project have been enhanced. Additional safety measures, such as mandatory acclimatization stopovers including consultation with the project doctor for workers along the route to Thorthormi Lake and purchase of inflatable high-altitude pressure bag used by trekkers and mountaineers in the event of altitude sickness, have been identified and incorporated into the project.

Another barrier of the project is in the area of documentation and reporting of the technical/programmatic aspects of the project. This is a major concern, particularly with respect to capacity development, which involves change in knowledge, skills, attitude, and behavior. Without good documentation of the progressive results, lessons and issues, assessment of these non-physical project products become even more difficult. In addition, most of the media and communication products related to the project pertain to the artificial lowering of Thorthormi Lake rather than capacity development. Reporting mechanisms from the district and community-levels to better assess non-physical changes based on the progressive results, lessons and issues, therefore, need to be monitored closely.

## LESSONS LEARNED

### Results and Learning

At the policy level, the project has enabled the formulation of a Disaster Management Bill (DM Bill) for Bhutan and the completion of GLOF hazard zoning, identifying high-risk zone and evacuation sites, of the Punakha-Wangdi and Chamkhar valleys. The DM Bill drafted in 2008 was reviewed and revised in 2011 by international experts and stakeholders and is expected to be deliberated at the next Parliamentary session, scheduled to take place in January 2012, for ratification during the summer session 2012. A government circular for GLOF-resilient land use planning, based on the GLOF hazard zoning, has been disseminated to the local authorities of Punakha, Wangdi and Bumthang. This represents a significant policy-level outcome of the project, as it restricts new construction in the high-risk zone.

In terms of capacity development, the project has established District Disaster Management Committees, District Disaster Management Awareness and Planning Teams, and Gewog (sub-district) Disaster Management Committees in all three districts covered by the project area. The project has trained these committees in Community-Based Disaster Risk Management and GLOF risk management, and the bottom-up disaster management planning process at district, sub-district and village level has started.

GLOF and Flood awareness has been promoted through the national newspapers and broadcasting services. This includes the development and dissemination of a hazard awareness map and publishing of an Emergency safety and First Aid handbook. A number of media and advocacy materials have also provided insights and knowledge on the issues and challenges associated with the artificial lowering of Thorthormi Lake and reduction of GLOF risks and vulnerabilities (e.g. WWF Publication "The Cost of Climate Change: The story of Thorthormi Lake"). These materials have immense promotional value and potential to generate global interest and resources to support similar activities in the future.

Making progress toward risk reduction from one of Bhutan's most dangerous Glacier Lakes (Lake Thorthormi), the project has successfully lowered the Thorthormi Lake level by 3.63 meters in total, including 1.4 metres level reduction achieved in the 2011 field season. The mitigation work has moreover generated valuable experience in artificial drainage design and monitoring, and also provided income to more than 300 people.

An interim manually operated Early Warning System is operational based on focal persons equipped with mobile phones in 21 particular vulnerable communities downstream along the Punatsangchu river in the Punakha-Wangdue valley. The project has demonstrated its abilities for adaptive management by mobilizing additional government partners (Department of Energy) and co-financing for the up-scaling of a GLOF Early Warning system (EWS). As a result, an automated EWS can now be established at a more comprehensive scale than earlier targeted under the project. The project team has finalized the installation of the automatic Early Warning System in the 21 vulnerable communities, and the 17 siren towers, 4 automatic water levels sensors and 2 automatic weather sensors in the lower valley) and a control station in Wangdue are operating.

## **Mainstreaming Components**

This project is highly relevant in the overall development context. It supports the overarching Bhutanese development philosophy of Gross National Happiness (GNH) and specifically contributes to the main GNH objectives of sustainable socio-economic development and environmental conservation. The project mainstreams climate change adaptation through the following approaches:

UN programming in Bhutan creates the political traction needed to keep climate related considerations firmly integrated in national development policy and programmes. In line with the United Nations Development Assistance Framework (UNDAF), the project directly supports UNDAF Outcome 5 outlined in the Common Country Action Plan (2008-2013) agreed between the United Nations System and the Royal Government of Bhutan. As stated in the UNDAF: "The UN will focus on supporting capacity strengthening of key government agencies to implement a disaster management framework, mainstream disaster/climate risk reduction into plans and policies and to strengthen national and local capacity for disaster preparedness and response systems." The United Nations Common Country Assessment (CCA) operationalizes this strategy and addresses Bhutan's need to systematically build national capacity in climate risk reduction.

The project will help the government integrate GLOF risk into the National Disaster Risk Management Framework (NDRMF), a comprehensive strategy for disaster management which was developed in 2006 with assistance from the UNDP Bureau for Crisis Prevention and Recovery, and has been instrumental in highlighting climate-related risks and integrating them into Bhutan's UNDAF. Finally, the project will also contribute to achieving the Millennium Development Goals (MDGs) by reducing the vulnerability of the poor and ensuring environmental sustainability.

## **Sustainability**

The sustainability of the project interventions can be considered high. The project has relied on existing institutional arrangements and human resources for project implementation. In-country technical capacity developed through earlier GLOF field activities has been used profusely and further reinforced through experiential learning as a result of direct engagement of a Bhutanese team in the technical studies, planning, supervision and implementation of activities. The integration of capacity development component to complement the hard components, namely the artificial lowering of Thorthormi Lake and establishment of GLOF-EWS, also suggests that at the end of the project there will be improved capacity in terms of legislation, policy, guidelines, trained personnel, and better public awareness to continue with various interventions after the conclusion of the project.

The training and awareness programmes on CBDRM are aimed inter alia at enabling local authorities and communities to develop dzongkhag- and gewog-level disaster management plans. The intent is to eventually mainstream the activities outlined in these management plans into the overall dzongkhag and gewog development plans and programmes. This approach is expected to enable the local authorities to internalize and continue project-supported activities as a part of regular government programme after project completion.

A key deliverable of the project is the Disaster Management Act, which will, when ratified, provide legitimacy to the Dzongkhag Disaster Management Committees and Gewog Disaster Management Committee that the project has helped set up in Punakha, Wangdue and Bumthang, and strengthened through training and awareness programmes. Furthermore, the legislation will provide for appointment of Dzongkhag Disaster Management Officers on a full-time basis to facilitate and assist the implementation of disaster management plans and activities at the Dzongkhag level.

Adaptive engagement of other stakeholders during the course of project implementation, for instance the inclusion of the Dzongdags of Punakha, Wangdue and Gasa Dzongkhags in the Project Board and the mobilization of additional funds from the Punatsangchu Hydropower Plant authority for the GLOF-EWS, is expected to have enhanced local ownership and commitment for the sustainability of project interventions.

## **Replicability**

The project has considerable demonstration value and replicability. This is especially true as the project is the first of its kind in the world and because similar GLOF risks are present in other parts of the country as well as in many other countries with comparable geophysical conditions. Notably, experiences from Bhutan's project have fed into the design of GLOF projects in Pakistan (Adaptation Fund) and Nepal (Global Environment Facility – Least Developed Countries Fund).

With the exception of financing, the project has been almost entirely implemented through the use of national technical and human resources, and within the existing institutional set-up of development governance. The experiential knowledge and skills accrued from the project have built the confidence and capacity of the Bhutanese to plan and implement similar projects in other areas that face similar GLOF challenges. These areas include Mangde Chhu sub-basin; Mo Chhu sub-basin; Chamkhar Chhu sub-basin; and Kuri Chhu

sub-basin.

The project is also replicable in a number of other countries especially in the Himalayan region given the existence of a high number of potentially dangerous glacial lakes in these countries with geophysical conditions similar to Bhutan. In addition to the 24 potentially dangerous lakes in Bhutan, the Report 'Formation of Glacial Lakes in the Hindu Kush-Himalayas and GLOF Risk Assessment' produced by the International Centre for Integrated Mountain Development in May 2010 has compiled a list of 179 potentially dangerous glacial lakes in various parts of China, India, Nepal, and Pakistan.

## Funding

GEF (LDCF): US\$3,445,050  
Co-financing: US\$3906,224  
TOTAL: US\$7,351,274

## Time Frame

2008-2012

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Previously Updated: September 2010

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