Technical Review and Social Impact Assessment

Reducing Climate Change-induced Risks and Vulnerabilities from Glacial Lake Outburst Floods in the Punakha, Wangdue and Chamkhar Valleys

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Acronyms

ACO	Austrian Development Coordination Office
ADB	Asian Development Bank
ALM	Adaptation Learning Mechanism
AWLS	Automatic Water Level Sensor
AWS	Automated Weather Station
CBA	Cost-Benefit Analysis
CB-DRM	Community Based Disaster Risk Management
CBDMP	Community Based Disaster Management Plan
CDMC	*Chiwog* Disaster Management Committee
DCP	Data Collection Platform
DDM	Department of Disaster Management
DDMC	*Dzongkhag* Disaster Management Committee
DGM	Department of Geology and Mines
DHMS	Department of Hydro-met Services
DM Bill	Disaster Management Bill
DoE	Department of Energy
DoR	Department of Roads
EIA	Environmental Impact Assessment
ELOS	Extended Line Of Sight
EOC	Emergency Operation Center
EWS	Early Warning System
FP	Focal Person/Point
FYP	Five Year Plan
GAO	*Gewog* Administrative Officer
GDMC	*Gewog* Disaster Management Committee
GEF	Global Environment Facility
GLOF	Glacial Lake Outburst Flood
HF	High-Frequency
HH	Household
JICA	Japan International Cooperation Agency
JDNP	Jigme Dorji National Park
JST	Japan Science and Technology Agency
LDCF	Least Developed Countries Fund
LLM	Left Lateral Moraine
MoAFPS	Ministry of Agriculture and Forestry
MoEA	Ministry of Economic Affairs
MoHCA	Ministry of Home and Cultural Affairs
MTR	Mid-Term Review
NAPA	National Adaptation Programme of Action
NCDM	National Commission for Disaster Management
NDRMF	National Disaster Risk Management Framework
NEC	National Environment Commission
NGO	Non-Governmental Organization
OHS	Occupational Safety and Health
PHPA	Punatsangchu Hydro Power Authority
RBA	Royal Bhutan Army
RGoB	Royal Government of Bhutan
SIA	Social Impact Assessment
SL	Subsidiary Lake

SOP	Standard Operation Procedures
TA/DA	Travel Allowance/Daily Allowance
ToR	Terms of Reference
TSAT	Technical Support Advisory Team
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
WWF	World Wide Fund for Nature

Figure 1 *The main source area of Thorthormi glacier on the south slope of Singye Kang or Table mountain*

Glossary of Dzongkha Terms

Chhu	River
Chiwog	A village or a combination of villages depending on the area and population
Chorten	Stupa
Dushing	Protection forest
Dzong	Fortress, which usually functions s as the district headquarters for public administration as well as for monastic affairs
Dzongda	District Administrator
Dzongrab	Deputy District Administrator
Dzongkha	Bhutan's national language
Dzongkhag	District
Gewog	Smallest geographic unit of public administration made up of many
Gup	Head of a *gewog*, elected by the local community
Mangmi	Deputy Gup
Tsho	Lake

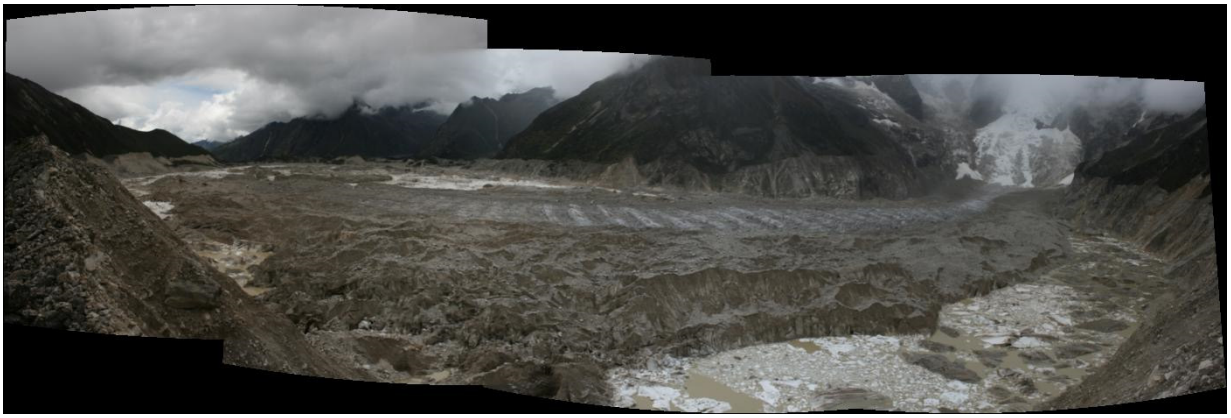

Figure 2 *Panoramic overview of Thorthormi Glacier from the left lateral moraine. Note the outspoken wave pattern in the central part of the glacier and the intense calving into the lake on the right hand side of the picture.*

Figure 3 *Overview map of the project area in Gasa, Punakha, Wangdue and Bumthang Dzongkhags. Lunana is indicated in red and Pho Chhu and Putsangchu are indicated in blue. Source: DGM (2007)*

Acknowledgements

The technical review and social impact assessment of the GLOF mitigation project was an extraordinary assignment. It was out of the ordinary, as it required the review team to trek for 24 days- to be able to visit Lunana and Thorthormi Lake, other glacier in the direct surroundings, and to have the opportunity to meet the multi-disciplinary team, the labourers and local communities.

The team thanks UNDP Bhutan for the trust shown and the extensive logistical support received. The technical guidance by Karma Lodey Rapten and the smooth support by Tshering Palden and Sonam Rabgye facilitated the work of the team greatly and enabled the team to focus on the review without logistical constraints.

The Project Management, represented by the Project Director, Sonam Yangley, and the three project managers, has been extremely cooperative and supportive, by providing clear and frank guidance and feedback. Karma Dupchu, project manager for the Department of Hydromet Services (DHMS) and Chencho Tshering, project manager for the Department of Disaster Management (DDM), accompanied the review team during the stakeholder consultations and field visits in Wangdue and Punakha *Dzongkhags*, with a focus on the Early Warning System (EWS) and the Community Based Disaster Risk Management (CB-DRM) component. Their views, suggestions and guidance were of great help and their support was essential.

In the field, the team had the opportunity to meet the *Dzongkhag* administration teams in Wangdue, Punakha and Gasa. Their comments, feedback and views shared were of great value to build our understanding of lessons learned and key experiences. We thank them all for their kind contribution and support. The same appreciation goes out to the communities and *geog* administration staff the team was able to meet in Wangdue, Punakha and Gasa *Dzongkhags*. Meetings with school faculties and with the faculty of the Vocational Training Institute in Kuruthang helped the team to build their understanding of the CB-DRM approach. The staff of the Punatsangchu Hydropower Project Authority is thanked for the very frank and open discussion on their involvement with the project and their concern with regards to potential GLOF impact.

Dowchu Drukpa, project manager for DGM, took the effort and time to accompany the review team on our trek from Gasa to Lunana and back. His support, guidance and information, and great companionship, have made our 24 day trek a memorable undertaking. The trekking crew of Adventure Bhutan Travel of Pema Wangchuk, headed by Tenzin as guide, provided excellent support during the trek and our stay in Lunana. Their professional care has contributed to an efficient and safe mission.

We thank all the members of the multi-disciplinary team, headed by Karma Toeb, and the RBA team, headed by Major Sonam Tshering, for their hospitality and invaluable feedback and insights. The Project Board members gave guidance and opinions during short stakeholder consultations prior to the field mission and provided constructive and essential feedback during the debriefing presentation after the field work, the team has tried to infuse in this report.

Finally, the review team is highly indebted to the constructive feedback received from the project managers and Karma Lodey Rapten in particular, which has contributed considerably to enhance a draft version of this report.

Dil Maya Rai, Hans van Noord November 29 2012

Executive Summary

The purpose of the review was to examine and document technical and social lessons and impact of the project since the beginning of its implementation from 2008 till date, in order to extract best practices and formulate recommendations for an exit strategy which increases sustainability and enables scaling-up and replication of the project and its approach. The scope of the review focused on capturing knowledge built within the project, documenting best practices and extracting key learning from implementing a complex and challenging project in a difficult environmental setting.

Special emphasis of the technical review is on the methods applied for the artificial lowering of Thorthomi lake (outcome 2) and the installation of a GLOF Early Warning System (outcome 3). Additional attention was given to the development and implementation of a community based disaster risk management planning (CB-DRM) approach (outcome 1) and the documentation and dissemination of lessons learned (outcome 4).

The review's focus was on learning and documentation and therefore relied heavily on the feedback, comments and experiences of all stakeholders involved, at national, district and local level. A concise desktop review phase with a literature review was followed by a stakeholder consultation round at national and district level. Further consultations were carried out at community level with municipality level (*gewog*) staff and community members. Additionally, school representatives were met and other stakeholders, such as those responsible for hydropower development. An extensive field visit to the remote Lunana area enabled the review team to consult the multi-disciplinary team members involved with the lake mitigation work at Thorthormi Lake site and the labour force and communities involved. To facilitate the consultative meetings at decentralized level, questionnaire formats were prepared with a series of questions related to experience with GLOF, expectations and impact of Project, hazard zonation and implications, the EWS and CB-DRM training and awareness, and finally key lessons and suggestions for recommendations aligned to sustainability and replication.

After return from the field, the observations and meetings were worked out as key information for the report. A debriefing presentation was held for the Project Board on October 4th, 2012. Comments, feedback and suggestions by the Project Board members incorporated in the report.

Artificial Lowering of Thorthormi Lake (Outcome 2)
Based on extensive scientific research of the glaciers and glacial lakes in the Lunana area and their inherent Glacial Lake Outburst Flood (GLOF) hazard a comprehensive site investigation was carried out to weigh mitigation options and to come to a detailed engineering plan for excavation work to lower Thorthormi Lake. A conscious decision was taken to lower the existent spillover channel with a labour-based approach, involving the multi-year recruitment of over 300 workers per year in a very remote location at 10 days walk from road head, in contrast to a more high-tech approach, which would require extensive use of helicopter services.

Clearing and breaking of large boulders required a lot of effort and slowed down the excavation process considerably. The use of drilling machines and silent explosives proved successful, but procurement issues and reliability limited their effectiveness. During the excavation work in the 2012 season, ice lenses were encountered in the immediate inlet zone of the channel. This hampered the excavation works, was difficult for the labourers (safety concerns) and ultimately caused concern for the stability of the immediate surroundings of such ice lenses. In a broader context, ice cores along the Rapstreng-Thorthtormi moraine are of serious concern. At surface, active collapse structures can be observed and there is very active mass wasting on either side of the moraine ridge, resulting in the thinning of the moraine. The on-going monitoring of this fragile section of the terminal moraine is critical.

It appeared to be complicated to create dry working conditions along the outlet channel making only use of sand bags, tarpaulin sheets and boulders. This has resulted in the necessity for the labourers to stand in at least knee-high, and often hip-high streaming water of just a couple of degrees. These are sub-optimal working conditions and this has created very unfavourable working conditions. It has seriously affected the output of the labour force, and ultimately, affected overall progress.

Despite the very adverse site conditions and many logistical challenges the lowering target of 5m was achieved at the end of the 2012 season. The lowering was reached in gradual steps, spread over 4 years. The gradual lowering is essential to limit the inducement of any slope failure of the moraine slopes bordering the lake shore.

An Environmental Impact Assessment (EIA) was carried out to identify possible negative impacts of project interventions and a mitigation plan was compiled to reduce the negative impact, while weighing alternative options. It is noted that the EIA was compiled by the project team itself and not by an independent authority.

The project made use of a multi-disciplinary team with representatives, with well-defined tasks, of all key stakeholders. The management of a large work force, with over 300 persons in the first 2 years, proved to be a serious challenge. Apart from the logistical challenges of supplying such a large group in a very remote location, occupational safety and health issues and medical care at high altitude, the most difficult challenge were related to law and order and discipline. Recruitment became a problem in the last two years of the project as the daily wage, which initially was found to be attractive, was perceived to be just sufficient. During the last year of field work (2012) personnel of the Royal Bhutan Army (RBA) assisted the project in reaching its set target.

Apart from the technical challenges of a GLOF mitigation project at high altitude, the project had to face a set of serious logistical challenges to be able to get all the necessary resources and materials from road head to project site and back. Over 1500 horse loads a year were needed to transport 70 to 80 tonnes of equipment, supplies and food. A number of additional challenges complicated logistical matters even further, amongst which the tropical Cyclone Aila in May 2009, late snow in 2011 and a flash flood in June 2012 washing out parts of the Gasa access road.

In 2010 three work force members died due to Acute Mountain Sickness (AMS) and the project reviewed it’s medical management system through an independent study. The recommendations made by this assessment were incorporated and have become standing procedure:

- an extensive medical screening for all work force and team members,
- medical transit camps en route to Lunana and back, with obligatory stop-overs to check for any signs of AMS symptoms, and
- a targeted training of the medical staff in High Altitude Medicine and Remote Emergency Care.
- The medical team provides important medical services to the local communities.

Direct benefits of the project are through daily wages, personal gear as rain jackets and sleeping bags and payment to horsemen for ferrying goods and supplies. Indirect benefits are related to an increased ease of mind with the achieved risk reduction, and additional services to the local communities.

The assessment of the artificial lowering is completed with an overview of a series of key findings, best practices and a number of recommendations, of which the most essential ones are presented at the end of this Executive Summary.

Review of the Early Warning System (EWS) (Outcome 3)
Design and specifications of the desired GLOF EWS had to be taken up by DHMS staff and turned out to be rather complicated. As one cannot purchase such a system off the shelf, the compilation of the bidding documents for the procurement of the hard- and software of the EWS were complicated tasks. Ultimately, it was decided to procure turn-key system with a 3-year warranty (subject to fund availability), which is important to avail technical support and guidance when the system was going through its “infancy”, with usual “teething problems”. This can be regarded as a “best practice” to replicate for future system development, if scaling-up or replication is considered to other river basins. Initially, the supplier provided training on testing and installation of the equipment, but in the upper region system elements were installed independently by DHMS staff, in collaboration with a local contractor.

In total there are 17 siren stations and six hydro-met monitoring stations, of which four check water levels (AWLS) and two monitor both water levels and meteorological parameters (AWS). The system is divided into two geographical areas: the upper sites near the glacial lakes in Lunana, and the lower sites in the Punakha-Wangdue valley, where the majority of the population lives (Tagg, 2010). It was preferred to make use of satellite communication. This ensures a reliable communication platform, not perturbed by atmospheric problems and without the need for repeater stations for extended line of sight (ELOS) communication, taking into account the considerable distance between the upper region and the lower regions and the EWS control room in particular (over 100km).The existing flood warning system functions as a back-up system and was already equipped with satellite phones.

The EWS installation is supported extensively by Punatsanchu Hydropower Authority (PHPA), presently developing two large hydropower schemes downstream along Punatsangchu, employing 7 to 8,000 staff and very vulnerable to flood hazard as the dams are being constructed. The present partnership with the hydropower sector is seen as an important collaboration, which should be continued if the present EWS is expanded to other river basins where hydropower is being developed, such as Mangdechu and Chamkarchu basins.

Installation of sensitive high-tech equipment at high altitude under extreme climatic conditions is seen as a complex challenge. The EWS installed is considered to be well-tailored to Bhutanese conditions, robust and versatile, as it also monitors meteorological parameters. The GLOF EWS is a first of its kind, in producing real-time information and offering the ability to be monitored over the internet. However, it has to prove its apparent robustness over time.

The EWS elements are comprehensively documented and detailed in the EWS Manual, as compiled by the supplier. The Manual describes not only the stream gauge station, the meteorological stations and siren stations, but also the control centre software and website configuration. Additionally, DHMS has compiled Standard Operating Procedures (SOP) for the standardized operation of the EWS. As the Punakha-Wangdue GLOF EWS is the first of its kind and there is little experience with real-time monitoring systems, the SOP is essential to prescribe standard procedures and to offer a crystal clear series of steps in case a GLOF alert or alarm levels are triggered. The SOP is a critical document to ensure that the operation of the EWS will conform to the prescribed expectations and that it offers a platform to improve the EWS parameters, by building on experience gained over time.

A series of detailed key findings, best practices and recommendations are presented, of which the most essential ones are presented at the end of this Executive Summary.

Community Based Disaster Risk Management Approach (Outcome 1 &3)
Awareness raising and capacity building on GLOF hazard of local government authorities and communities along Pho Chhu and Punatsangchu is the responsibility of the Department of Disaster Management, to complement the lake lowering mitigation work and the installation of the EWS. At policy level, DDM developed the crucial Disaster Management Bill, which is submitted to Parliament and will, when passed, provide a comprehensive legal and regulatory framework on disaster risk management for the country.

In the pilot *Dzongkhags* of Wangdue, Punakha and Bumthang, DDM developed and tested a comprehensive participatory community-based disaster risk management planning methodology (CB-DRM). The process started with the development of a tailor-made CB-DRM planning manual. With the help of this manual a ToT was organized at *Dzongkhag* level for *Dzongkhag* Officials forming the *Dzongkhag* Disaster Management Committee and *Dzongkhag* Disaster Management Planning teams. These members then trained *gewog* officials and local functionaries such as *gup*, *mangmi*, t*shogpas* and *geydrung*, who carried out the CB-DRM planning process at *chiwog* level with the local communities. Making use of participatory tools, hazard, vulnerability and capacity assessment in particular on GLOF is conducted and reflected in a *chiwog* DM planning template, compiled, prioritized and consolidated into a *gewog* DM plan. At *Dzongkhag* level the *gewog* plans are prioritized and consolidated into a *Dzongkhag* DM plan.

Key challenges of the CB-DRM approach are related to a certain lack of sustainability due to the fact that presently there is no permanently designated person or Department of Disaster Management's officials at *Dzongkhag* level to be responsible for the CB-DRM planning process. This results in complications as staff transfers have a negative effect on the base of trained local officials. Suggestions are made to enhance sustainability of the CB-DRM approach at decentralized level.

In the pilot *Dzongkhags* critical facilities for disaster management like basic Emergency Operation Centres (EOCs) are established, equipped with communication tools like VHF sets, office equipment, basic Search & Rescue (SAR) equipment and emergency family kits, aimed at improved coordination and quick response in case of disasters and related emergency operations.

The review made use of focus group discussions with *Dzongkhag, gewog* and *chiwog* representatives to record their experiences with the CB-DRM approach and their knowledge and awareness on risk of GLOF, hazard zonation for land use planning, GLOF evacuation sites and

related evacuation procedures. Although the review did not aim at quantification of awareness levels, it became evident that the majority of community members are well aware of the GLOF hazard present, the EWS and foreseen evacuation procedures.

Some recommendations are made to enhance the CB-DRM planning approach as developed and to improve the sustainability of the planning process. A series of detailed key findings, best practices and recommendations are presented, of which the most essential ones are presented at the end of this Executive Summary.

For each of the three outcome areas discussed above, a concise qualitative cost-benefit analysis (CBA) is presented. For all three outcome areas, the investments made are considered to be reasonable and cost efficient in comparison to the tangible direct and indirect benefits to the communities and socio-economic infrastructure downstream in the river basin.

Finally, in Chapter 6 outcome 4, documentation and dissemination of project outputs, is discussed. This is based on compilation and documentation of field experiences related to the mitigation works, the development and installation of the EWS and the CB-DRM awareness raising and capacity development. The project has received considerable attention internationally, as can be deducted from the fact that three separate documentaries are made of the project activities, with an emphasis on the lake lowering activities in Lunana. Other important means of dissemination are through a regional UNDP project on GLOF, providing a platform to exchange experiences on CB-DRM and the Adaptation Learning Mechanism (ALM) of UNDP, mapping good practices, providing information, sharing knowledge and building networks on climate change adaptation. In December 2012 the project will organize an international GLOF workshop offering an excellent platform to share the project experiences with a wider international audience and to discuss how to scale up activities and to link with upcoming GLOF related projects in the regions and in other mountainous areas exposed to GLOF hazard. Overall, the last year of the project will be essential to consolidate the large amount of information gathered during the field activities, documenting the learning and lessons and sharing the experiences of the project.

In Chapter 7 attention is given to the series of challenges the project was faced with and had to overcome during its implementation period. Many of these challenges were out of the direct control of the project management, or *force majeure,* and required the project management to adapt to the new conditions. Apart from climate related incidents, the Cyclone Aila in May 2009, late snow in 2011 and flash floods in June 2012, challenges were related to issues posed by procurement regulations and difficulties with labour recruitment.

Chapter 8 formulates an exit-strategy for the project as it enters its last year of implementation. The focus is on measures recommended to enhance the sustainability of impacts the project has been able to make for the main outcome areas. In Chapter 9 recommendations are made for replication and scaling-up of project interventions inside Bhutan and in the region. As GLOF hazard is a reality for other river basins within Bhutan a number of key lessons of the project are extracted and discussed in the light of replication and scaling-up. Key recommendations are:

- A move towards a more high-tech based approach, away from the present labour-based method,
- EWS as a catalyst for an upgraded flood warning and monitoring system,
- Expand the CB-DRM approach from the present pilot experience,
- The integrated management approach, bringing technical line departments together in a management set-up,
- The necessity of an adequate high altitude medicine management, and

- A focus on good OHS standards and proper technical equipment.

The review draws up a number of Key Findings and Recommendations in the final Chapter 10.

Key Findings

- The project set-up, with an integrated approach connecting upstream technical mitigation efforts with a basin-wide EWS and downstream awareness raising and capacity building efforts, is found to be commendable. The close collaboration of three technical line departments with specific mandates, but cooperating closely in planning, management and execution, has clearly created synergies.
- The labour-based approach, as chosen by the project, has tangible direct positive livelihood impacts for the workers and local communities involved, but the management of more than 300 workers at site has been complex, challenging and confronted the multi-disciplinary team with many challenges beyond their normal technical and professional mandate.
- The project has achieved its set target of lowering Thorthormi lake level and thereby has reduced risk levels. Risk however remains to exist and the fragility and complexity of ice-cored moraines and the challenge of neighbouring glacial lakes in Lunana will require continued vigilance and on-site monitoring. It is thought to be not unlikely that the present trend continues, with a gradual transition from a glacier with multiple supra-glacial lakes to a glacier in retreat with an extending pro-glacial lake. An analogue development towards a pro-glacial lake as Rapstreng would counteract the present risk reduction achieved and would increase the risk of ice- and rock avalanches as potential trigger of a flood wave and related risk of overtopping and back-cutting erosion.
- The EWS installed is considered to be well tailored to Bhutanese conditions, robust and versatile, as it also produces meteorological information. The GLOF EWS is a first of its kind, in producing real-time information and offering the ability to be monitored over the internet. However, it has to prove its apparent robustness over time.
- The sirens of the EWS are located on locations close to communities and PHPA facilities. It is thought that the spatial spread of the system is such that all inhabitants at risk can hear the siren (audibility). Mock drills of the EWS however, have to confirm this and will be essential to train the population to evacuate to the designated evacuation areas.
- The present EWS set-up is seen to be a catalyst for an upgraded hydro-meteorological monitoring network for the whole nation. It sets standards and can be expanded by adding additional river basins to the existing system.
- The manual and SOP for the EWS are essential to enhance sustainability, maintain a clear information flow between all stakeholders and to improve system parameters as experience is gained over time.
- The CB-DRM planning approach constitutes a commendable methodology to build awareness at local levels related to disaster management, capturing in a participatory manner local knowledge and infusing this into local planning procedures.
- The piloting of the CB-DRM planning approach is seen as a stepping stone for national roll-out of the planning process to all *Dzongkhags*.

Recommendations

- Working in “wet conditions” has proven to be extremely challenging and it has certainly reduced the effectiveness of the work force. In future GLOF mitigation projects it is recommended to work as much as possible under dry conditions through more advanced engineering of the outlet channel/excavation site through use of water pumps, pipes, temporary dams etc., based on study of possible alternatives.
- Considering the challenges faced in managing a large work force, it is recommended for future GLOF mitigation projects to consider a more high-tech approach, with less dependence on unskilled labour, if local site and access conditions allow.
- The multi-disciplinary team, with representatives of all key agencies involved, is a recommendable approach to be replicated. It is however advisable to try to maintain the same staff members over the years to enhance the learning and experience gained in the project work.
- Considering the critical importance to have information on the condition of the 4 Lunana pro-glacial lakes, and Thorthormi in particular, it is recommended to consider the possibility to add a visual check to the EWS. A simple CCTV or webcam could give a visual confirmation if anything has changed at lake level. The present B-mobile coverage in Lunana has simplified communication and a dedicated mobile connection could be an opportunity to have a regular visual update of the lakes.
- At present the AWLSs record an arbitrary water level. It is recommendable to measure the exact water level to allow the measurement of river discharge, assuming the wet perimeter at site is known. Discharge expressed in m^3/sec would give additional information about the yearly band width of discharge and to monitor change over time from the various lakes. Continued monitoring of the discharge volume of the glacial lakes over time will be extremely helpful to better understand lake levels and glacial development.
- To enhance community engagement and ownership, and thereby ensure sustainability of the EWS, it is recommended to think of arrangements to involve the local communities in the maintenance of the EWS facilities. It is recommended that DHMS collaborates with the *Dzongkhag* authorities to explore modalities to enhance the involvement of geog authorities (drafting of by-laws etc.).
- It is recommended to consolidate the present *chiwog*, *gewog* and *Dzongkhag* DRM plans to document all the local knowledge and to review the CB-DRM planning process, based on feedback of the stakeholders involved.
- Mock drills of the EWS are needed at regular intervals to test the siren towers and to review the community awareness and ability to reach the designated evacuation areas in case a GLOF alarm is triggered.
- As the project moves into its final phase, attention has to shift to documentation of the field activities, lessons learned and approaches developed in a more analytical manner. A series of tools to disseminate information efficiently has been set up by the project (website, ALM, publications, international workshop) and will assist in sharing experiences.

1 Introduction

This introductory Chapter gives attention to the purpose and scope of the review and sketches its broader context. The methodological approach applied by the review team is discussed and a concise outline of the buildup and content of the report at hand are presented.

Purpose

The purpose of the review is to examine and document technical and social lessons and impact of the project since the beginning of its implementation from 2008 till date, in order to extract best practices and formulate recommendations for an exit strategy which increases sustainability and enables scaling-up and replication of the project and its approach. The lessons learned as formulated in the assessment report are expected to be applied in on-going and future GLOF risk management projects in Bhutan and other GLOF-prone countries. The intention of the review is to document the lessons emanating from the project[1] experience and to extract best practices implemented to overcome the specific technical and logistical challenges.

Scope

The scope of the review contains a technical and social assessment of:

a) the technological and methodological approach the project has applied in each Outcome area
b) a review of the social and institutional impact of the project.

The review follows the Mid-Term Review (MTR) of the project carried out in 2010 and is preceding the terminal evaluation of the project, planned during the end of project implementation in 2013. The scope of the review is less focused on a comprehensive evaluation of indicators, financial efficiency, targets met and objectives reached, but more on capturing knowledge built within the project, documenting best practices and extracting key learning from implementing a complex and challenging project in a difficult environmental setting.

Emphasis

Special emphasis of the technical review is on the methods applied for the artificial lowering of Thorthomi lake (outcome 2) and the installation of a GLOF Early Warning System (outcome 3). Additional attention is given to the development and implementation of a community based disaster risk management planning (CB-DRM) approach (outcome 1) and the documentation and dissemination of lessons learned (outcome 4). As a cross-cutting theme, attention is given to the direct and indirect social impacts the project has made on the communities and stakeholders involved throughout the outcome areas covered.

Context

The support for the project is directly related to a global concern for the negative impacts of climate change, as framed under the UNFCCC, and as defined as important themes for

[1] In this report the term “project” is used to refer to the full title of the UNDP-GEF project: “Reducing climate change induced risks and vulnerabilities from glacial lake outburst floods in the Punakha, Wangdue and Chamkhar Valleys”

multilateral support by the Global Environment Facility (GEF) and the United Nations Development Programme (UNDP). The project is unique as it is the first project supported by the Least Developed Countries Fund (LDCF) to adapt to the negative impacts of climate change. The project is a follow up to the recommendations for urgent and immediate actions interventions as presented in the National Adaptation Programme of Action for Bhutan under UNFCCC and is supported by UNDP, GEF, RGoB, the Austrian Development Cooperation programme in Bhutan and WWF. The project therefore represents a translation of global concern for the impacts of human-induced climate change at local level and offers a learning platform on how tangible efforts can be made to adapt to and limit the effects of climate change on the ground.

Approach and methodology

The review's focus was on learning and documentation and therefore relied heavily on the feedback, comments and experiences of all stakeholders involved, at national, district and local level. The review methodology therefore was geared towards listening to and learning from the implementers, the administrations involved in the project, and the communities embedded in the project. A concise desktop review phase with a literature review was followed by a stakeholder consultation at national and district level. Further consultations were carried out at community level with geog staff and community members. Additionally, representatives of schools, hydropower projects and other stakeholders were interviewed. An extensive field visit to the remote Lunana area enabled the review team to consult the multi-disciplinary team members involved with the lake mitigation work at Thorthormi Lake site and the labour force and communities involved in the project.

Outline

This report presents a short overview of the methodological approach followed in Chapter 2. Chapter 3 focuses on the artificial lowering of Thorthormi Lake under Outcome 2 and gives an analysis of the technical approach, challenges, key findings, best practices and lessons learned. In Chapter 4 the Early Warning System (EWS), under Outcome 3, is reviewed and assessed. The Community Based Disaster Risk Management (CB-DRM) approach, under Outcome 1, is analyzed in Chapter 5, whereas the documentation and dissemination component, under Outcome 4, is treated briefly in Chapter 6. The adaptive management of the project is treated in Chapter 7, describing how the project management adapted to and was able to cope with a series of serious constraints and challenges. In Chapter 8, a series of recommendations is made to formulate an exit-strategy to enhance the sustainability of the impact the project is able to make. Based on the project lessons and experiences, recommendations are compiled in Chapter 9 for future GLOF mitigation project in other regions of Bhutan or in the region. Chapter 10 finally, brings together the key findings, best practices and recommendations of the review.

2 Methodology

The methodology followed for the review is described in this Chapter. Starting with a desktop review, stakeholder consultations were carried at national level, followed by focus group discussions at district and community levels, making use of pre-defined questionnaires. The last phase of the review consisted of a field visit to Lunana, and Thorthormi lake and adjoining glaciers, to interview the team and labourers directly involved with the GLOF mitigation work and to assess the local conditions, technical approaches and challenges encountered.

Desktop study

The assignment started with the review of a series of project documents to give the review team a proper understanding of the objectives, context and approaches of the project. Documents were downloaded from the project website (http://www.bhutanglofproject.gov.bt/) and provided by the project management and UNDP. An overview of references consulted for this review is given in Chapter 11.

Stakeholder consultation at national level

As a follow up of the desktop review, a series of short consultations with key stakeholders at national level was carried out in Thimphu on August 23rd and 24th. In total, 11 meetings were conducted to seek guidance for the review, to solicit specific feedback and get insights into the views and experiences of the stakeholders, all represented in the Project Board. See Appendix 6 for concise transcripts of these consultative meetings.

Questionnaires

To facilitate the consultative meetings at decentralized level questionnaire formats were prepared with a series of questions related to:

A. GLOF experience, expectations and impact of project
B. Hazard zonation and implications of the red/yellow zone
C. EWS and training/awareness
D. Key lessons:
E. Recommendations:

Separate questionnaires were formulated for focus group discussions at *Dzongkhag*, geog and community level (See appendix 2 for the questionnaire formats).

Consultative meetings and field visits in Punakha and Wangdue Dzongkags

During the period of August 27th to 31st, a series of meetings was conducted in Wangdue and Punakha *Dzongkhags* to provide an opportunity to listen to the local experiences of the *Dzongkhag* and geog administration staff in collaborating with the project. At community level, two meetings were organized to draw upon the experiences and feedback of local community members. Additionally, meetings were conducted with the teaching staff of 2 schools and the Institute of Electrical Engineering in Kuruthang. In Lobeysa, a meeting was held with the staff of Punatsangchu Hydropower Project Authority (PHPA I + II), as a critical stakeholder downstream. Overall, the focus of the consultative meetings was on the experiences with and perception of GLOF hazard, the CB-DRM approach as developed and rolled out, and the EWS as installed. See Appendices5 and 6 for transcripts of the focus group discussions and consultative meetings.

High-altitude trek from Gasa to Lunana

During the period of September 1st to 24th the review team traveled by foot from Gasa to Lunana to visit Thorthormi Lake and observed the ongoing excavation work at site. The team was accompanied by Dowchu Drukpa, project manager for DGM. In Gasa, the team had the opportunity to meet Dasho Dzongda and some of the sector heads to learn from their experiences with the project and the considerable logistical support that Gasa *Dzongkhag* provided to the project. In Lunana, the focus was on the extracting lessons from the excavation work at Thorthormi lake site and the experiences of the multi-disciplinary team over the project period.

Reporting

After returning from the field, the observations and meetings were worked out in the period September 5th to October 3rd and, combined with additional literature review, used as key information for the report here presented. A debriefing presentation was held for the Project Board on October 4th. Comments, feedback and suggestions by the Project Board members were incorporated in the present version of the Review Report.

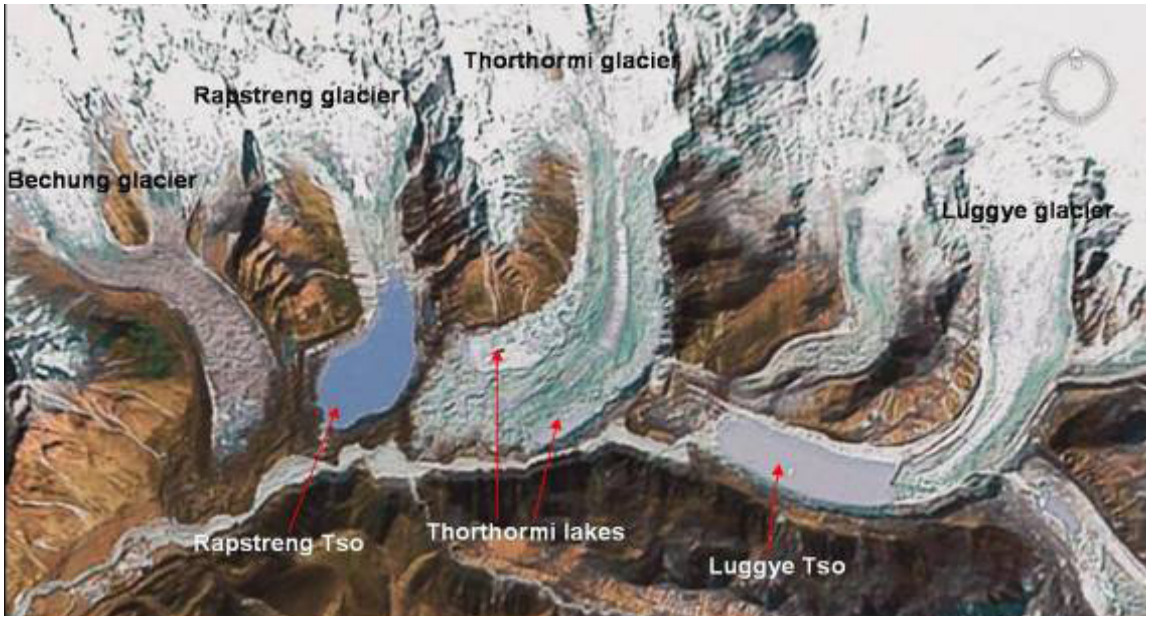

Figure 4 *Overview of the Lunana glacier complex with indication of the 4 main glaciers and associated lakes. Source: DGM, 2007 on a Google Earth satellite image.*

3 Artificial Lowering of Thorthormi Lake (Outcome 2)

In this Chapter the mitigation work intended to lower the level of Thorthormi Lake is reviewed. The location and excavation approach is discussed as well as the overall approach to manage the work with a multi-disciplinary team. The impact of the project on the immediate surroundings and the local communities is treated together with the specific social and health safeguards the project has put in place. Best practices and key findings, as well as a series of related recommendations are also presented.

Technical Approach and Methodology

Thorthormi Lake and Glacier have received ample attention over the last decade. After the successful Rapstreng Lake mitigation Project (1997-1999), in reaction to the Luggye Lake GLOF of 1994, attention shifted to Thorthormi Lake, as critical part of the 4 glacier complexes that constitute the source of the eastern branch of the Pho Chhu. The Austro-Bhutanese research collaboration (2000-2004) resulted in a series of reports, in which Thorthormi became the focus of attention (amongst others: Leber et al., 2002, Brauner et al. 2003). The JICA-JST and DGM scientific collaboration (2009-2012) made Thorthormi lake and glacier a central subject of their joint scientific research (SATREPS, 2012).

Uniqueness of Thorthormi and its neighbouring glacial lakes

An important cause of the interest for Thorthormi lake and glacier is related to the size of the glacier area (3.42km^2 and 6.7km in length, Leber et al. (2002)) and the on-going transition from a complete debris covered glacier body to a glacier with multiple supra-glacial lakes with the possibility of development of a full blown pro-glacial lake with a glacier tongue in retreat.

The uniqueness of Thorthormi is that it is part of an interlinked system of glacial dammed lakes at different altitudes, as vividly described in Leber et al. (2002), which should be addressed in the hazard assessment of the system. The hazard of Thorthormi Lake and the risk of a potential lake outburst has to be assessed not as an isolated glacial lake with inherent risk potential, but as part of an interlinked system of glacial lakes with an interrelated risk profile. From this perspective the decision to concentrate glacial lake outburst flood mitigation works on Thorthormi is considered most appropriate. After the Lugge lake GLOF of 1994 and the Rapstreng mitigation work (1997-199), combined with the limited risk perceived for Beychun Lake, focus on mitigation efforts for Thorthormi developed. Brauner et al. (2003) compiled a detailed report, on request of DGM, on technical mitigation measures for the Thorthormi Outlet, which has served as a base for the mitigation component of the UNDP-GEF GLOF project.

Mitigation options and choices

The GLOF Project made a conscious decision to take sufficient time to prepare for the actual start of the excavationat the Thorthormi terminal moraine complex through a series of comprehensive site investigations by a multi-disciplinary team in the summer of 2008. The resulting report, the Engineering and Safety Plan (2008), contains a detailed engineering design for the excavation and safety and health safeguards for the site work. Based on comprehensive geological, geophysical, geomorphological and glaciological investigations a choice was made for the location of the excavation in order to lower the lake level. A comparison between the two options considered, a paleo channel on the Left Lateral Moraine (LLM) and the present spillway of Thorthormi Lake, led to the decision to focus excavation on the present outlet channel. This decision was based on the length and volume of material to be excavated, effectiveness for lowering the lake level and stability comparison (including ice core presence) of the two options. A

site visit to the two options considered for this Review confirms the logic to focus excavation on the present outlet channel.

Figure 5 *Excavation works in the channel between Subsidiary Lake 1 and 2: difficult working conditions in cold fast flowing water*

Mitigation approach: labour-based excavation works

The mitigation methodology chosen follows the earlier Rapstreng mitigation approach closely: a labour-based excavation effort with limited, simple tools, without the involvement of heavy machinery. Considering the fact that it takes about 10 days to get to Thorthormi from the nearest road head, with passes above 5000m, this is understandable. Another option, as suggested by the Austro-Bhutanese project, Brauner et al. (2003), would involve making use of some equipment and resources flown in by a helicopter (e.g. pipes for diversion of water to ease excavation works). The Tsho Rolpa mitigation project in Rolwaling Himal, Nepal, (1999-2000), the only other large GLOF mitigation project outside of Bhutan to date, made use of helicopters to fly in heavy machinery and parts to excavate the lateral moraine, situated at similar altitudes as Thorthormi, and to construct a permanent sluice, see Figure 6.

Figure 6 *Excavation of the left lateral moraine of Tsho Rolpa and the installation of a permanent sluice to control outflow of the lake, succeeding the lowering of the lake level by 3m. Photo source: rolwaling.tripod.com/2k/2k-tr-fix.html*

The use of helicopter in Bhutan for transportation purposes is still very limited. There is no national company owning a helicopter, and there is no air force and the country therefore has to rely on its neighbours, India and Nepal, for helicopter assistance. Recent deployment of helicopters in Lunana for telecommunication tower installation (2011) shows however that helicopter use is feasible to bring in heavy equipment. It was understood that the project management considered the possibility of airlifting equipment, but that it was decided to give preference to a labour-based approach. Deploying helicopter from outside of Bhutan would be expensive, with resources flowing outside the country, whereas a labour-based approach resulted in an attractive income source for a low-skilled national labour force.

The outlet channel

The topography of the terminal moraine of Thorthormi is complex. It comprises of a series of undulating and partly very steep ablational morainic ridges, with many large angular boulders, typical for an ablational moraine. The spillway of the present outlet channel has to cut through a series of ridges and flatter terrain sections before it flows steeply over the frontal moraine slope, joining in the river bed the Lugge Chhu. The inlet channel develops into a channel that enters into the so-called subsidiary lake 1 (SL1). This SL1 is drained again by a channel that leads to subsidiary lake 2 (SL2) from which the final outlet channel reaches the frontal moraine slope.

The mitigation work therefore has to ensure that the channel and the subsidiary lakes are all lowered to such an extent that an overall acceptable gradient of the outlet channel is maintained. The gradient before excavation was about 2% and the goal of the mitigation work was to maintain this existing natural gradient to limit outflow velocity and erosive power of the water draining through the channels from the main lake and thus limit spillway erosion and potentially hazardous backward cutting erosion.

Figure 7 *Excavation work near the inlet where an ice lens complicates the work conditions considerably. The workers are part of the 123 RBA personnel.*

The engineering design of the channel excavation recommended to broaden the channel where possible to about 10m, to have ample working space and to limit flow velocity and erosion in a narrow channel (the initial channel had a width of about 5-6m).

Figure 8 *To the left: drilling hole made with a Penjor drilling machine and use of silent explosives to split the boulder; to the right: sub-optimal working conditions near the inlet.*

Big boulders as main concern

The channel was characterized by many large angular boulders that obstructed the spillway and posed a major challenge for the labourers. In the first excavation season of 2009, up to 50% of the time was used to break down and pull away boulders, which ultimately resulted in an overall limited lowering of the lake level by 86cm. The boulder clearing process is called “site development” by the Project (2009 Technical report) preceding the actual excavation works, leading ultimately to lowering of the lake level. Portable drilling machines, Penior machines, were used to drill holes in the largest boulders, after which silent explosives were used to crack the boulders. In 2009 only 1 drilling machine was available, after which an additional machine was purchased for the 2010 season. By the end of the 2012 season both machines were not functioning any more, although they have proven to be of good use in combination with silent explosives to break down large boulders.

Ice cores and lenses

The 2008 engineering and safety plan had indicated, through geophysical investigation, that ice cores are present in many parts of the Thorthormi terminal complex. The existence of ice cores are of concern as they induce surficial and deep-seated instability as the ice cores melt and the overlying morainic burden collapses. Closed, circular depressions on the terminal moraine complex surface are abundant as indication of the on-going melt of ice cores (also named “thermal karst”). Along the channel there were indications of ice lenses at greater depth and at distance of the channel to be excavated. The report however indicated that no ice cores or lenses were identified inside the margin of the existing outlet channel. This proved to be incorrect. During the 2012 excavation season, ice lenses were encountered in the immediate inlet zone of the channel, roughly along the first 10m. This hampers not only the excavation but also is difficult for the labourers (safety concerns) and ultimately causes concern for the stability of the immediate surroundings of such ice lenses, especially if steeper slope sections are affected.

The Rapstreng-Thorthormi moraine
In a broader context, the identified ice cores along the Rapstreng-Thorthtormi moraine are of serious concern. At surface, active collapse structures can be observed and there is very active mass wasting on either side of the moraine ridge, resulting in the thinning of the moraine, which has been noted by Leber et al. (2002) and which was also reflected with concern in the Engineering and Safety Plan of 2008. Continuous monitoring of this fragile section of the terminal moraine is critical.

Dry working conditions
Brauner et al. (2003) suggested easing the excavation work by limiting the "wet work" (below the channel water line) as much as possible. They suggested the construction of a simple coffer dam at the channel inlet and the drainage of the existing discharge (up to $4m^3$/sec) by an artificial pipe system. The coffer dam idea was rejected by the multi-disciplinary team in 2008 based on the limited availability of fines in the immediate neighbourhood of the coffer dam lake location and the complication of having to fly in pipes by helicopter.

Alternatively, water diversion works using sand bags and boulders were recommended, a method which has been employed in the excavation process in the years 2009-2012. In practice, it has turned out to be complicated to create dry working conditions making use of only sand bags, tarpaulin sheets and boulders. This has resulted in the necessity for the labourers to stand in at least knee-high, and often hip-high streaming water of just a couple of degrees. These are sub-optimal working conditions and this has created very unfavourable working conditions from occupational safety and health perspective, and it has seriously affected the output of the labour force, and ultimately affected the overall progress. Workers take shifts of at the most 30 minutes in the freezing water, after which they have to recover from the exhausting conditions. On a sunny, warm day this approach is acceptable, but on windy, rainy days the workers have no opportunity to recover sufficiently before they have to enter the water again.

Wet suits and gloves have been purchased by the project to ease the work in the cold flowing water, but the quality of the wet suits and gloves was not sufficient to withstand the abrasive environment of angular stones in the spillway channel. During the initial excavation work, the use of wet suits was non-existent

Stabilization works
The engineering and safety plan of 2008 contains several suggestions for slope stabilization and erosion control during and after the channel excavation works. First of all the design of the channel excavation limits the channel bed slope to about 2%, and certainly below 5% (Brauner et al. 2003), to reduce the flow velocity and erosive power of the water draining through the channel. An increased width of about 10m also contributes to limiting the flow velocity.

It was suggested to armour the channel with boulders of up to 0.5m (boulder rip-rap) and continue this armouring upslope to reinforce the slope foot above the channel water line. It was also recommended to limit the excavated slope angle to below 2:3, to guarantee slope stability. In practice, the wet excavation conditions have made it very difficult to establish a sufficient armouring of the channel. In some slope sections armouring was observed, with deposition of larger boulders and rock fragments immediately along the water line. In other slope sections no armouring was observed and undercutting by the fast-flowing water could be observed.

Some slope stabilization was observed in the form of small support walls, build-up of small boulders. No gabion walls were observed, although explicitly named in Brauner et al. (2003) and in the Engineering and Safety Plan (2008).

The 5m lowering target
The Engineering and Safety Plan (2008) clearly states a goal of lowering the lake by 5m. This level conforms the level mentioned in Brauner et al. (2003). However, the reasoning behind this target of 5m lowering is not explained explicitly. Why would 5m lowering of Thorthormi Lake be an appropriate target for the mitigation work? Why not 4m or 6m? As the implications for the project in terms of volume of material to be excavated, labour costs involved and time needed are considerable, it is important to understand an appropriate justification for the set target.

In consultation with project team members, it was suggested that a reduction of the lake level with 5m would result in a volume reduction which would be in the same order of magnitude as the total flood volume of the Lugge 1994 GLOF (of about 18million m^3), but no written confirmation can be found of this in the reports of the Austro-Bhutanese collaboration.

It was also suggested that the main worry for the Austrian scientists focused on the LLM of Thorthormi, which is severely undercut and eroded by the Lugge GLOF event. It was suggested that the 5m level lowering target was assumed to lower the risk of slope failure of the LLM of Thorthormi. Another assumption is that the Rapstreng project also had a lowering target of 5m, which might have served as a basis for the Austrian mitigation design.

All in all, it is recommended to justify the set lowering target more comprehensively with casual factors on how this target level is determined. That does not say that the target as defined is not right, but it creates an impression that it is arbitrary. The 5m lowering as achieved will reduce the hydrostatic pressure on the moraines, limit the lake volume, create a larger margin in case of a flood wave and potential overtopping, and is assessed to have contributed to an overall reduction of risk.

Lowering in gradual steps
The project initially intended to reach the lowering target of 5m in three summers, 2009-2011. As a result of series of incidents and events, the working period was extended with another summer, 2012, to finalize the excavation and reach the target set. The initial projected period of 3 working summers would have resulted in a gradual lowering of 1.67m per year. During the first year the lake was lowered by only 86cm, so in the remaining 3 years 1.38m had to be lowered yearly. The gradual lowering is essential to limit the inducement of any slope failure of the moraine slopes bordering the lake shore. A gradual lowering of the water level means a slow retreat of support to the slope and the possibility for the slope foot to drain from a saturated state to dryer conditions. The gradual lowering of the lake level therefore can be regarded as a best practice and the project should be commended for conscientiously reducing the risk of inducing slope instability along the lake shore.

Seepage points and undercutting by Lugge GLOF
Exfiltration of water from spring points or zones, or seepage, is a serious concern for the stability assessment of glacial lakes and their terminal and lateral moraines. Seepage can be the precursor of lake water flowing through the moraine, mobilizing and transporting fine material, and development towards piping and internal erosion and ultimately liquefaction and break trough of moraine sections.

Seepage can also be related to the multiple ice cores and lenses present in moraine complexes and confirm ice core presence and indicate the rate of ice core or ice lens melt. Seepage points have been observed in the Thorthormi moraines, but mainly along the LLM complex. Leber et al. (2002) describe these seepages as not related to the lake water, except for one minor seepage point close to the Thorthormi outlet, which was not active (any more) in 2012. They perceive the

risk of seepage induced moraine instability as very limited. Continued monitoring however is critical as seepage is one of the few clear indicators of future failure mechanisms.

Assessment of the impact on the surrounding environment

Rapstreng experience
The Rapstreng mitigation project (1997-1999) in the same area of Lunana served as a lesson for the present project. As an identical labour-based project with hundreds of temporary workers in a high-altitude environment, the Rapstreng project resulted in serious complaints by the local communities regarding excessive collection of fire wood and poaching of alpine wildlife such as musk deer and blue sheep. In contrast to the earlier project, the present project has a forest ranger and representative of the Jigme Dorji National Park (JDNP) as a permanent member of the multi-disciplinary team.

EIA
At the request of the National Environment Commission (NEC), the multi-disciplinary team carried out an Environmental Impact Assessment (EIA) for the artificial lowering of the Thorthormi Lake, DGM (2009). The fact that DGM as proponent of the activity carried out the EIA is understandable considering their technical expertise related to GLOF hazard, glaciology, engineering geology and GLOF mitigation. It is legally correct for DGM to carry out an EIA on request of NEC, but, notwithstanding the content and quality of the EIA produced, it is suggested in future to engage an independent body to carry out an EIA.

Potential impacts and mitigation
The EIA spells out the potential impact of the project interventions in social and environmental terms and looks at potential alternatives to the undertaking. Some of the key negative impacts are:

- Loss of habitat and biodiversity (fire wood and poaching)
- Social impacts (control/misbehaviour of a large work force)
- Sewage and garbage disposal
- Occupational hazards (health risk) and risk related to the lowering work.

A concise and clear mitigation plan was formulated to limit and counteract the possible negative impacts identified. Based on the site visit for the review it was confirmed that the mitigation plan has been implemented adequately and that the organization and management of the project site occupied by the project is clearly in line with the mitigation measures as proposed.

Human-induced /project-induced GLOF: a real risk?
The EIA, however, lacks an essential section on the risk involved with a GLOF mitigation project. In about two sentences this potential risk is named, without mentioning more details. A serious undertaking as this GLOF mitigation project deserves a critical section on the risk that is contained in excavation work on an ice-cored moraine complex in order to drain, in a controlled manner, substantial amounts of water. The site visit and interviews with project team members have convinced the review team of the perceived risk and responsibility felt by the team members. The risk should however be described in some detail, including a section on adequate mitigation and communication steps to be taken in case of a man-induced GLOF event. Apart from the EIA, a detailed safety and evacuation plan and a line of communication schedule was prepared by the project team and presented and accepted by the Project Board (DGM, 2009). The plan details how to handle in case of an unforeseen project-induced GLOF and how to alert the relevant communities and authorities.

JDNP representative in multi-disciplinary team
The forest ranger that is delegated by JDNP to the multi-disciplinary team is very experienced and has been instrumental in limiting the negative impact of the project on the environment. Encroachment on protected forests of the local communities, or *dushing*, is not allowed for fire wood collection, and generally should be “no-go areas” because of the local belief that these areas are guarded by deities and should be left untouched.

The ranger allots firewood and poles to the project labourers and issues permits for collection in designated areas. He collects royalty on the basis of number of loads and poles. The total amount collected is about 150 loads of firewood a week (2012).Of every 10 labourers 1 is kept for firewood collection, which sufficed 10 people for 1 day. The project has explored alternatives as fuel-efficient stoves and kerosene as fuel, but found these options to be less attractive from a cost-benefit perspective.

The firewood is collected in forest areas downstream, close to Tsojo, where tree growth is better compared to Thanza. The areas are rotated upon availability and growth rate and are at considerable distance from the camp, up to 2.5 hours walking distance and the species consisted of mainly *Rhododendron*, *Salix* and *Betula* spec. No *Juniper* is allowed to be collected (except for the Lam (a Buddhist Monk/Priest)).

In 2010 35 truckloads of firewood were collected; in 2011 29 truckloads of firewood were collected; in 2012 30 truckloads of firewood were collected. 1 truck load translates to $5m^3$ of firewood. Over 4 years about 2,000 poles of varying sizes were collected, for each of which royalty was collected.

Figure 9 *A comprehensive attempt to minimize negative environmental impact*

The ranger briefs all staff and workers on the do’s and don’ts regarding conservation and wildlife. In collaboration with the doctor, cleaning campaigns are organized every Sunday, to maintain sanitation and hygiene. Garbage is collected in clearly visible locations and garbage bags are located along the path from the camp to the lake site. At the end of each summer period an extensive cleaning campaign is organized as the camp is dismantled. No poaching of wildlife is allowed, in contrast to the Rapstreng experience, when musk deer and blue sheep were poached.

Lunaps complain about:
- the negative impact of grazing of horses from Gasa and Laya used for the project,
- the collection of firewood (although collection is regulated), and

- the fact that after the reduction of the lake water level the risk will still be there.

Multi-disciplinary team, workforce management and transportation

Multi-disciplinary team
The project has set up a multi-disciplinary team for the mitigation work of Thorthormi lake since the first field work for the Engineering and Safety Plan in 2008. The team, with a core DGM staff, consists of:

- A team leader (Karma Toeb, DGM, Head of the Glaciology Division),
- A project manager (Dowchu Drukpa, DGM, Head of Seismology and Geophysics Division).
- A civil engineer (DoR, MoWHS)
- A surveyor (Lalit Kumar Chhetri, DGM, Survey Division) with a survey assistant,
- A project doctor (Dr. Suresh Mothey (2011-12), Gasa *Dzongkhag*, MoH), assisted by two health assistants,
- A Lam (Central Monastic Body, Thimphu),
- A Park Ranger (Phuntshok, JDNP, MOAFS),
- Gasa *Dzongkhag* representatives (either GAO's or other *Dzongkhag* officials),
- An officer of RBA (an official in the rank of Major, Tencholing, Wangdue base),
- A store In-Charge (DGM, Chado Rinchen for the Taksimakha transit store in Laya, another DGM staff for the Damji transit store),
- An engineering geologist (DGM, Engineering Geology Division),
- A geologist (DGM, Geology Division),
- Additional support staff to man the project team mess (kitchen and cooks).

All project team members have an individual ToR and have well defined tasks. A well-coordinated team management is essential to guide the large work force and ensure an efficient and effective implementation of the excavation works as planned.

As many project team members have come from different line agencies in different Ministries it is more complicated to coordinate the team. Key challenge has been the rotation of staff so that some functions, like that of engineer, represented by DoR, have been changed every year. Ideally, from a perspective of continuity and management, it would be preferable to have the same composition of the multi-disciplinary team to build on the experience and knowledge acquired.

Labour force: multiple challenges
The GLOF project, as a labour-based project, is heavily dependent on manual labour. The recruitment, selection, screening, briefing and travel of the labourers have proven to be a complex challenge. In 2009 and 2010 the project was able to recruit a large number of labourers (2009: 330+, 2010: 350+). The management of such a considerable work force has posed the project team many challenges. Especially at night, after consumption of alcohol, fights were common and "crowd control" became sometimes a real issue. Especially many of the young drop-outs from the urban areas had difficulties to adapt to the harsh working environment and productivity of these workers was not optimal, with an emphasis in 2010, when less local workers joined the work force. In 2009 more local workers, 103 in total (85 from Lunana and 18 from Laya and Sephu), turned up, who seemed to be better adjusted to the harsh working conditions, and who were used to hard physical work. The project team expresses to have gone through a steep learning curve on how to deal with and manage a labour force of such size, with issues that go far beyond their professional technical backgrounds.

The RBA staff member, with a mandate to maintain law and order and discipline in and around the project camp, tried to mitigate the social issues of the work force as much as possible, but project officials were confronted with verbal threats and even were attacked with knives. Disciplinary options however are limited: as an example, 5 workers were expelled in 2009 on disciplinary grounds and 7 in 2011.

Daily wage: from attractive to just sufficient
The project has set a daily wage for the labour force of Nu.500. In the first and second year this attracted a good number of workers, combined with a more enlightened goal of contributing to the wellbeing of the nation. During the second year the fraction of local workers, especially from Lunana, reduced drastically, due to a bumper harvest of *Cordyceps*, after which the Lunaps showed little to no interest to join the work force. In 2011, and especially in 2012, it proved more difficult to recruit labourers, most likely due to a combination of an inflationary environment, in which a daily wage of Nu.500 was no longer as attractive as it was in the first two years of the project, and aenhanced awareness of the difficult nature of the working conditions and casualties the project suffered in 2010.

Year	Lunaps	Layaps - Sephu	Other	Number of workers	Remarks
2009	85	18	241	344	
2010	11	20	321	352	
2011	96		132	227	
2012	5	45	57	230	RBA work force: 123

Table 1 *Overview of origin of the work force (Source: technical reports 2009, 2010 and 2011)*

Other incentives
Apart from the daily wage, the labour force expressed keen interest in the additional resources they were provided with, such as sleeping bags, gum boots and rain coats. In the initial years not all of these incentives were supplied (sleeping bag in 2012 and rain coats by Bhutan + Partners Foundation in 2011), but for the work force, and especially for the local communities, these incentives such as sleeping bag and rain coat, were essential to encourage them to join the project.

Transportation of goods
Apart from the technical challenges of a GLOF mitigation project at high altitude, the project had to face a set of serious logistical challenges to be able to get all the necessary resources and materials from road head to project site and back. Materials and supplies have to travel 9 days on horse and/or yak back from Gasa to Lunana. The project has installed stores to facilitate the transportation process:

- A transit store at Damji, along the Gasa access road
- A transit store at Taksimakha, the military camp below Laya, and
- The camp store at Thanza.

Figure 10 *The project has to rely on horses and mules to transport annually 70 to 80 tonnes of material*

Each store has a store keeper (DGM staff) who keeps track of the stock, communicates with all the horsemen responsible for transportation of loads and acts as store keeper. Gasa *Dzongkhag* authorities have been very cooperative in enabling the project to find enough horses to transport all the goods.

Challenges

It is already an immense logistical challenge to be able to ensure a smooth transportation of all project goods under normal conditions. The project however has had to endure a series of events that have further complicated the logistical challenge:

- Cyclone Aila in May 2009 resulted in extreme floods in Bhutan and resulted in road sections and bridges being washed away and affected road access to Gasa. Along the trekking path to Lunana numerous flash floods and landslides occurred, which hampered easy access and caused delays. The excavation works could only start in early August and the overall working period was reduced to only 2 months from the planned 3 months.
- On June 28th 2012 a flash flood occurred in Gasa and immediately below the Damji transit store the road was washed away at several sites, electricity was cut and workers were stranded on their way up from Damji. The road connection to Gasa is disrupted with several persistent road blocks, which clearly hampers the logistics of the project.
- In 2011 late snow on the passes delayed the working season with several weeks as horses and labourers were not able to cross over to Lunana.
- The large number of loads makes it often difficult to find sufficient horses to carry the loads up or down.
- The engagement of the RBA in the project in 2012 meant that a large number of horses needed to be arranged (115 in total) to transport the RBA loads to Thanza, which was an obvious challenge.

Figure11 *The road section close to Damji after the destructive flash floods of June 2012. Multiple road blocks closed the Gasa road for about 3 months, complicating supply and access for the project.*

High-altitude Health and Safety Management

In the first two years of the project the workers were required to produce a valid health certificate to qualify for recruitment. No specific and focused health check was carried out. In hind sight it is rather remarkable that with a work force of 340+ labourers no serious medical incidents were reported during the initial period. Especially the trek to and from Lunana was reported as not very orderly, with many workers ill-equipped and unprepared to travel high altitude passes. The return journey, marked by snow fall on the high passes, resulted in numerous cases of snow blindness, a case of frost bite and workers that were without rations towards the end of their trek, as they were not following the guidance of the project staff.

The project endured a tragic season in 2010 when 3 labourers died, 2 on trek to Lunana and 1 at the camp. Although the tragic cases were managed properly by the multi-disciplinary team, the Project Board expressed its deep concern and UNDP commissioned a Health and Safety Assessment to look into the causes of the 3 casualties and to seek recommendations to prevent similar incidences in the future. The Health and Safety Assessment is a very thorough and decisive report with clear cut recommendations to improve the overall Health and Occupational Safety management of the project. Key recommendations and changes within the project taking effect from 2011 included:

- A proper medical screening of all work force and project team members, consisting of a 6 page test protocol, carried out by the project doctor,
- Medical transit camps established en route to Lunana and back, with obligatory stop-over at critical altitude points to check any signs of Acute Mountain Sickness (AMS) symptoms. A transit coupon is issued after a 24h stay in transit camp (Rodophu at 4200m) before passage is allowed towards Narethang and Tarina. In Tarina the coupons are collected to conduct a check of all workers registered and to ensure that they have undergone mandatory stop-over procedures,
- A better compliance with Occupational Safety and Health standards was conducted, and,
- A targeted training of the medical staff (project doctor and 2 health workers) on High Altitude Medicine and Remote Emergency Care in Cork, Ireland.

Figure 12 *Medical facilities in Thanza base camp: available for project staff, labourers and community members*

In 2011 and 2012 fortunately no further casualties occurred, which can be certainly attributed to improved medical procedures and a better-trained medical staff. In 2011 a severe case of AMS occurred of a worker that fell sick towards Ganglakarchung. He was rescued by the project doctor and 10 other volunteers and survived the ordeal.

The project is equipped with a gamow bag, 4 oxygen cylinders and has a separate medical unit in the camp. Sufficient stock of a wide range of medicines is available. In principle, there is always health personnel at lake site to cater to any medical emergency and also at the camp site.

It is important to note that all work force members are insured through a collective insurance scheme in case in case of serious injury and death.

Medical service to the local community
Apart from their primary role to cater to the medical needs of the work force and the project team, the medical staff are frequently consulted by the local community. The nearest Basic Health Unit (BHU) is in Lhedi, a day's walk away, so many Lunaps turn to the project doctor for his assistance. This is a clear and tangible benefit for the community, unfortunately only of temporary nature.

Impacts and benefits of the project related to livelihoods of project workers and local communities

Local Communities
Impacts and benefits of the project to the local communities can be divided into several categories:

Direct tangible benefits:

- Daily wage of local community members working for the project (a worker engaged for a whole season earns about Nu. 45,000 to 50,000)
- Additional incentives for workers, such as rain coat, sleeping bag etc.
- Income earned through transportation of supplies for the project with horses and/or yaks. The project has made an agreement with Gasa *Dzongkhag* that for each load carried for the project Nu. 400 will be paid. Each season 70,000 to 80,000kgs of supplies have to be transported for the project, which consists of 1,400 to 1,600 loads (Nu. 560,000 to 640,000). The agreement with Gasa *Dzongkhag* specifies that horses will be used for the stretches connecting Gasa to Laya, Laya to Lunana and Lunana to Laya by the respective communities. In practice, the Laya community has taken up a considerable percentage of the transportation as the Lunaps are less inclined to this task with their large yak herds. On the contrary, the Layaps have a large number of horses.

Figure 13 *Left: pay day for local workers; right: horsemen receiving the payment for transporting supplies*

Indirect benefits:

- Direct access to medical service by the project doctor and health staff (especially for Thanza and Töncho),
- The peace of mind that reducing the lake level, and thus reducing GLOF risk, gives to the local communities, combined with the existence of an extensive EWS in their communities,
- The arrival of the project has led to some permanent shops in Thanza and some temporary shops, which eases life considerably for the community members.
- The project has constructed a *chorten* at a strategic position along the main path at Thanza. The *chorten* was built by the labourers in 2009, following direct instructions of the Lama, who assisted the project as a member of the multi-disciplinary team. The Lama himself is often consulted by the local communities and has been assisting in many household ceremonies and rites during his stay at the project site.

Cost-benefit analysis[2]

The budget estimated for the GLOF mitigation works at Thorthormi amounts to US$2.7million. The project management expects to have spent about US$2.5million at the end of the calendar year 2012, which would result in a balance of about US$200,000. The balance is mainly due to the fact that the project was unable to recruit the number of labourers it had planned for during the last 2 working seasons.

Assuming that the achieved lake lowering will be lasting, it will reduce the GLOF risk of Thorthormi and the interrelated risk of a cascading, combined GLOF (worst case scenario) with Rapstreng. Continued growth of Thorthormi lake however, as a consequence of glacier retreat and disintegration, would counteract this risk reduction over time, as the volume of the lake will grow if length and depth increase.

The on-going construction of PHPA is an enormous investment (estimated at US$3billion) of strategic importance for the economic growth of Bhutan. The dam site construction is a limited phase of high vulnerability for PHPA (about 4 years) and the cost for reducing the GLOF risk during that critical period of construction is therefore considered very reasonable as compared to an alternative scenario with higher risk (no intervention). Apart from the potential direct economic impact for PHPA (and Basochu), there are of course reduced risk to thousands of community members along Pho Chu and Punatsangchu and cultural values of significant importance (e.g. Punakha Dzong). Another factor to be weighed is that a large amount of the mitigation budget (over 50%[3])has been spent on hiring local workers, who have clearly benefited from the project through their wages, positively affecting their livelihoods and that of their households.

Best Practices

- To carry out a comprehensive site investigation (including geophysical, geomorphological, hydrological and engineering geological approaches) to compile a detailed engineering and safety plan, including a weighing of alternatives, with explicit ToRs for all multi-disciplinary team members, prior to the actual start of the excavation work.
- The gradual lowering of the lake level, in relatively small steps spread out over a number of years, can be regarded as a best practice and the project should be commended for conscientiously reducing the risk of inducing slope instability along the lake shore.

[2] The Cost-Benefit Analyses presented in this report are qualitative and not based on a thorough analysis of actual expenditure or quantification of perceived benefits.

[3] Personal communication Dowchu Drukpa, based on preliminary estimate of total expenditure

- To have in place, during transit, in camp and at excavation site, medical staff that is well trained in High Altitude Medicine and emergency response, to ensure, to the best possible level, direct medical care for work force members and project team members.

Key findings

- The labour-based approach, as chosen by the project, has tangible direct positive livelihood impacts for the workers and local communities involved, but the management of more than 300 workers at site has been complex, challenging and confronted the multi-disciplinary team with many challenges beyond their normal technical and professional mandate.
- Indirect benefits of the project are considerable, such as ease of mind because of the reduced risk, direct access to medical services and improved local services (shops) to communities.
- The economic boom in Lunana, due to Cordyceps harvesting, has resulted in a sharp decrease in interest of local community members to contribute labour and to transport supplies. Although the Lunana communities are most directly exposed to GLOF risk, some of the community members expressed to be relatively indifferent to the hazard as such.
- It is striking that an essential target, as the lowering of a glacial lake by a certain level, does not have a clearly documented set of reasoning and justification. That does not say that the target as defined is not right, but it creates an impression that it is arbitrary.
- It is found that the project has carried out a comprehensive effort to limit its negative environmental impact. The most critical aspect is the large amount of firewood consumed by the project, to be collected in a fragile high-alpine environment with low growth rates and with risk of encroachment into local community forests.
- The EIA is carried out by the proponent itself rather than by an independent entity. Although this is legally justified in Bhutan, it is recommendable to engage an independent entity in the future. The EIA lacks a comprehensive section on risk assessment, in particular the assessment of a project-induced GLOF event and a related mitigation plan to limit risk as much as possible this risk. The project team is clearly aware of the risks involved and has tried to limit this risk as documented in a separate risk mitigation plan and a comprehensive communication schedule in case of emergency.
- The project has increasingly faced problems to recruit sufficient work force. The daily wage was initially found to be attractive, but has now become just sufficient, probably due to an overall inflationary environment in Bhutan, combined with the growing awareness of the hard physical work and challenging conditions involved. Another negative factor has been the *Cordyceps* boom in recent years, which has resulted in very limited numbers of local community members coming forward to work for the project.
- 2010 has been a watershed year for the project. The three casualties during that season resulted in a critical assessment of the medical and occupational safety and health management. The findings and recommendations have been fully adopted by the project and the present medical screening, checks en-route and back from Lunana and medical training of the staff involved are excellent. It is thought that the training on High Altitude Medicine and Emergency Care will benefit many others after the project has ended, and is seen as an important “spin off” of the project.

Recommendations

- Considering the challenges faced in managing a large work force, it is recommended for future GLOF mitigation projects to consider a more high-tech approach, with less dependence on unskilled labour, if local site and access conditions allow.

- The clearing of big boulders has proven to be a very time consuming activity and for future GLOF mitigation work it is recommended to have continuous access to multiple drilling machines, combined with silent explosives, to speed up the excavation process.
- Working in “wet conditions” has proven to be extremely challenging and it has certainly reduced the effectiveness of the work force. In future GLOF mitigation projects it is recommended to work as much as possible under dry conditions through more advanced engineering of the outlet channel/excavation site through use of water pumps, pipes, temporary dams etc.
- Armouring of the channel bed and slope stabilization works have proven to be difficult to execute under wet conditions. Dry working conditions would ease such necessary slope stabilization and erosion control works considerably. They are essential to sustain the stability of the outlet channel and are needed to limit scouring, undercutting and secondary stability along the channel.
- Continued monitoring of seepage points along the Thorthormi outer moraine is critical as seepage is one of the few clear indicators of future failure mechanisms.
- It is recommended to one looks into alternatives for the present high dependency on locally available firewood for future GLOF mitigation projects. Fuel-efficient stoves, use of kerosene, and solar cookers could be considered, depending on local site and access conditions.
- The multi-disciplinary team, with representatives of all key agencies involved, is a recommendable approach to be replicated. It is however advisable to try to maintain the same staff members over the years to enhance the learning and experience gained in the project work.

Figure 14 *The chorten constructed by the project in 2009 at the entrance of Thanza*

4 GLOF Early Warning System (Outcome 3)

The GLOF EWS is reviewed in this Chapter with special attention to the design, robustness and overall set-up of the system. The different system elements, both hardware and software and the internal communication system, are analyzed as well as its spatial distribution and functionality. The integration and communication flow with designated authorities is discussed as well as the co-existence with a manual EWS set-up. Key findings and recommendations are presented to document best practices and suggestions for enhanced sustainability and functionality for the EWS are made.

Technical approach and methodology

To procure an EWS: not a standard procedure
A GLOF Early Warning System is not something one can procure over the shelf. It is rather unique, especially aimed at GLOF hazard, as there are very few examples in the world, if any. The Department of Hydro-met Services (DHMS) therefore had to go through an interesting learning curve what to ask for, where and what would be a reasonable cost and method of technology transfer from a preferred supplier to their staff in Bhutan.

The compilation of the bidding documents for the procurement of the hard- and software of the EWS were a challenging task. It was decided not to hire a consultant, but to do this within the expertise available with the Department. This proved to be an excellent learning experience, although it took about 2 months to finalize the bidding documents.

- The EWS equipment is pre-calibrated at the factory, which eases installation later in the field.
- The equipment had to pass three separate tests:
  1. Factory acceptance test
  2. Site acceptance test (after installation on-site), and
  3. Overall system acceptance test, aimed at checking appropriate internal communication of the system, through all its respective system elements, integrating hardware and controlling software.

The turn-key system comes with a 3-year warranty, (subject to fund availability that has to be renewed every year), which is important to avail technical support and guidance when the system is going through its “infancy”, with normal “teething problems”. This can be regarded as a “best practice” to replicate for future system development, if scaling-up or replication is considered to other river basins.

Trained to be independent
DHMS staff went to the supplier’s facility to be trained on the use and installation of the equipment. After this, the supplier provided technical supervision, on-site, while the DHMS staff installed the respective system elements. This proved to be a very good procedure to build skills and confidence of the DHMS staff and to ensure future independence. The EWS in the lower valley section was installed with supervision of the supplier, but the in the upper region, system elements were installed independently by DHMS staff in collaboration with a local contractor.

EWS build up
The EWS contains the following components:

- The Data Collection Platform (DCP), consisting of a data logger, power system, solar panel and regulator, Iridium antenna and modem, mast with lightning protection and fencing enclosure,
- Stream Gauge Stations or Automatic Water level Sensors (AWLS), consisting of a stream gauge and Dual Orifice Constant Flow Bubbler,
- Hydromet Stations or Automatic Water and Weather Stations (AWS), consisting of a stream gauge and Dual Orifice Constant Flow Bubbler, added with rain gauge, tipping bucket (lower region) and total precipitation gauge (upper regions), temperature/relative humidity sensor, wind sensor, solar radiation sensor and atmospheric pressure sensor,
- Siren Stations, and
- The EWS Control Centre, with system control software, data base and related website.

In total there are 17 siren stations and six hydro-met monitoring stations, of which four check water levels (AWLS) and two monitor both water levels and weather (AWS). The system is divided into two geographical areas: the upper sites near the glacial lakes in Lunana, and the lower sites in the Punakha-Wangdue valley, where the majority of the population lives (Tagg, 2010).

The terrain conditions in the upper region pose a constraint for installation and maintenance of the system elements, in particular the siren towers.

Communication between the elements
There are several communication options for linking the EWS elements: High-Frequency (HF) or Very-High Frequency (VHF) radio, or satellite link-up. Although technically it would be feasible to use HF or VHF for the upper or lower region independently, it was preferred to make use of satellite communication. This ensures a reliable communication platform, not perturbed by atmospheric problems and without the need for repeater stations for extended line of sight (ELOS) communication, taking into account the considerable distance between the upper region and the lower regions and the EWS control room in particular (over 100km).

Figure 15 *The siren tower near Tshojo village, Lunana.*

Figure 16 *Siren towers at Samdingkha (top left), Wangdue (top right), Lhedi (bottom left) and the AWLS at Thorthormi (bottom right)*.

Flood warning as a back-up system

Before the 1994 Lugge GLOF event,the responsibility of flood warning was under the Ministry of Communications. The flood warning network was based on a wireless network. The Hydro-met Services Division became responsible in 2002.The existing flood warning system functions as a back-up system and was already equipped with satellite phones.

The initial project design was built upon a DGM assessment and comprised of a relatively limited system. This has now been upgraded by DHMS to a much more comprehensive system.
The present EWS is intended not only to warn, but also to collect and monitor hydro-meteorological data. It includes 6 water level measurement stations and 2 automatic weather stations.

Other glaciers to monitor

Tarina Tsho is considered to be another hazardous lake, but its outburst flood would not be detected by the lowest sensor of the Upper Region. It will be detected first by the sensor at Dangsa, upstream from Punakha, reducing the lead time to react.

Tsojo glacier, in Lunana, has resulted in recurrent floods (most likely related to englacial lake/water outbursts, called a **jökulhlaup,** any large and abrupt release of water from a subglacial or proglacial lake/reservoir (http://en.wikipedia.org/wiki/J%C3%B6kulhlaup), often occurring as episodic releases. A recent outburst was reported in April 2009. The SATREPS Project (2012) has studied Tsojo glacier and its water outbursts in detail.

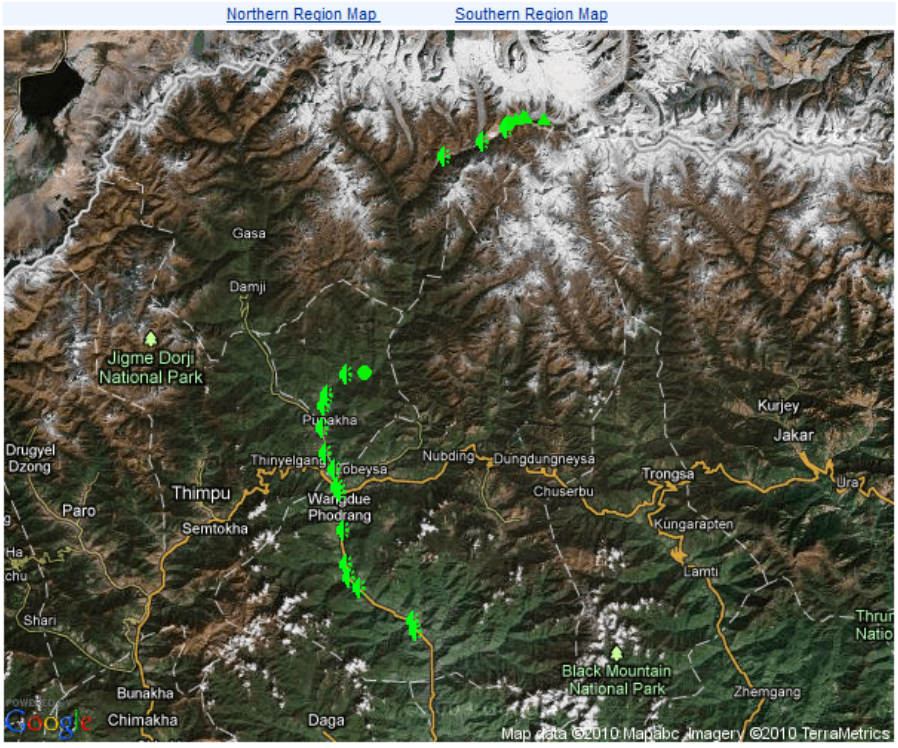

Figure 17 O*verview of the graphical display of the 6 sensors and 17 siren stations of the EWS, split up in a northern and southern region*

Partnership and co-financing

DHMS took over the responsibility for the EWS from DGM at the start of the project during the Inception workshop in June 2008, in light of the fact that flood warning had been the core mandate of DHMS. It was then also deliberated that the initial EWS design had to be expanded into a more comprehensive system, with more system elements and more technical capabilities. Based on their inherent interest in accurate and timely early warning in case of a possible catastrophic outbreak flood, the hydropower sector showed clear interest to partner with the project and put forward co-financing for the EWS component. Punatsangchu Hydropower Authority (PHPA) I and II together have funded about Nu.20 million to enable the development and installation of the comprehensive EWS in its present form. PHPA presently is focusing on construction of the dams of the projects and recognizes the importance of early warning. Many staff are working considerably below present river level (up to -70m for the dam foundation) and the vulnerability of their 7,000 to 8,000 staff and the project infrastructure under development to a GLOF event is a genuine concern for PHPA. After completion of dam construction, PHPA would feel much more comfortable to be able to accommodate any incoming GLOF wave. The PHPA dam is designed to withstand a maximum flood wave of 15,000m^3/sec and through opening of dam gates and sluices the dam can release an equivalent amount downstream, upon early warning. PHPA is directly linked to the EWS control room and will be informed immediately in case an alarm is triggered upstream, to ensure enough lead time for evacuation measures. Considering the overall investment into PHPA I and II, about USD$3 billion, and the socio-economic interest for the country, the present partnership with the GLOF project is seen as commendable and of strategic interest for both partners.

The present partnership with the hydropower sector is seen as an important collaboration, which should be continued if the present EWS is expanded to other river basins where hydropower is being developed, such as Mangdechu and Chamkarchu basins.

Challenges

The extreme weather conditions, especially in the Lunana region, proved to be a serious constraint for EWS installation and monitoring and maintenance work in snow and icy conditions. There have been problems with the chosen site at Thorthormi Tsho: last winter (2011-2012) the sensor tube got blocked by ice formation and caused a malfunction and false alarm, which inevitably causes a certain degree of panic and fear within the Lunana community. The data of the data logger are downloaded and sent to SUTRON, the supplier, to be analysed to see what is the precise cause of the malfunction and how to this can be corrected. It is intended to shift the present AWLS to a location close to ThorthormiLake near the inlet of the channel, after the excavation works at site have been finalized. With the sensor in deeper lake water the ice formation might not be a problem any longer. If problems continue under cold conditions it might be advisable to consider a back-up technology to monitor the lake water level, especially for the critical Thorthormi Lake.

The DDM trainings on community based disaster risk management planning (CB-DRM) were carried out later, but they should have taken place directly after installation of the EWS components within the community. Sequencing should have been refined for maximum results.

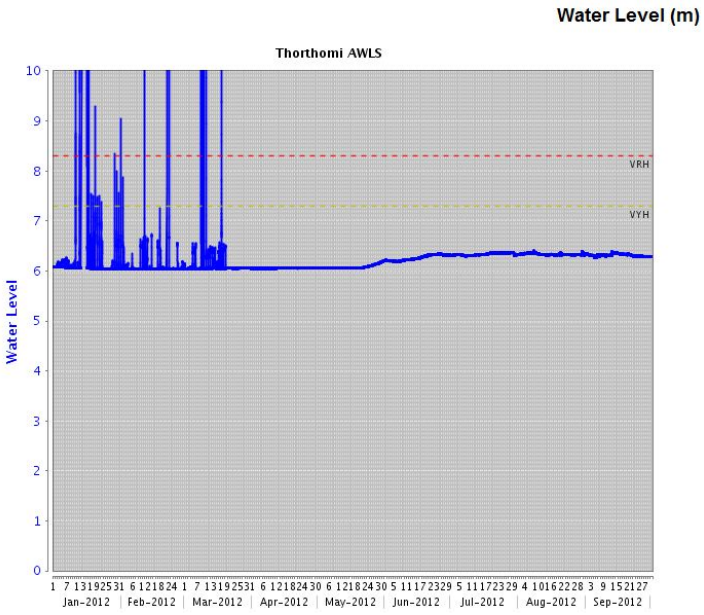

Figure 18 *Graphic output for the Thorthormi water level sensor*

There is no support from the project for DHMS staff in training or maintenance. This is related to the fact mentioned earlier that DHMS joined the project after the project actually started implementation. Support is provided only for the hardware component. Training/capacity building of DHMS staff therefore had to be incorporated in the turn-key tender for the EWS equipment. Some of the additional financing for the EWS by PHPA has been used for training purposes.

Documentation and Operating Procedures

The EWS elements are comprehensively documented and detailed in the EWS Manual, as compiled by the supplier SUTRON for DHMS (Sutron 2011): *Bhutan GLOF Early Warning System in the Punakha-Wangdi Valley*. The Manual describes not only the stream gauge station, the Hydromet stations and the siren stations, but also the Control Center Software and Website configuration. In addition to the technical descriptions of the EWS elements there is also a section on maintenance and calibration and on trouble shooting. Overall the Manual appears to be a professional product, which should enable DHMS to carry out regular monitoring and maintenance.

DHMS has drafted a Standard Operation Procedures (SOP) for the GLOF EWS, DHMS July 2012, Draft Final version of August 6th. This SOP was compiled "…*in order to organize, operate and maintain these components purposely. This Operation Manual provides the basic principles and concepts of GLOF warning procedures, which are to be observed and referred to by all flood monitoring and warning staff*." As the Punakha-Wangdue GLOF EWS is the first of its kind and there is little experience with real-time monitoring systems, the SOP is essential to prescribe standard procedures and to offer a crystal clear series of steps in case a GLOF alert or alarm is triggered.

The SOP is a critical document to ensure that the operation of the EWS will be conform to expectations and offers a platform to improve the EWS parameters, by building in experience gained over time. For instance, it might be necessary to adjust the presently set alert and alarm levels, based on field experience.

A few suggestions are presented here to adjust some of the information of the SOP:

- Table 2 in the SOP gives approximate distances from the sensors and the related approximate time for evacuation, the lead time. The distance given for Bey Tsho as1.5km from Thanza would mean a considerably shorter lead time than indicated in the table: 20 minutes. In case of a GLOF from Bey Tsho, the lead time for evacuation for Thanza would be very limited and certainly less than 10 minutes. It is recommended that Table 2 be revised to reflect the correct lead time.
- The alert and alarm level criteria are depicted in Table 4 of the SOP. These threshold levels are based upon a review by SUTRON of available stage data for the 4 lakes and Thanza (2004-2010). Alert levels are reached when the water level reaches 40 to 60% of its capacity. Alarm levels are reached when the river channel reaches 100% of its capacity. As an additional criterion for both alert and alarm triggering, the rate of change over time is used, set at 0.75m rise per 15 minutes. This rate is also triggered when there is a similar rate of fall of water level per 15 minutes for the sensors at lake side. Table 4. does only indicate a **rise** of water level of time, not a **drop**! Rate of change should take into consideration both possibilities.

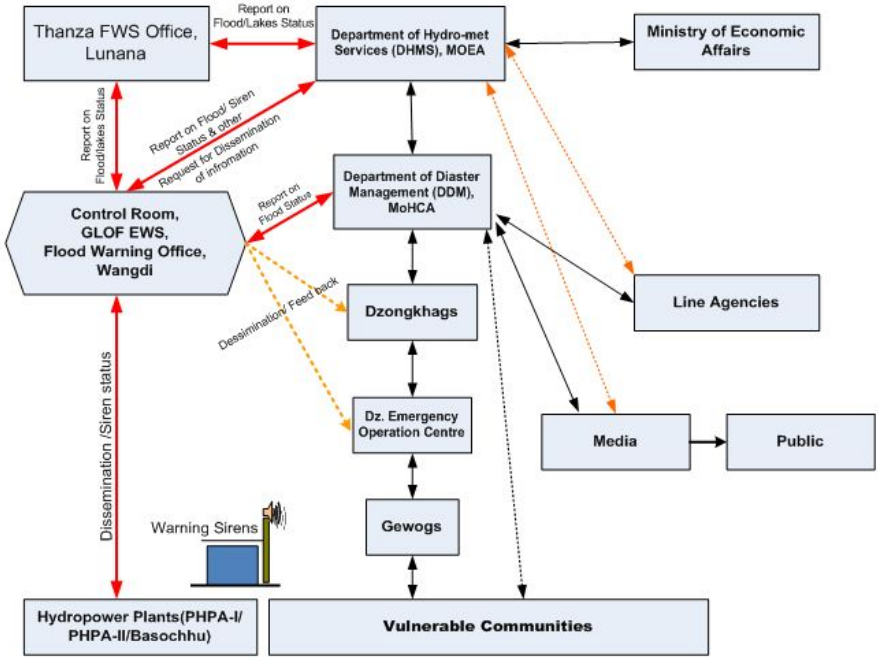

Figure 19 *Information flow chart for the EWS (DHMS (2012): SOP, page 23)*

Sustainability

DHMS is confident that they will be able to maintain the EWS after the project, as it is their core mandate to ensure continuous flood warning and meteorological data collection.

At the end of the project, additional funds are needed for payment of the annual subscription fee to Iridium for satellite services and to maintain the EWS (costs for spare parts and maintenance/monitoring work).

The present data-base, as part of the EWS, is designed to be expanded nation-wide, but one needs the same or compatible equipment (compatible with the present SUTRON hardware/software).Based on the experience gained and success achieved from the

implementation of the Punakha-Wangdue EWS, JICA has committed itself to fund the basic set-up of two more EWS (Chamkhar and Mangdechu basins).

As part of the second NAPA follow-up project, it is foreseen to upgrade the existing hydro-met network to a state-of-the-art system, and to link the system with the current EWS.

As stated earlier, there is also a clearly enhanced collaboration between the technical line Departments of DDM, DGM and DHMS.

As of now, most of the direct consultations with the *Dzongkhag* administration are through DDM. There is a need to think of a continued link with the *Dzongkhags* and geogs after the project end. The present Project Board composition, with the Dasho Dzongdas, could serve as an example.

It is envisaged that hydropower projects in future will support the EWS (in continuation of their present support).

There is some minor concern about the civil engineering structures built by local contractors, whether they will be of sufficient quality to endure the harsh climatic conditions.

False alarms are an issue, but are restricted mainly to the upper region.

Planned mock drills of the EWS, through testing the sirens and related evacuation plans, in close collaboration with DDM, should be carried out to build awareness of the communities.

Manual EWS, community based back-up downstream

As part of a manual EWS, DDM in collaboration with Punakha, Wangdue, Tsirang and Dagana *Dzongkhags* has designated gups, mangmis and some local people in the villages as community focal persons in each vulnerable community to keep watch on the river levels, assist in possible evacuation procedures and inform the downstream localities using mobile phones(through the *Dzongkhag* focal person). At the same time, this communication link enables the *Dzongkhag* to inform communities along the river on possible alerts or alarms as provided by DHMS, in addition to the EWS with sirens. These focal persons are provided with vouchers and simple cell phones (which need upgrading as expressed in the interviews). However, it was reported that mobile services are unreliable as it tends to suffer network congestion in times of emergencies. Since the manual EWS acts as a backup system to the technical EWS, it was reported that sustaining it would require some incentives like minimal budget allocation for mobile vouchers beyond the project phase. DHMS makes use of their flood warning staff in Lunana as a formal back-up system, as they will be able to confirm the signals generated by the EWS, thus acting as a check-and-balance system.

Community awareness of EWS, evacuation routes and sites

The downstream communities along the Pho Chhu and Punatsangchhu banks were found to have a substantial level of awareness and knowledge about the EWS in place, in that, most of the people met and interviewed in this area had heard and seen the EWS station installed in their locality and that the purpose of the siren is to warn local communities of an approaching flood. However, this need to be substantiated with a mock drill at the earliest, as the communities have not yet been trained on how to react when the sirens go off. Awareness and advocacy programs

on GLOF and disaster risk management were conducted by DDM in Wangdue and Punakha *Dzongkhags* which are among the six pilot *Dzongkhags* for CB-DRM. Refer Appendix 5 on the training, knowledge and awareness of EWS in the communities interviewed.

Evacuation Routes and Sites

With the exception for a couple of interviewees, almost all had the knowledge of evacuation sites. They knew where they should gather for help in times of GLOF. Others had the laymen knowledge that they should run to safer places, by which they meant to higher elevations when there is a flood. Khuruthang has an Emergency Operation Center (EOC) constructed within the town premises making it convenient and easily accessible to the business community and the Institute of Electrical Engineering, which is located in the red zone.

Figure 20 *DHMS staff in the EWS control room in Wangdue, who supervise the system 24/7, and responsible for effective communication as soon as alert or alarm levels are reached*

Best Practices

- The procurement of the EWS as a turn-key system with a warranty, which allows availing technical support and guidance when the system is going through its “infancy”, with normal “teething problems”, can be regarded as a “best practice” to replicate for future system development, if up-scaling or replication is considered to other river basins.
- The EWS installed is not a “stand-alone” system, but will be integrated into a larger hydro-meteorological network, covering multiple river basins, and ultimately the whole country. The EWS therefore becomes a catalyst for a state-of-the-art hydro-met monitoring system, essential for a country such as Bhutan, which is heavily reliant on hydropower generation.
- The development of a dedicated set of Standard Operation Procedures (SOP) for the EWS is considered a best practice as it will guide staff involved on how to handle information and how to act under alert and alarm levels and will ensure a timely and sustained maintenance of the EWS elements.

- The Emergency Operation Centers constructed will facilitate an improved line of communication between local stakeholders in case of occurrence of a natural disaster and provide the first supplies of emergency relief materials to vulnerable communities.

Key Findings

- The EWS installed is considered to be well tailored to Bhutanese conditions, robust and versatile, as it also produces hydro-meteorological information.
- The GLOF EWS is a first of its kind, in producing real-time information and offering the ability to be monitored over the internet. However, it has to prove its apparent robustness over time.
- The compilation of the bidding document, the procurement process and the equipment testing and installation has been all carried out by DHMS staff. They have gone through a steep learning curve and are now confident to carry out maintenance and monitoring work of the EWS. It is excellent to see that specific technical expertise is available “in house” or that it can be developed with limited external support.
- The AWLS at Thorthormi has had problems in winter, most likely due to ice formation in the sensor tube. The data logger file has been downloaded and is being analyzed to determine what the precise cause of the malfunction is and how this can be corrected. The AWLS will be shifted to a position close to the lake now that the excavation works have been completed. It is likely that the sensor will operate without problems as it is inserted in deep lake water.
- The sirens of the EWS are located on locations close to communities and PHPA facilities. It is envisaged that the spatial spread of the system is such that all inhabitants at risk can hear the siren (audibility). Mock drill tests of the EWS however have to confirm this and will be essential to train the population to evacuate to the designated evacuation areas.
- The present manual flood warning system represents an essential back-up system if there are any technical problems with the EWS and to have visual confirmation of alert and alarm levels as registered by the EWS.

Recommendations

- Considering the critical importance to have information on the condition of the 4 Lunana pro-glacial lakes, and Thorthormi in particular, it is recommended to consider the possibility to add a visual check to the EWS. A simple CCTV or webcam could give a visual confirmation if anything has changed at the lake. The present B-mobile coverage in Lunana has simplified communication and a dedicated mobile connection could be an opportunity to have a regular visual update of the lakes. It has to be confirmed if this is possible at limited costs.
- The present EWS focuses on the Pho Chhu basin, with the critical set-up of 4 neighboring glaciers and glacial lakes. The Mo Chhu basin however has proven to be flood –prone during the last few years, in particular during the Cyclone Aila in May 2009. The gorge like incision upstream from Gasa, from Koina to the bridge crossing south of Taksimakha, is extremely exposed to the potential of temporary blockades of Mo Chhu by tributaries or landslides. At several locations lacustrine deposits can be observed of former blockades and (temporary) lake formation, and recent debris flows/flash flood deposits from Cyclone

Aila in May 2009 can be observed that have blocked Po Chhu. An AWLS station near Gasa could pick up potential devastating flashfloods from Mo Chu and be connected or "plugged-in" to the present EWS.

- It is recommended to maintain the measurement interval in the Upper Region at 5 minutes at the most in summer to ensure sufficient lead time in case of a GLOF occurrence.
- In case of an earthquake in the Po Chhu basin it is recommended to trigger an alert mode for the EWS. Seismic events are known to be a potential trigger for moraine dam failure and for rock or ice avalanches, which could lead to creation of a flood wave and overtopping of the moraine barrier and consequent back-cutting and breaches. There are field indications that the Lunana area has seen neo-tectonic activity, Leber et al. (2002), and that the E-W trending broad glacial Lunana valley could be a fault zone. There is no historical record of an earthquake triggering a GLOF in Bhutan, but the recent seismic activity in the country, with events of magnitude > 5 on Richter Scale should be interpreted as a reminder of the possible occurrence of a seismic event as a trigger of a GLOF.
- One of the siren towers in Lunana, at Lhedi, is located in a zone prone to rock fall. Although local residents confirmed that there has been no rock fall incidence for a long period of time, it is clearly exposed and rock fall is a hazard for the integrity of the siren tower. The tower is now situated just above a large boulder, whereas it would have been logic to locate the tower ***below*** the boulder to protect it from any rock fall hazard from the rock slope above. For future tower locations it is advised not only to consider flood or GLOF hazard, but also to consider other natural hazards as slope instability/rock fall that might affect the facility.
- It is recommendable to combine the exact water level measurements of the AWLSs with flow velocity measurements, to establish a rating curve, to allow the measurement of river discharge, assuming the wet perimeter at site is known. Discharge expressed in m^3/sec would give additional information about the yearly band width of discharge and to monitor change over time from the various lakes. Continued monitoring of the discharge volume of the glacial lakes over time will be extremely helpful for a better understanding of the lake and glacial development.
- To minimize mistakes and/or false alarms it is recommendable to build in an extra confirmation command in the software interface to turn on/off sirens at the control center.
- The present alert and alarm levels are taken from historic flood information and the 1994 GLOF levels. It is necessary to confirm if these levels prove to be valid over time and to see if they need any adjustment.
- It is recommended to have at least a yearly test of the sirens, in combination with a drill, to see if all system elements are working correctly.
- It is recommended to have a solid and robust UPS system in Wangdue control center to ensure the EWS to be active and monitored during any prolonged period of black-out, which might not be only imaginary.
- Cyber security is vital in the globalized world. As the GLOF EWS contains critical elements, it is important to maintain limited access to the software platform and the website. The present LINUX OS will ensure a relative safe environment, but it is important that the server and workstation are only used for EWS activities.

- To enhance community engagement and ownership, and thereby sustainability of the EWS, it is recommended to think of arrangements to involve the local communities in maintenance of the EWS facilities. It is suggested to DHMS to collaborate with the *Dzongkhag* authorities to explore modalities to enhance the involvement of geog authorities (drafting of by-laws etc.).
- It is recommended to DHMS to formally link up with the Khuruthang Institute of Electric Engineering (KIEE) to bring some of the students on study trips to the EWS elements and to engage some of them in maintenance work as internships or on-the-job training, as part of their curriculum. The EWS elements are rather high-tech and a sound technical education is needed to be able to maintain it.

Cost-benefit analysis

The cost of the entire EWS, consisting of 17 siren towers and 6 hydro-met monitoring stations (4 AWLS and 2 AWS) with a central control system with dedicated software and an internet interface, is about US$1 million. This includes training of the staff by the supplier (testing and calibration) and installation, assisted by a local contractor. Yearly maintenance costs are estimated to be in the order of US$10,000, mainly to cover the subscription fee of the Iridium satellite communication system. PHPA has contributed about Nu20million (about US$400,000) to the EWS installation and training of DHMS staff.

US$1million is a substantial amount of investment, but the EWS has a vital role to fulfill to provide timely warning to the population of one of the most populated valleys in Bhutan in case of a GLOF. It also will be of great value to give enough lead time for the hydropower projects downstream, PHPA I and II and Basochu to evacuate their staff and take emergency measures to limit physical damage to the hydropower facilities. Considering the overall investment costs for PHPA I and II, the amount does not seem excessive. An additional benefit of the EWS is that it provides real time hydro-met information to DHMS, which is of use beyond early DRM and GLOF mitigation, but helps to carry out the core mandate of DHMS. Lastly, the present EWS lays the foundation for a real-time, state-of-the-art flood warning and monitoring system, and can be regarded as a catalyst for future expansion and upgrading, based on the foundation of the standard set by the present EWS.

Figure 21 *The siren tower above Lhedi village, in lower Lunana*

5 Community Based Disaster Risk Management Approach (Outcome 1 & 3)

This chapter discusses the relevance, adequacy, best practices and the key findings with respect to the activities related to awareness raising and capacity building of the authorities and communities directly exposed to GLOF hazard. It addresses the interventions at policy level, the participatory community based disaster risk management planning approach and recommendations are made to consolidate and sustain the impacts made.

Assessment of the adequacy of policy-level interventions conducted under the project, and effectiveness of the CB-DRM approach

The Department of Disaster Management, MoHCA, has the mandate to execute the policy directions they get from the Ministry of Home & Cultural Affairs and Government. The Ministry of Home & Cultural Affairs oversees the implementation of the NDRMF (2006) under which DDM is the executing body to create Disaster Resilient Communities in the country. With one of the three project managers coming from DDM, his key role under the supervision of the Project Director, TSAT and the Project Board, is to ensure timely delivery of the Outputs 1.1,1.2,1.4,3.2,3.3 and 3.4. (Project Document, 2007,pg 51).

Policy Level Interventions

Going by the International Policy(ies), Bhutan is signatory to the Hyogo Framework of Action, 2005-2015, which has 5 main priority areas in building the resilience of nations. It emphasizes the importance of disaster risk reduction under five main areas as mentioned here:

(i) Governance: organizational, legal and policy frameworks;
(ii) Risk identification, assessment, monitoring and early warning;
(iii) Knowledge management and education;
(iv) Reducing underlying risk factors; and
(v) Preparedness for effective response and recovery.

At the national policy level, DDM functions under the mandate of NDRMF (2006) and as a department of the MoHCA, specifically to manage and implement capacity building programmes for the communities concerned and awareness raising of the impending disasters. The Draft Disaster Management Bill, 2011 is still with the Parliament to be passed as an Act. The Bill will create a conducive legal environment in which it will be easier for DDM to fully implement activities related to its mandate. The Bill, if passed, will be a major output of the project and set rules and regulations beyond GLOF hazard, in treating the whole scope of disaster risk management and all potential natural hazards and risk Bhutan is facing.

GNHC, in coordination with DDM, has incorporated the Disaster Risk Reduction (DRR) concept in the Local Development Planning Guidelines as disasters and vulnerability are found to be related or directly correlated to development.

DDM has emphasized it is mainstreaming DRR into National Plans, Policies, and activities with a Strategy and Action Plans and that separate budget is allocated for it.

CB-DRM Approach

The CB-DRM approach is a decentralized training methodology rolled out in *gewog*s and *chiwogs* through a Training of Trainers (ToT) approach in the *Dzongkhags*. It is commendable in its participatory approach of building capacity to the *Dzongkhag* officials down to the grassroots level, through which communities are taught to come up with their own Disaster Management Plans, namely *Dzongkhag* Disaster Management Plans, *gewog* DM Plan, and at the village level, the c*hiwog* DM Plan.

The CB-DRM planning training manual was developed based on international examples (IFRC CB-DRM manual) and tailored to the specific Bhutanese conditions. Within the project the CB-DRM planning approach was piloted in Wangdue, Punakha and Bumthang *Dzongkhags*, with a complete cycle starting at *Dzongkhag* level training of trainers, training of *geog* administration staff and finally CB-DRM planning of all *chiwogs*. The CB-DRM planning approach builds on local knowledge and with a series of participatory tools, records the key natural hazards and vulnerabilities and documents the mitigation steps to be taken to reduce hazard, risk and vulnerability.

Effectiveness of CB-DRM Approach

The CB-DRM approach initiated and implemented by DDM had the objective of not only building capacity, but also of ensuring sustainability given the scenario that the Department is faced with a limited budget and staff constraints. In order to infuse the ownership of the communities in making their disaster plans, a participatory method was adopted. With these noble objectives, they set out training the *Dzongkhag* Focal Persons, the *Dzongkhag* Disaster Management Planning Teams and the Disaster Management Committee as trainers who would further train the *gewog* level officials. The *gewog* Officials in turn train the *chiwogs* and village members who are the final recipients of the CB-DRM trainings.

In as much as it was an attempt to reduce cost and time for the department by resorting to the ToT methodology, effectiveness and quality of the trainings received at the field level may need review and quality assurance monitoring.

Another big challenge facing the DDM is the difficulty of not having a permanent designated person at the *Dzongkhag* level. Without the DM Act, there is no permanent designated/appointed focal person in the *Dzongkhags,* making it all the more challenging in terms of sustainability and cost effectiveness, as the newly transferred officials need to be trained from the beginning if they are new to the CB-DRM methodology and trainings. This was obvious in the Wangdue DDMC, when the Review Team found that only one officer had full knowledge of CB-DRM and other GLOF activities among the 15+ that attended the Focus Group Interview.

Best Practices

- Success stories of the DDM in its activities is commendable in coming up with the CB-DRM Training Manual; it has also published a study on “Assessment on Awareness: Preparedness and Response Capacities related to Climate Change induced Risks and Vulnerabilities” which has done a comprehensive survey and analysis on the awareness

levels of the stakeholder communities and officials related to disaster risk management and climate change.

- The establishment of the EOCs in the three pilot *Dzongkhags* was one of the landmarks in the efforts of DDM as part of reducing the impacts of GLOF. Equipped with necessary tools, it is hoped that EOCs will function as a decision making point and disaster relief center in times of disasters (with focus on GLOF) in the three *Dzongkhags* of Punakha, Wangdue and Bumthang.

- The Emergency Safety and First Aid Handbook published for laymen and students is an essential manual published as part of the project. The manual is simple to understand and full of pictures to grab the interest of readers.CB-DRM trainings have been completed in the *gewog* levels of GLOF Pilot *Dzongkhags* and they are ready to be replicated in other *Dzongkhags* in the future.

- DDM has also been able to create links with agencies and international organizations like the ADB, World Bank and works closely with UNICEF and UNDP in its ventures to mitigate the impacts of disasters around the country.

- Another milestone achievement on DDM's side is the process initiated for "bottom up" and "participatory approach" of preparing disaster management plans from the *chiwog* and upwards to the *Dzongkhag* and the national level. A handful of the *chiwogs* and *gewog*s have already prepared their Disaster Management Plans and submitted to DDM.

- Disaster Risk Reduction Initiatives like the Safe School Initiative to build capacity in Schools to cope witha series of disaster is yet another important activity implemented by the department. As part of the initiative, schools practice regular drills on earthquake safety and First Aid to mitigate the impacts. Audio Visual documentation like the "*Aza Chure*" for floods, which is broadcast and telecast over BBS, has created nationwide awareness on GLOF and flash floods. Impact of such a venture, however needs a study beyond the scope of this review exercise.

- The following documents and products have been developed by DDM for education and empowerment of the communities:
    a. The Disaster Management Bill, 2011;
    b. CB-DRM Training Manual;
    c. Participant Workbook on Disaster Preparedness and Response for Safe Schools;
    d. Emergency Safety and First Aid handbook, 2009.
    e. Templates for *gewog* and *chiwog* Disaster Management Plan;
    f. Survey Report (Consultancy Research) on the "Assessment to Awareness: Preparedness and Response Capacities related to Climate Change induced Risks and Vulnerabilities," 2011.
    g. Documentary Clip on Disaster Management in Bhutan
    h. Posters and pamphlets on Flash Flood (GLOF and its safety measures)

Key findings:
Apart from carrying out the essential CB-DRM trainings, other important outputs achieved by DDM are the Emergency Operation Centers, First Aid and Safety Manuals, Safe School Initiative Handbook, and awareness-raising on the EWS and GLOFS.

These outputs all contribute to building capacity of the nation at large to make communities more disaster-resilient. Albeit in absence of the DM Act, institutions like the *Dzongkhag* disaster management committee with focal persons at all levels of the Local Government Structure are a clear sign of the engagement and ownership by the local government institutions.

Documentation of the Initiatives/Activities
With the excellent efforts put in place and considerable knowledge and experienced gained in the last four years of this project implementation, what is now a priority area for the department is the adequate documentation and consolidation of the information gathered and of the processes and tools developed. Documenting the actual planning process, going from *Dzongkhag* via *gewog* to *chiwog* level, and reflecting stakeholder feedback will be essential, particularly as the project *Dzongkhags* are pilots for a national roll-out of the methodology. The CB-DRM plans are recommended to be compiled at *gewog* and *Dzongkhag* level, so that a clear overview can be given in a single document. Proper documentation will be essential to support replication and up-scaling of similar projects in the future.

Challenge of Sustainability (of the trained Focal Persons)
One the biggest challenge facing DDM at the moment is the lack of a permanent focal person in the *Dzongkhags* making continuity of knowledge and DRM approaches very challenging. From the interviews in the *Dzongkhags* of Punakha and Wangdue, it was learned that the Disaster Management Focal Persons in both these *Dzongkhags* came from different professional backgrounds like the Administrative Officer in one and Planning Officer in the other. Having a fixed professional as a uniform focal person in all the *Dzongkhags* would render uniformity and standardize the implementation of activities. Civil Service Rules of transferring the staffs after 3-5 years of serving in one *Dzongkhag* has a toll on the resources of the department in terms of building and retaining capacity if the focal persons are not standardized/fixed.

In Wangdue, (see Appendix 5) it was found that there was only one officer trained on the aspects of disaster management (GLOF) when the review team met with the *Dzongkhag* officials there. The rest of the Disaster Management Committee members were new to the *Dzongkhag* and they were not fully conversant with the CB-DRM components and trainings.

Participatory Approach of CB-DRM
The CB-DRM approach was started by DDM with the objective of listening to the communities, making use and incorporating their local knowledge and experiences in drafting the *chiwog* DM Plans with locally prepared geographic and resource maps. A series of participatory tools was applied, such a historic time line and a local sketch map of disaster that have hit the *chiwog* over time. The Review Team suggests that the *chiwog* planning approach makes use of pictures as much as possible to ensure that the illiterate community members are able to participate in the

process. An inclusive approach, allowing all groups to participate, will ensure a true bottom-up planning approach and result in a broad-based sense of engagement and ownership by the communities consulted.

Need for area-based maps

As hazards are inherently area-based, sketch maps of the local communities are an essential participatory tool to capture local knowledge, delineate areas prone to hazards and to record historic events. With modern technology, detailed photo-maps, based on recent detailed satellite imagery such as ALOS, are available and these are recommended to be used while working with the *chiwogs* and *gewog*s in order to come up with hazard zonation maps at *chiwog* and *gewog* level. By using the photo maps, the communities will be able to demarcate specifically the past history of disasters. They have the advantage over sketch maps in that they are accurate and can directly be compared and linked to existing hazard zonations and GIS data bases. Such area based DM Plans are found to be relevant to the concerned localities as they are prepared by the local people living in the communities, who have the local knowledge.

Consolidation of CB-DRM Plans at the*Dzongkhag* and National levels.

The CB-DRM Plans are being made at different levels, namely *chiwog*, *gewog* and *Dzongkhag* independently at each stage. Consolidation of the *chiwog* and the *gewog* plans with the *Dzongkhag* plans will not only make the reference work easier for DDM, but it will also help mainstream disaster reduction plans at the national policy levels, which will merit priority for implementation.

Recommendations

- Development of area-based maps with reference to local people's knowledge.Use of photo maps for demarcation of past history of disasters and resource mapping to be used as a participatory tool for making mitigation plans for disasters in the *chiwogs*.
- Consolidation of the *chiwog* and the *gewog* plans with the *Dzongkhag* plans will not only make the reference work easier for DDM, but it will mainstream the disaster reduction plans at the national policy levels which will merit priority in implementation.
- The rolled out CB-DRM trainings with the approach of ToTs cascading down to *chiwogs* merits reviewing from the perspective of ensuring not only sustainability in the Dzonkhags but also quality control mechanisms should be developed to monitor the capacity building process of CB-DRM.
- The CB-DRM Training Manual needs a content revision to make it more user friendly and understandable at the grass root level. More pictorial and practical sessions of the trainings are suggested to be incorporated in the manualto ensure that all participants are able to digest the technical information and are confident of training community representatives independently.
- There is a clear need for adequate documentation and dissemination of information of all the activities carried out so far, especially to the concerned *Dzongkhags* like Punakha, Wangdue and Bumthang. And also for future reference to ensure continuity of the knowledge gained in this project.

- CB-DRM Training and GDMP and CDMP process needs to be taken to Gasa *Dzongkhag* for Lunana Community at the earliest, as they will face the direct impact being the first community/ settlement from the glacial lakes. Unlike other communities downstream, they have a lead time of only 15 minutes to prepare for evacuation. Concrete evacuation plans with specific action plans needs to be drafted at the earliest for Lunana Community.
- Mock Drills as part of awareness raising for GLOF EWS to be conducted at the earliest to all communities including Lunana, in close collaboration with DHMS to test the siren towers.
- Deliberate efforts to ensure equal representation of gender for CB-DRM trainings should be made by DDM by customizing trainings and meetings separately for men and women. The team was reported that attendance in the trainings and workshops was left at the voluntary discretion of the community members which resulted in imbalanced participation of gender. Therefore equal representation of gender is recommended while building capacity for DRR initiatives.
- Awareness raising for GLOF preparedness should continue. It is however, important to inform communities that GLOF risk has been reduced, but not removed for good.
- Insurance schemes of the labourers need to be reviewed, especially in cases of casualties. The present approximate Nu. 140,000 for life insurance may need to be revised considering inflation.

Women's Empowerment

Gender representation in the Project was found to be highly skewed towards men in the decision making positions. Except for a woman district health officer in Punakha *Dzongkhag*, who is a member of the *Dzongkhag* Disaster Management Committee, there was only one woman directly involved in the Project, a staff member of DHMS at the EWS Control Room in Wangdue. The only female officer on board as part of the project management is a GEF-Focal Person who did not have direct participation in the actual implementation of the project. She represented the GNHC and was involved at the coordination of the GEF funds between UNDP and the RGOB.

DDM and the DMCs have made their own implicit efforts to include a fair representation of women in the meetings by commending those who attended such meetings and workshops. However, no deliberate efforts were made in that women representation was emphasized explicitly but rather left to the community to decide

It is to be noted that underrepresentation on the part of the women should not be taken negatively nor does it say that Bhutanese society is highly patriarchal. Mostly, Bhutanese women, especially the rural lot are shy to come out in the public and express their thoughts/ideas. They tend to rely on men for the out of home decisions, although they may be the heads of the households and are normally the heir to family properties.

Gender Equality

Respecting gender equality, the project had the same policy for recruitment of labourers for both men and women in the project site. There were twenty female labourers, making about 9 percent of the total workforce working at the Thorthormi Lake site in 2012. Some of them had worked as

labourers for the last four years. Interestingly, these women came from Sephu under Wangdue *Dzongkhag* and had travelled about 6 days up to the project site for this work, which pays them Nu.500 (five hundred), an equivalent of USD 10/ day. According to the interviews, most of the women labourers came from economically and socially challenged family backgrounds, and some of them were single mothers who had no better opportunities to earn cash to send their children to school. It is to be noted that the project paid both men and women labourers the same amount of wages and there was no discrepancy in the workplace in any manner.

Recommendations:

- To encourage equal representation of gender in managing such projects in the future, deliberate efforts have to be made by the project from the very start.
- Women and children, along with the elderly who are classified as vulnerable groups, should be targeted for more sensitization in staying prepared should a GLOF strike. It is important to ensure that these vulnerable groups are included in trainings, such as mock drills, and that they are given knowledge of the EOCs established.
- In similar projects in the future, women should be encouraged to participate- incentives such as children's allowance and Difficulty Allowances may be considered by the project, especially if women labourers are single mothers. Some women labourers in the project were found to be single mothers who had come to work to educate and support their children/families.

Cost-Benefit Analysis

As discussed for the previous outcome areas, it is not the intention to present a comprehensive cost-benefit quantitative analysis. The analysis presented here is qualitative. The benefits of the CB-DRM component overall are less tangible than the more visible physical outputs of lake lowering and hard ware components of the EWS.

According to the project budget, a total amount of US$1,065,000 will be spent by project end on the strengthening of the national capacity for environment and disaster management. Important benefits created by the project are the drafting of a comprehensive Disaster Management Bill, creating a fundamental legislative environment with an Act, rules and regulations. Such a conducive environment is needed to enforce measures related to disaster risk management, for instance in the context of GLOF hazard the implications of a red zone for spatial planning. The Bill will have a nationwide impact and is therefore seen as a key output of the project and of great value. Another important output is the development of a tailored CB-DRM manual, which is being used across the nation, after having been piloted in the project *Dzongkhags*. The project work can be seen as a catalyst of the capacity building process, being rolled-out nationally.

At decentralized level, in the *Dzongkhags* and *geogs*, public awareness and local capacity related to CB-DRM have been raised, enhancing the impact of the mitigation work carried out upstream and essential to have full benefit of the EWS as installed along the river basin. Awareness levels related to hazards and disaster risk management, and GLOF hazard in particular, have been raised considerably, but these benefits need to be consolidated by repeated and continued training and awareness events to make the benefits more sustainable.

Considering the benefits created, going beyond the mere scope of the project area, the costs made for the CB-DRM component are considered to be justified. The increased awareness levels of all communities, prone to GLOF hazard, forms an essential output to limit their vulnerability and

to raise their capability to effectively manage disaster risk. These benefits are complementary to the benefits of upstream risk reduction and downstream hard ware components for early warning.

Therefore, the overall total Social Impact created in terms of monetary value, would be positive, considering the large investment of PHPA I and II (USD 3 billion) and the invaluable cultural wealth of the Punakha Dzong, followed by Khuruthang town, Bajothang HSS and the Khuruthang IEE. Additional positive impact is linked to the livelihood generated for the labourers and porters which came to approximately USD 1.35 million (*this figure is derived from the estimation that little over 50% of the Project Cost (USD2.7million) was spent for the labour payment*).

Figure 22 *The new Bajothang township, upstream from Wangdue. The buildings along the river bank fall partly in the red and yellow hard zone and the community is made aware of evacuation procedures if a GLOF alarm is triggered*

6. Documentation and Dissemination (Outcome 4)

In this Chapter a concise overview of the project activities related to documentation of project activities and outcomes is provided, including and how the project has been able to share its experiences with key stakeholders within the country and in the region.

The documentation and dissemination component of the project has been coordinated by UNDP Country Office under Outcome 4. In line with the sequencing of the project outcome areas, the emphasis on sharing lessons and experiences of the project will be in the last phase of the project period. This will be based on compilation and documentation of the field experiences related to the mitigation works, the development and installation of the EWS and the CB-DRM awareness raising and capacity development.

Visual Documentation: series of documentaries

It is striking to note how much attention the project has been able to generate internationally, considering the considerable interest to cover the project in visual documentaries. A series of documentaries has been filmed of the project activities and shown on international TV channels such as Discovery Channel and during numerous film festivals. The following documentaries were filmed:

- **Himalayan Meltdown**: Arrowhead Films, at the request of GEF and broadcast on Discovery Network. This program was screened at various international film festivals, and was included in Himalayan Meltdown, a feature-length documentary that is part of the Discovery Asia "Revealed" series.http://www.arrowheadfilms.com/documentary/bhutan-silent-tsunami.It won the prestigious Platinum Award in April 2012 in the broadcast documentary category at the 45th Annual Worldfest International Film Festival, the oldest independent film festival in the world.
  http://www.undp.org/content/undp/en/home/presscenter/pressreleases/2012/04/23/undp-s-himalayan-meltdown-wins-top-prize-at-international-film-festival/
  http://asiancorrespondent.com/56978/himalayan-meltdown-new-climate-change-film-to-screen-at-asia-society/
- **86centimetres**: Peter Jan van der Burgh, Tshering Gyeltshen for Bhutan and Partners (2012). A documentary about Tashi and his fight against the threat of a glacial lake outburst flooding (GLOF) in Bhutan. www.86centimetres.org. This documentary was screened at various international film festivals such as the Washington DC Environmental Film festival in 2012: http://www.dcenvironmentalfilmfest.org/films/show/813.
- **The Cost of Climate Change, the Story of Thorthormi Glacial Lake in Bhutan:** a communications project by the WWF Living Himalayas Network Initiative conducted in October 2009. The project highlights the plight of the Himalayas in the wake of climate change with a publication and a documentary.
  http://worldwildlife.org/stories/wwf-sponsored-documentary-the-cost-of-climate-change-wins-award-at-the-national-annual-journalism-award.
- A short documentary, "Tsunami from the Sky", was compiled by United Nations TV in September 2009 and uploaded to the internet in March 2010: http://www.youtube.com/watch?v=HxOz2v6HKQo. It featured on CCN and BBC.

Regional collaboration on GLOF mitigation

Some of the initial experiences from the project have been shared with regional partners by UNDP in a publication named “GLOF RISK Reduction through Community-based Approaches,” Regional GLOF Risk Reduction Initiative in the Himalayas (UNDP/BCPR 2010). In a regional context, UNDP is preparing projects on GLOF hazard mitigation in Nepal and Pakistan. Lessons and experiences from the project are considered to be very valuable to be shared with these upcoming projects.

ALM (Adaptation Learning Mechanism)

Documentation generated through the project is being shared through the Adaptation Learning Mechanism (ALM) of UNDP, www.adaptationlearning.net. ALM is mapping good practices, providing information, sharing knowledge and building networks on climate change adaptation.www.adaptationlearning.net/bhutan-reducing-climate-change-induced-risks-and-vulnerabilities-glacial-lake-outburst-floods-punakh.

International GLOF Conference

The project is planning to organize an international Conference on GLOF in Bhutan in December 2012. This will be an excellent platform to share project experiences with a wider international audience and to discuss how to scale up activities and to link with upcoming GLOF related projects in the regions and in other mountainous areas exposed to GLOF hazard. See the conference website at: http://conference.bhutanglofproject.gov.bt.

A wealth of information to consolidate and share

Overall, the last year of the project will be essential to consolidate the large amount of information gathered during the field activities, documenting the learning and lessons and sharing the experiences of the project. The wealth of knowledge acquired within the project over the last years need to be reflected in analytic documents so that key findings, best practices and recommendations related to scaling-up or replicating GLOF mitigation activities are accessible for all interested.

Figure 23 *Screen capture of the Silent Tsunami documentary. (Source: http://www.youtube.com/watch?v=HxOz2v6HKQo)*

7. Lessons learned from managing the project: experiences with adaptive management

This Chapter presents some of the key lessons related to adaptive management as the project had to overcome a series of challenges and issues during implementation period.

A mountain of challenges

As stated earlier in Chapter 3, the project has had to endure a series of events that have further complicated the logistical challenge. Most of these events can be considered to be "*force majeure*", beyond the reasonable control of the project:

- Cyclone Aila in May 2009 resulted in extreme floods in Bhutan and large sections of the road and bridges were washed away and this affected road access to Gasa. Along the route to Lunana, numerous flash floods and landslides occurred, which hampered access and caused delays. The excavation works could only start in early August and the overall working period was reduced to only 2 months from the planned 3 months.
- On 28 June 2012, a flash flood occurred in Gasa and the road immediately below Damji transit store was washed away at several places, electricity was cut off and workers were stranded on their way up towards Damji. The road connection to Gasa was disrupted with several persistent road blocks, which hampered the logistics of the project.
- In 2011 late snow on the passes delayed the working season with several weeks as the horses and labourers were not able to cross over to Lunana.
- The transportation of materials and supplies to and from the project site was very challenging as was difficult to find sufficient horses to carry the loads up or down.
- The engagement of the RBA in the project in 2012 meant that a large number of horses needed to be arranged (115) to transport materials and supplies to Thanza, which was an obvious challenge.
- The recruitment of workers has become increasingly difficult towards the end of the project implementation. The daily wages which were initially perceived as attractive became just sufficient after 4 years. In addition, people were aware of the physical and challenging nature of the work and trek to and from Lunana. The project therefore had to rely on the assistance of the RBA in its last year of excavation work at Thorthormi.
- Procurement for the project proved to be challenging as the specific nature of the project resulted in extraordinary requirements, which turned out to be difficult to address under the existing procurement and financial regulations of RGoB. The project had to request on several occasions for exemptions from standing rules and regulations. The turn-key procurement process of the EWS, e.g., was not an existing procurement option and specific exemptions had to be requested for TA/DA allowance amounts and for transportation arrangements.
- One of the best practices in managing the project was the close coordination among three departments under two different ministries implementing the project activities. With project managers from three departments, with their own mandates and varied expertise in their professional background, the management set-up could have been complicated. In practice, the project managers expressed that the close collaboration within the project setting has created synergies beyond the project scope, because of an enhanced mutual trust and understanding. Initial start-up difficulties related to fund releases and financial management were overcome due to joint planning and reporting sessions, enabling a smoother planning and sequencing of project activities. At the same time, there is still scope for improvement related to taking overall responsibility in terms of reporting results

and sequencing and monitoring of project activities. UNDP often had to coordinate between the departments, which was hampered by their more limited focus on implementation of the activities within their technical mandate.

Figure 24 *Overview of the Thanza base camp in September 2012. The main camp is located on the right side, the RBA camp on the left side.*

8. Formulation of an exit-strategy for the project

A series of recommendations to enhance the sustainability of the positive impacts of the project is presented in this Chapter, along with a forward looking strategy for the remaining project period.

Little time left, a lot to do

As the project has entered its final year, it is vital to take stock of the positive impact the project has been able to generate and sustain these efforts through supportive interventions or activities to reinforce and enhance the impacts made so far.

Documentation

In Chapter 6, attention was given to the need to document extensively the lessons and experiences gained over the last few years in the field. Although considerable effort is already given to reporting and disseminating learning from the project, e.g. through the various audio-visual documentaries related to the project, there is still ample scope to document in a more analytical manner the key lessons from the various outcome areas.

DGM and GLOF hazard

- As stated in Chapter 3, there is still a continued need for long-term monitoring and evaluation activities in Lunana. The stability of the outlet channel, the development of Thorthormi lake, the stability of critical sections of the moraine (such as the Rapstreng-Thorthormi section) and seepage along the LLM, all require attention. Funds are necessary to ensure that these activities can be taken up as regular activities by DGM staff in the 11th FYP, as a form of mainstreaming GLOF hazard research and monitoring into the regular RGoB plans.

DHMS and an expanding EWS / hydro-met monitoring system

- As suggested in Chapter 4, it is recommended to seek further involvement of local communities in EWS maintenance, through close collaboration with the *Dzongkhag* administrations. This will enhance and consolidate the engagement and ownership of local communities of the EWS facilities close to their villages. It might be necessary to formulate simple local by-laws to establish tasks and responsibilities, which could also include minimal financial incentives, to be included in the *Dzongkhag* budgets.
- The existing interest and commitment shown by the hydropower project authorities (PHPA I + II) is necessary to be continued and formalized after the formal closure of the project so as to contribute to the recurrent maintenance costs of the existing EWS, which is estimated at about US$10,000.
- The linkage to upcoming projects,NAPA2 and the possible JICA funding for EWS / hydro-met network development in Bhutan, would form an ideal opportunity to infuse key lessons and best practices of the present project. The project could act as a catalyst to build up a nation-wide state-of the-art flood-warning system, consolidating and building on the technical standards set by the present project. Other basins, such as Mangdechu and Chamkarchu could be easily connected and “plugged-in” to the present EWS set-up.

DDM and the roll-out of CB-DRM

- As recommended in Chapter 5, there is a clear need for DDM to focus on compilation, revision and documentation of the CB-DRM planning approach as developed and rolled-out. Compilation of the many *chiwog*-level plans into *gewog*-level DRM pans, and the compilation of *geog*-level plans into a unified *Dzongkhag* DRM plan are essential to safeguard the information gathered and to build on the planning process and awareness created.
- In close collaboration with DHMS, it is recommended to carry out a mock drill to test the functionality of the EWS and to check the actual awareness levels of the communities in relation to the designated evacuation areas. These mock drills should become a regular activity to keep people aware at all times, as well as toensure proper functioning of the EWS (audibility etc.).
- As discussed, it is also suggested to establish a system where a dedicated focal person is designated for the CB-DRM at *Dzongkhag* level. Additionally, it is important to undertake follow-up or refresher trainings (ToT) on CB-DRM at *Dzongkhag* and *gewog* levels.
- The endorsement of the pending DM Bill by the Parliament will provide the necessary legal teeth to DDM and create a conducive legal environment in which DRM activities will be embedded sustainably within planned activities, with related budgetary support.

Suggestions for key documents to compile

In addition to the recommendations listed above to enhance the sustainability of project impacts it is suggested to the key departments to consolidate their learning is the following documents:

DGM:

- After completion of the report on the last field season of 2012, it is suggested to bring together the key lessons of the four consecutive field work seasons in Lunana. Such a more analytical report should compile the most important learning points, critical challenges and how these were overcome and give recommendations for future GLOF mitigation work. Although the review report covers these themes, it is important to carry out a self-evaluation, to consolidate learning by the DGM staff involved. This should include the experiences with GLOF hazard zonation approaches.

DHMS:

- Now the EWS has been in service for over a year, it is recommended to review its performance and to evaluate the manual and SOP, based on the field experiences and first mock drills. Emphasis should be given to necessary maintenance routines and it is suggested to compile a graphical overview of water levels of all sensors for the year 2012, making use of the dedicated software. It is suggested to evaluate if such reports of the EWS functioning are valuable to produce on a yearly basis.

DDM:

- It is recommended to consolidate the *chiog*, and *geog* CB-DRM plans at *Dzongkhag* level, to document the CB-DRM planning process and to work out a smart, concise

way of presenting the key information of the planning process and link this to priority interventions.

- A revision of the CB-DRM manual, based on the feedback of the trainers and implementers at *Dzongkhag*, *geog* and *chiog* level is suggested. The revised manual will be of great value for the ongoing planning process in other *Dzongkhags* in the country and capture many learning points emanating from the project experience.

An international platform

- The upcoming International GLOF Conference in December 2012 will provide an excellent opportunity to present key findings and lessons from the project and to discuss way forwards to consolidate and build on the positive impacts of the project.

Figure 25 *Panoramic overview of Thorthormi lake, as seen from the frontal moraine complex. The outlet area is in the extreme right corner of the image (red arrow)*

9 Recommendations for replication and scaling-up of project interventions in Bhutan and other GLOF-prone countries

This Chapter explores how the key findings, best practices and recommendations emanating from the GLOF project could be applied to potential GLOF related projects in other regions of Bhutan and in other countries having to cope with GLOF hazards.

A source of learning

The project experience of the last five years of implementation is unique in itself, as an integrated approach along an entire river basin to tackle GLOF hazard from source to downstream areas, from hands-on mitigation to awareness raising and education. The wealth of information generated within the project and the lessons learned by overcoming multiple challenges, and learning-by-doing, need to be consolidated, documented and made accessible, so that project experiences can be shared with all interested and disseminated via all accessible media.

From labour-based toward more high-tech based

The project has made a conscious choice to follow a labour-based approach, considering, amongst others, the very remote location of the mitigation site, the absence of a national helicopter service and the preference to share the benefits of the project within the country to a local work force. The management of a large work force at a remote, high altitude location, and under extremely difficult working conditions, has proven to be an enormous challenge. Occupational health and safety concerns, combined with general medical concerns related to the high altitude working conditions have also been very challenging.

If new cases of tangible GLOF hazard within the country emerge, and require mitigation efforts, it is recommended to study seriously an approach with more reliance on technology and equipment than on unskilled labour. Depending on local site conditions and accessibility, equipment for excavation, drilling and proper drainage to enhance dry working conditions should be considered.

EWS: a catalyst for an upgraded flood warning and monitoring system

The EWS as it has been developed and installed seems to be well-tailored and robust, but has to prove itself over time. The system itself is versatile, as it provides more than just GLOF warning: it generates consistent real-time water level and meteorological information. It provides the basis and sets standards for systems in other river basins with potential GLOF hazard, such as Mangdechu and Chamkarchu. As these basins will see hydropower projects being developed over the coming years, it is recommended to build Early Warning Systems in analogy to the Punatsangchu system. Even if it is assessed that full mitigation works are not needed at this time, it is still essential to have a proper early warning system in place, able to monitor flood levels, be it of glacial lake origin, landslide- dammed lake breaches or meteorological flash floods. The current EWS setup has the potential to be upgraded and extended to other river basins, which could be “plugged-in” to the present monitoring set-up.

CB-DRM: expand the approach as developed

The Community-based Disaster Risk Management planning approach, as developed by the project, will be instrumental in up-scaling the initiative to have a nation-wide coverage. The approach goes beyond GLOF hazard, but is designed to assess the whole range of natural hazards communities in a dynamic mountainous setting as Bhutan can be faced with. The approach still needs to be improved along the way, building on the feedback of the project stakeholders, but can be considered as a good stepping-stone to have a proper nation-wide CB-DRM planning approach. Close alignment with possible upcoming early warning systems, be it GLOF or flash flood warning, is recommended to link awareness raising with an active real-time early warning set-up.

An integrated management approach

The project set-up has proven to be able to bring together technical line departments, with very specific technical mandates, in a management configuration that is able to create synergy. The feedback of the three project managers depict better interpersonal links, based on mutual trust and understanding, which is expected to last beyond the project period. The integrated set-up, however, requires frequent coordination and joint planning sessions to optimize sequencing of interventions and to safeguard an adequate information exchange. The integration of tackling upstream hands-on mitigation works with downstream development of an EWS and awareness raising and capacity building at decentralized level has been commended by all stakeholders involved and is certainly recommendable for other river basins or countries.

High Altitude Medicine training

A critical lesson of the project is the necessity for a labour-based project working in a remote high-altitude location to have tailored-made medical procedures in place. Screening of potential workers in the recruitment phase, screening of project team members and close medical supervision during transit to and from the high altitude working environment, and on site, are critical. This relies heavily on a medical staff that is well trained on high altitude medicine and emergency care, confident, equipped and skilled to deal with symptoms of Acute Mountain Sickness. The present project procedures deserve to be replicated to possible future GLOF mitigation projects, or any project operating at high altitudes. A definite spin-off of the project is seen in the fact that now Bhutan has medical personnel with a proper background in high altitude medicine. It is intended by the staff to infuse principles of high altitude medicine into the curriculum of the national nursing education system.

Focus on OHS and quality equipment

The project experience has shown that it is essential to invest, from the very start of the project, in a sound occupational health and safety (OHS) management, based on good quality protective gear for all work force and team members. This will minimize any physical problems and enhance the efficiency and output of the work force. Procurement of quality equipment has to be timely, with a focus on quality and durability. Procurement procedures should, where possible, take into consideration the specific conditions and requirements of a project at high-altitude and with specific needs regarding durability and suitability of the equipment needed.

Infuse personal expertise

The project staff have gained considerable hands-on experience with the pros and cons of managing a complex project, having had to deal with numerous challenges and developing tailor-made approaches. Apart from the need to condense and to compile their experiences into a series of documents, it is recommended to make use of their personal expertise in their respective technical fields in future GLOF related projects. Personal exchange visits and meetings with officials from regional GLOF-prone countries such as Nepal and Pakistan are thought to be of considerable use to infuse their personal expertise in project design. It is not only though their knowledge of best practices, but it is also their experience in overcoming problems and mistakes, through which one can often learn most.

Figure 26 *View towards Chumulhari Kang (6300m), towering above the moraine complex of Lugge Tsho. Note the clear breach of the 1995 GLOF (red arrow)*

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10 Key findings and Recommendations

In this Final Chapter, Key Findings and Recommendations are summarized, based on the assessments of the review of the four key outcome areas of the project. The reader is kindly referred to the individual Chapters for a comprehensive overview of all Key Findings, Best Practices and Recommendations on which this Chapter is based.

Key Findings

- The project set-up, with an integrated approach connecting upstream technical mitigation efforts with a basin-wide EWS and downstream awareness and capacity building efforts, is found to be commendable. The close collaboration of three technical line departments with specific mandates, but cooperating closely in planning, management and execution, has clearly created synergies. The integrated set-up, however, requires frequent coordination and joint planning sessions to optimize sequencing of interventions and to safeguard an adequate information exchange.
- The labour-based approach, as chosen by the project, has tangible direct positive livelihood impacts for the workers and local communities involved, but the management of more than 300 workers at site has been complex, challenging and confronted the multi-disciplinary team with many challenges beyond their normal technical and professional mandate.
- The project has achieved its set target of lowering Thorthormi lake level and reduced risk levels. Risk however remains to exist and the fragility and complexity of an ice-cored moraine complex and an interrelated set of multiple glacial lakes in Lunana will require continued vigilance and on-site monitoring. It is not unlikely that the present trend continues, with a gradual transition from a glacier with multiple supra-glacial lakes to a glacier in retreat with an extending pro-glacial lake. An analogue development towards a pro-glacial lake such as Rapstreng would counteract the present risk reduction achieved and would increase the risk of ice- and rock avalanches as potential trigger of a flood wave and related risk of overtopping and back-cutting erosion.
- The EWS installed is considered to be well tailored to Bhutanese conditions, robust and versatile, as it also produces meteorological information. The GLOF EWS is a first of its kind, in producing real-time information and offering the ability to be monitored over the internet. However, it has to prove its apparent robustness over time.
- The sirens of the EWS are located on locations close to communities and PHPA facilities. It is thought that the spatial spread of the system is such that all inhabitants at risk can hear the siren (audibility). Mock drill tests of the EWS however have to confirm this and it will be essential to train the population to evacuate to the designated evacuation areas.
- The present EWS set-up is seen to be a catalyst for the upgradation of a hydro-meteorological monitoring network for the whole nation. It sets standards and can be expanded by “plugging-in” additional river basins to the existing system.
- The manual and SOP for the EWS are essential to enhance sustainability, maintain a clear information flow between all stakeholders and to improve system parameters as experience is gained over time.
- The CB-DRM planning approach constitutes a commendable methodology to build awareness at local levels related to disaster management, capturing in a participatory manner local knowledge and infusing this into local planning procedures.

- The piloting of the CB-DRM planning approach is seen as a stepping stone for national roll-out of the planning process to all the remaining *Dzongkhags*.

Recommendations

- Working in “wet conditions” has proven to be extremely challenging and it has certainly reduced the effectiveness of the work force. In future GLOF mitigation projects it is recommended to work as much as possible under dry conditions through more advanced engineering of the outlet channel/excavation site through use of water pumps, pipes, temporary dams etc.
- Considering the challenges faced in managing a large work force, it is recommended for future GLOF mitigation projects to consider a more high-tech approach, with less dependence on unskilled labour, if local site and access conditions allow.
- The multi-disciplinary team, with representatives of all key agencies involved, is a recommendable approach to be replicated. It is however advisable to try to maintain the same staff members over the years to enhance the learning and experience gained in the project work.
- Considering the critical importance to have information on the condition of the 4 Lunana pro-glacial lakes, and Thorthormi in particular, it is recommended to consider the possibility to add a visual check of the EWS. A simple CCTV or webcam could give a visual confirmation if anything has changed in the lake level. The present B-mobile coverage in Lunana has simplified communication and a dedicated mobile connection could be an opportunity to have a regular visual update of the lakes.
- At present, the AWLSs record an arbitrary water level. It is recommended to measure the exact water level to allow the measurement of river discharge, assuming the wet perimeter at site is known. Discharge expressed in m^3/sec would give additional information about the yearly band width of discharge and to monitor change over time from the various lakes. Continued monitoring of the discharge volume of the glacial lakes over time will be extremely helpful to get a better understanding of the lake and glacial development.
- To enhance community engagement and ownership, and thereby ensure sustainability of the EWS, it is recommended to explore arrangements to involve the local communities in the maintenance of the EWS facilities. DHMS should collaborate with the *Dzongkhag* authorities to explore modalities to enhance the involvement of *geog* authorities (drafting of by-laws etc.).
- It is recommended to consolidate the present *chiwog*, *gewog* and *Dzongkhag* DRM plans to document all the local knowledge captured and to review the CB-DRM planning process, based on feedback of the stakeholders involved.
- Mock drills of the EWS are needed at regular intervals to test the sirens and to review the community awareness and ability to reach the designated evacuation areas in case a GLOF alarm is triggered.
- As the project moves into its final phase attention, has to shift to documentation of the field activities, lessons learned and approaches developed in a more analytical manner. A series of tools to disseminate information efficiently has been set up by the project (website, ALM, publications, international workshop) and will assist in sharing experiences.

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APPENDICES

Appendix 1 Terms of Reference for the Review

POST TITLE:	Review of technical lessons and social impact
PROJECT NAME:	Reducing Climate Change-induced Risks and Vulnerabilities of Glacial Lake Outburst Floods (GLOF)
COUNTRY OF ASSIGNMENT:	Bhutan

1) GENERAL BACKGROUND

The most significant climate change impact in Bhutan is the formation of supra-glacial lakes due to the accelerated retreat of glaciers with increasing temperatures. The risk of potential costly economic damages on key development sectors such as agriculture, hydropower, and forestry by Glacial Lake Outburst Floods (GLOFs) is mounting. Climate change is attributed as the primary reason that water levels in glacial lakes approach dangerous thresholds. This poses a new dimension to the existing range of threats to lives, livelihoods, and development.

As a follow up to the UNDP-supported National Adaptation Programme of Action (NAPA, 2006), Bhutan is currently implementing the first project funded by the Least Developed Countries Fund on Climate Change Adaptation titled *"Reducing climate change induced risks and vulnerabilities from glacial lake outburst floods in the Punakha, Wangdue and Chamkhar Valleys"*. The project is addressing climate risks in two Sub Basins - Pho Chhu and Chamkhar Chhu - which represent the two most GLOF-vulnerable areas in the country and pose a major threat to life and infrastructure in downstream communities. The goal of the project is to enhance adaptive capacity to prevent climate change-induced GLOF disasters in Bhutan through the following project outcomes:

- Outcome 1: Improved national, regional and local capacities to prevent climate change-induced GLOF disasters in the Punakha-Wangdue and Chamkhar Valleys
- Outcome 2: Reduced risks of GLOF from Thorthormi Lake through an artificial lake level management system
- Outcome 3: Reduced human and material losses in vulnerable communities through GLOF early warnings
- Outcome 4: Enhanced learning, evaluation and adaptive management

2) OBJECTIVES OF THE ASSIGNMENT

The purpose of the review is to examine and document technical and social lessons and impact of the project since the beginning of its implementation from 2008 till date, in order to extract best practices and formulate recommendations for an exit strategy which increases sustainability, enables up-scaling and replication of the project. The lessons learned formulated in the assessment report are expected to be applied in on-going and future GLOF risk management projects in Bhutan and other GLOF-prone countries.

3) SCOPE OF WORK

The scope of the review contains a technical and social assessment of:

c) the technological and methodological approach the project has applied in each Outcome area
d) a review of the social and institutional impact of the project

Special emphasis of the technical review will be on the methods applied for the artificial lowering of Thorthomi lake (outcome 2) and the installation of a GLOF Early warning System (outcome 3). The evaluation should address the following:

a. Assessment of the project approach to GLOF/climate risk reduction in terms of overall coherence and complementarity of project interventions, and contribution towards overall vulnerability reduction and capacity development objective;
b. Assessment of the adequacy of policy-level interventions conducted under the project, and effectiveness of the Community Based Disaster Risk Management approach (Outcome 1)
c. Review of the artificial lowering of Thorthormi lake (Outcome 2), covering the following:
    - Technical approach and methodology
    - Environmental footprint assessment
    - Multi-disciplinary team and workforce management and transportation
    - High-altitude Health and Safety management
    - Impacts and benefits of project related to livelihoods of project workers, herdsmen and local communities
    - Cost-benefit analysis
d. Review of the GLOF Early Warning System (Outcome 3), covering the following:
    - Technical approach and methodology
    - Response plans, communication and information flow
    - Coverage and anticipated avoided losses of lives and infrastructure
    - Manual EWS: synergies with automatic EWS and sustainability
    - Partnership and co-financing
    - Community awareness of EWS, evacuation routes and sites
    - Cost-benefit analysis
e. Adequacy of technical documentation and the corresponding dissemination among different government- and non-governmental entities;
f. Assessment of the project with regards to women's empowerment and gender equality impact;
j. Lessons learned from managing the project, including best practices, weaknesses and experiences with adaptive management;
k. Formulation of an exit-strategy for the project, based on recommendations for increased sustainability of project interventions, including budget requirements and suggested responsibilities for follow-up projects;
l. Recommendations for replication and up-scaling of project interventions in Bhutan and other GLOF-prone countries

4) DURATION OF ASSIGNMENT, DUTY STATION AND EXPECTED PLACES OF TRAVEL

The review will take place between August and October 2012 and include the following components

(tentative draft schedule is attached as Annex 1):

a. Desk review of relevant project documentation (project document, technical reports, manuals, training reports, publications, articles, documentaries, etc.);
b. Interviews with the Project Director, Project Managers, project staff, and UNDP staff;
c. Site visits to GLOF Early Warning System, evacuation sites and vulnerable communities (Punakha, Wangdue Phrodrang and Gasa districts) and Thorthormi lake (Gasa district, Lunana), including a high-altitude trek from Gasa to Lunana.
d. Consultations and/or interviews with relevant stakeholders, including representatives from local government administrations and communities.
e. Drafting and presentation of deliverables.

5) FINAL PRODUCTS

The review team will produce the following deliverables:

a. Presentation of the findings to key stakeholders/TSAT/Project Board (Powerpoint presentation to be shared with the project team and UNDP);
b. Detailed report covering Scope of work, including an executive summary of key findings and recommendations, photos, a list of annexes reviewed by the consultants including TOR, itinerary, list of persons interviewed, summary of field visits, list of documents reviewed, questionnaires, etc.
c. Text and photos for short project publication (lay-out excluded) presenting the project coherence between upstream/downstream activities, best practices and lessons learned for dissemination in- and outside Bhutan

The documents shall be written in English and shall be presented in electronic form in MS Office format. The consultants must use his/her own computer for the assignment.

6) PROVISION OF MONITORING AND PROGRESS CONTROLS

The consultant will report to the UNDP Assistant Resident Representative for Energy, Environment and Disaster Management for any support in effectively carrying out the assignment. The Project Director and Project Managers from the Department of Geology and Mines and the Department of Hydromet Services will provide logistics support related to field travel and coordination of meetings.

The quality monitoring of the outputs will be jointly undertaken by the UNDP CO and the project management team. The final deliverables should be delivered by the end of the mission, and comments incorporated within two weeks upon receiving comments and feedback from stakeholders compiled by UNDP.

7) DEGREE OF EXPERTISE AND QUALIFICATIONS

Two consultants with the following qualifications shall be engaged to undertake the review with joint responsibility of organizing the review and submitting the deliverables:

- An international consultant, who should have in depth understanding of GLOF risk reduction approaches including evaluation experience, will be designated as the team leader with responsibility of the assessment of technical aspects of the review;

- A national consultant, who will have in-depth knowledge of the local context, will be responsible for the assessment of social aspects of the review, and also provide supportive roles in terms of translation and logistic arrangements.

Qualifications of International consultant

1. International/regional consultant with academic and professional background in fields related to Climate Change Adaptation/Disaster Management. A minimum of 10 years of relevant experience is required;
2. Substantive technical experience with GLOF risk reduction approaches, including Early Warning Systems, and from similar interventions, preferably from the region;
3. Experience with participatory monitoring processes and evaluation of technical and social aspects of climate change adaptation and/or disaster risk reduction projects;
4. Be medically fit to travel in high-altitude up to 5,000 meter above sea-level (submission of medical certificate for high-altitude trekking required upon selection);
5. Familiarity with the challenges developing countries face in adapting to climate change, and with Bhutan or similar countries;
6. Excellent in human relations, coordination, planning and team work;
7. Excellent English writing and communication skills.

Qualifications of National consultant

1. Academic and professional background in fields related to Climate Change Adaptation/Disaster Management. A minimum of 5 years of working experience in the development sector in Bhutan is required;
2. Understanding of climate change adaptation and disaster management and risk reduction in Bhutan;
3. Demonstrated skills and knowledge in participatory monitoring and evaluation processes, preferably related to social aspects of climate change adaptation and/or disaster risk reduction;
4. Be medically fit to travel by foot to high-altitude up to 5,000 meter above sea-level (submission of medical certificate for high-altitude trekking required upon selection);
5. Excellent in human relations, coordination, planning and team work;
6. Proficient in writing and communicating both in English and in Dzongkha, including ability to interpret to the international counterpart.

8) SELECTION CRITERIA

The consultants who fulfill the above requirements will be assessed based on the following criteria:

- Technical evaluation comprising of 70%, and
- Financial evaluation of 30%

9) SUBMISSION OF PROPOSALS

The consultant should submit the following to procurement.bt@undp.org:

- Short proposal (1-2 pages) outlining the methodology and approaches of the assignment based on the outputs he/she is expected to deliver
- Financial proposal for lump sum payment of fee and DSA
- CV and P11-form

10. Payment schedule

The consultants will be paid on a lump sum basis including fees and DSA. International and local travel arrangements will be made and covered by UNDP.

- 15% payment upon signature of contract
- 85% payment upon finalization of deliverables

Annex 1: Tentative schedule

Date	Programme	Estimated number of working days	Responsible
August	Desk review (prior to Bhutan mission)	2 days	UNDP will share documents
End August	Consultations with key stakeholders in Thimphu (MoEA, DGM, DHMS, DDM, UNDP)	2 days	DGM
	Field visits to EWS and stakeholder consultations in Punakha and Wangduephodrang (district administrations, communities)	4 days	DDM and DHMS to accompany
1st – 4th week of September	Trek from Gasa to Lunana (10 days) Field visit to Thorthomi lake and consultations (workers, multi-disciplinary team, communities) in Lunana (5 days) Trek from Lunana to Gasa (10 days)	25 days	(DGM) DHMS to accompany
October	Drafting and presentation/submission of deliverables	4 days	
	Submission of final report after incorporation of comments (after Bhutan mission)	1 day	
		38 days (of which 20 days trek)	

Appendix 2 Questionnaire Formats

Interview Format for DzongkhagAdministration (DA)

Date:
Dzongkhag:……

Introduction: Objectives, scope, not a final evaluation, focus on learning points, best practices and key lessons and social impacts, and recommendations for exit strategy and sustainability post-project

1 Dasho Dzongda …… yr
Dasho Dzongrab……. yr
Dzongkhag Disaster Management Focal Point…….. yr

A GLOF experience and expectation and impact of Project

1. What is your personal knowledge of GLOF and/or personal experience with a Glacial Lake Outburst Flood?
2. What would be your main fear if a GLOF would happen in your *Dzongkhag*?
3. What do you consider to be most vulnerable in your *Dzongkhag*?
4. What were your expectations at the start of the project?
5. How do feel now, after 4 years of project? Has it lived up to your expectations?
6. What has been the impact of the project after 4 years (both in positive/negative sense and with examples if possible)
7. Do you think this this impact will last?

B Hazard zonation and red/yellow zone

1. Do you think there is good knowledge and awareness of the "red zone" in your *Dzongkhag*?
2. Is the red zone consistently applied for spatial planning purposes?
3. Do you agree that no one should live in the red zone?
4. Do people still live in the red zone?
5. Does the hazard zonation hamper your communities in their economic pursuit for development?

C EWS and training/awareness

1. Has there been a change in the sense of safety in the *Dzongkhag* through the activities of the Project?
2. Have you participated in any trainings related to GLOF/disaster management? Feelings/experience?
3. Are you confident that everyone knows what to do if the sirens start?
4. Have you taken part in drills? Apart from schools?
5. (*Frequency/necessity/urgency)*
6. Are there local by-laws how to maintain/take care of the EWS hardware? Fencing? Responsibility?
7. How would you describe engagement of women in the GLOF Project?
8. *(Women participation / gender sensitivity / inclusiveness of process/Pro-active steps of the project for women engagement)*
9. How would you describe the community engagement (role of geog administration)? Is there a difference between your geogs regarding community commitment, and if so, what are causal factors behind this?
10. What would you consider to be the key lessons to be learnt from the GLOF Project and why?
11. Do you have recommendations for future work on GLOF based on your experiences? Is there a need to develop new policies and/or regulations in relation to GLOF/DRM?
12. Would you have recommendations for an exit strategy of the GLOF Project, as it is nearing its project end, in order to enhance sustainability of the project impact?
13. What questions did you miss in this interview, or what information would you like to add?

Interview Format for Geog Administration (GA)

Date:
Dzongkhag:…… Geog:

Introduction: Objectives, scope, not a final evaluation, focus on learning points, best practices and key lessons and social impacts, and recommendations for exit strategy and sustainability post-project

Gup …….. yr
Mangmi…… yr
GAO…… yr
Disaster Management Focal Point……... yr
Others…… yr
Others…… yr

A GLOF experience and expectation and impact of Project

1. What is your personal knowledge of GLOF and/or personal experience with a Glacial Lake Outburst Flood?
2. What would be your main fear if a GLOF would happen in your geog?
3. What do you consider to be most vulnerable in your geog?
4. What were your expectations at the start of the project?
5. How do feel now, after 4 years of project? Has it lived up to your expectations?
6. What has been the impact of the project after 4 years (both in positive/negative sense and with examples if possible)
7. Do you think this this impact will last?

B Hazard zonation and red/yellow zone

8. Do you think there is good knowledge and awareness of the “red zone” in your geog?
9. Is the red zone consistently applied for spatial planning purposes?
10. Do you agree that no one should live in the red zone?
11. Do people still live in the red zone?
12. Does the hazard zonation hamper your communities in their economic pursuit for development?

C EWS and training/awareness

13. Has there been a change in the sense of safety in your geog through the activities of the Project?
14. Have you participated in any trainings related to GLOF/disaster management? Feelings/experience?
15. Are you confident that everyone knows what to do if the sirens start?
16. Have you taken part in drills? Apart from schools? (*Frequency/necessity/urgency)*
17. Are there local by-laws how to maintain/take care of the EWS hardware? Fencing? Responsibility?
18. How would you describe engagement of women in the GLOF Project? *(Women participation / gender sensitivity / inclusiveness of process/Pro-active steps of the project for women engagement)*
19. How would you describe the community engagement (role of chiog administration)? Is there a difference between your chiogs regarding community commitment, and if so, what are causal factors behind this?
20. Was literacy a handicap for community members to participate in trainings or is there good use of pictures, so that all can take part?
21. Are there NFE centers in your geog and have they been trained by the project?What would you consider to be the key lessons to be learnt from the GLOF Project and why?
22. Do you have recommendations for future work on GLOF based on your experiences?

23. Would you have recommendations for an exit strategy of the GLOF Project, as it is nearing its project end, in order to enhance sustainability of the project impact?
24. What questions did you miss in this interview, or what information would you like to add?

Interview Format for Community (chiog level meeting)

Date:
Dzongkhag:…… Geog:
Chiog:
Introduction: Objectives, scope, not a final evaluation, focus on learning points, best practices and key lessons and social impacts, and recommendations for exit strategy and sustainability post-project

Disaster Management Focal Point……... yr
Tshogpa…… yr
Others…… yr
Number of community members present at meeting: ….male / ….female

A GLOF experience and expectation and impact of Project

1. What is your personal knowledge of GLOF and/or personal experience with a Glacial Lake Outburst Flood?
2. What would be your main fear if a GLOF would happen in your chiog?
3. What do you consider to be most vulnerable in your chiog?
4. What were your expectations at the start of the project?
5. How do feel now, after 4 years of project? Has it lived up to your expectations?
6. What has been the impact of the project after 4 years (both in positive/negative sense and with examples if possible)
7. Do you think this this impact will last?

B Hazard zonation and red/yellow zone

8. Do you think there is good knowledge and awareness of the “red zone” in your chiog?
9. Do you agree that no one should live in the red zone?
10. Do people still live in the red zone?
11. Does the hazard zonation cause problems? Less economic opportunities?

C EWS and training/awareness

1. Has there been a change in the sense of safety in your chiog through the activities of the Project?
2. Have you participated in any trainings related to GLOF/disaster management? Feelings/experience?
3. Are you confident that everyone knows what to do if the sirens start?
4. Have you taken part in drills? Apart from schools?
5. (*Frequency/necessity/urgency)*
6. Are there local by-laws how to maintain/take care of the EWS hardware? Fencing? Responsibility?
7. How would you describe engagement of women in the GLOF Project?
8. *(Women participation / gender sensitivity / inclusiveness of process/Pro-active steps of the project for women engagement)*
9. How would you describe the community engagement (role of chiog administration)? Is there a difference between this chiog and other chiogs regarding community commitment, and if so, what are causal factors behind this?
10. Was literacy a handicap for community members to participate in trainings or is there good use of pictures, so that all can take part?
11. Is there a NFE center in your chiog and have they been trained by the project?
12. What would you consider to be the key lessons to be learnt from the GLOF Project and why?
13. Do you have recommendations for future work on GLOF based on your experiences?
14. Would you have recommendations for an exit strategy of the GLOF Project, as it is nearing its project end, in order to enhance sustainability of the project impact?
15. What questions did you miss in this interview, or what information would you like to add?

Appendix 3 Itinerary of the Review Team

Date	Time	Program	Remarks
Desk Review			
16-17 August		Review of existing project documents	Downloaded from Project web site
21-22 August		International Travel Amsterdam-Delhi-Paro International Consultant	
Consultation Meetings Thimphu			
23 August	09.00-10.00	Introduction Meeting with UNDP CO Karma Rapten, Head of Environment and Disaster Management Unit	
	10.00-10.30	Consultation Meeting with Sonam Yangley, DG DGM, PD of GLOF Project,	DGM coordinated the respective meetings, with exception of the meetings at DHMS and DDM
	10.30-12.00	Consultation Meeting with PMs and Dy. PMs of DGM, DHMS and DDM	
	14.00-16.00	Consultation Meeting at DHMS, Karma Tshering, Director and staff	
	16.00-17.20	Consultation Meeting at DGM with Dowchu Drukpa, PM for DGM	
24 August	09.00-10.00	Consultation Meeting at DDM, Namgay Wangchuk, DG of DDM	
	11.00-12.00	Consultation Meeting at GNHC, Tandin Lham, GEF focal person	
	12.00-13.00	Consultation Meeting at WWF Bhutan Programme, Vijay Moktan, Director Conservation Program	
	14.00-15.00	Consultation Meeting at DoE, Dasho Sonam Tshering, Secretary MoEA	
	15.00-16.00	Consultation Meeting at ACO, Mrs Christine Jantscher, Head of the ACO	
	16.00-16.30	Consultation Meeting at NEC, Thinley Namgyel, Chief of Climate Change Division	
25 August	09.00-10.00	Meeting at UNDP CO with Pema Wanchuk, General Manager of Adventure Bhutan Travel, together with Karma Rapten, UNDP, in preparation of trek to Lunana	
Field Visits in Wangdue and Punakha			
27 August	Am	Travel to Punakha	
	14.00-16.00	Meeting with Punakha *Dzongkhag* Disaster Risk Management Committee, chaired by Dasho Dzongda	Semi-structured interview, making use of questionnaire
	16.00-17.00	Visit to *Dzongkhag* Emergency Operation Centre (EOC) in Kuruthang	First EOC in Bhutan

Date	Time	Program	Remarks
28 August	09.00-10.00	Visit to Bajo Higher Secondary School, Meeting with Vice Principal and teaching staff	
	10.00-12.30	Meeting with Wangdue *Dzongkhag* Disaster Risk Management Committee	Semi-structured interview, making use of questionnaire
	13.30-14.30	Visit to DHMS Wangdue EW Control Room	Demonstration of facility and interview with staff
	15.00-17.00	Meeting PHPA I and II staff at Lobesa	Semi-structured interview, making use of questionnaire
29 August	11.00-13.00	Meeting at Wolothang Community Primary School and site visit to vulnerable Pho Chu river bank upstream from school	Semi-structured interview, making use of questionnaire
	15.00-16.30	Meeting with geog administration staff and community members of Teotang Geog, Samdingkha chiog	Semi-structured interview, making use of questionnaire
	16.30-17.00	Site visit to siren tower near Samdingkha	
30 August	10.00-11.00	Meeting and site visit at Kuruthang VTI (Kuruthang Insititute of Electrical Engineering, KIEE)	Open ended interview
	13.00-15.00	Interview with Chencho, PM DDM	
Trek Gasa-Lunana-Gasa			
1 September		Travel from Punakha to Gasa road head. Halt at DGM Transit store at Damji.	Multiple road blocks. Meet trekking crew at road head.
2 September		Travel from Damji to Gasa. Evening dinner at Dasho Dzongda's residence in Gasa	Multiple road blocks. Horses arrive only at night. Open ended interview
3 September		Trek from Gasa to Koina	
4 September		Trek from Koina to Taksimakha	
5 September		Acclimatization Day. Walk up to Laya.	
6 September		Trek from Taksimakha to Rodophu	
7 September		Trek from Rodophu to Narethang	
8 September		Trek from Narethang to Tarina NC returns to Rodophu	National Consultant returns
9 September		Trek from Tarina to Wooche NC returns from Rodophu to Taksimakha	
10 September		Trek from Wooche to Lhedi NC halts at Takshimakha	
11 September		Trek from Lhedi to Thanza, halt at project camp. NC returns to Koina	

Date	Time	Program	Remarks
12 September		Site visit to outlet channel excavation work; visit to Rapstreng moraine; meeting with RBA officers NC returns to Gasa	
13 September		Site visit to Lugge Tsho and Thorthormi LLM NC returns to Thimphu	
14 September		Interview with Major Leki Wangdi Interview with Dr. Suresh Chandra Mothey Interview with Phuntshok, Assistant Forest Officer of JDNP	
15 September		Site visit to AWL sensor and siren tower at Thanza Interview with labourers	
16 September		Interview with female labourers Interview with Jigme Jamtsho, Engineer of DoR, MoWHS Interview with Major Sonam Tshering, RBA Interview with Karma Toeb, Team Leader	
17 September		Trek from Thanza to Tekha	
18 September		Trek from Tekha to Wooche	
19 September		Trek from Wooche to Tarina	
20 September		Trek from Tarina to Rodophu	
21 September		Trek from Rodophu to Taksimakha	
22 September		Trek from Takshimakha to Gasa Tsa Chu Meeting with Dasho Dzongda	Halt at *Dzongkhag* Guesthouse
23 September		Halt at Gasa	
24 September		Travel from Gasa to Thimphu	Multiple road blocks complicate and delay travel considerably.
25 September-3 October		Working out of information, gathering of additional information, drafting of report, preparation of presentation,	
4 October		Debriefing presentation to the Project Board; debriefing to UNDP	
5-6 October		Travel Thimphu-Paro-New Delhi-Amsterdam-home base international consultant	

Appendix 4: List of People Interviewed

Table 1: Officials interviewed at Thimphu Head Offices

Serial No.	Name	Designation
1	Dasho Sonam Tshering	Hon. Secretary, MoEA
2	Dasho Sonam Yangley	DG, DGM and Project Director
3	Dasho Namgay Wangchuk	DG, DDM
4	Karma Tshering	Director, DHMS
5	Dowchu Drukpa	Project Manager, DGM
6	Karma Dupchu	Project Manager, DHMS
7	Chencho Tshering	Project Manager, DDM
8	Sangay Tenzin	Dy. Project Manager, DHMS
9	Vijay Moktan	Director, WWF
10	Phurba	Focal Person, Climate Change, WWF
11	Ms. Tandin Lham	Focal Person, GEF, GNHC
12	Thinley Namgyel	Chief of Climate Change Division, NEC
13	Christine Jantscher	Head, Austrian Coordination Office
14	Karma Lodey Rapten	UNDP, CO, Assistant Resident Representative, Head of Environment and Disaster Risk Management Unit

Table 2: Punakha *Dzongkhag* Officials

Serial No.	Name	Designation
1	Gyem Tshering	*Dzongkhag* Livestock Officer
2	Kuenzang Namgay Tshering	Dzongda
3	Rinchen Penjor	*Dzongkhag* Environment Officer
4	Zangmo	*Dzongkhag* Health Officer
5	Tandin Tshering	Asst. *Dzongkhag* Administrative Officer
6	Tashi Wangchuk	*Dzongkhag* Forestry Officer
7	Phuntshok Wangdi	Dzongrab
8	Tshering Norbu	Administrative Officer

Table 3: School teachers met at Bajothang Higher Secondary School

Serial No.	Name	Designation
1	Shankaraj Sharma	Principal
2	Tshewang Jamtsho	Vice Principal (Disaster Focal Person)
3	Bholanath	Teacher
4	Ugyen	Teacher

Table 4: Wangdue *Dzongkhag* Officials

Serial No.	Name	Designation
1	Sahadev Thapa	Dy.Chief Planning Officer
2	Kul Bahadur Gurung	*Dzongkhag* Livestock Officer
3	Lhapchu	*Dzongkhag* Engineer
4	Tika Ram Bhandari	Junior Engineer
5	Chhimi Tshering	Asst.Land Record Officer
6	Tshewang Penjor	*Dzongkhag* Education Officer
7	Yeshey Dorji	RO
8	Pelden Wangchuk	ICT Officer
9.	Dorji	*Gewog* Administrative Officer
10.	Wangchuk Tempa	Administrative Officer
11.	Dorji Wangdi	*Dzongkhag* Environment Officer

Table 5: Officials met at PHPA Office, Lobeysa

Serial No.	Name	Designation
1	Sonam Dawa	Chief Administrative Executive
2	JS Bajwa	Engineer In Charge, PHPA I, (Dam)
3	Wangchuk Hexzo	Chief Security Officer
4	Lobzang Dorji	Chief Environment Officer
5	Lhatru Dorji	Fire Officer
6	Chimi Dorji	Adm. Officer
7	Sonam Wangchuk	Junior Environment Officer
8	Yeshey Ngedup	Senior Labour Officer
9.	Chundi Dorji	Senior Labour Relations and Welfare Officer(PHPA II)
10.	Kelden Drukpa	Dy. Chief Security Officer, PHPA I

Table 6: Faculty and Trainees met at Khuruthang Institute of Electrical Engineering

Serial No.	Name	Designation
1	Kinley Penjor	Principal
2	Damber Thapa	Instructor
3	Samten Dorji	Instructor
4	Tenzin	Trainee
5	Duejang Wangchuk	Trainee
6	Ms. Tshering Choden	Trainee
7	Ugyen Lepcha	Trainee
8	Pavin Tamang	Trainee

Table 7: Teachers and RGOB Officials and local people met at Wolathang Primary School, Toewang, Punakha

Serial No.	Name	Designation/ Occupation
1	Chimi Tshewang	Principal
2	Namgay Thinley	Teacher
3	Ms. Pema	Teacher
4	Namgay Wangchuk	Teacher
5	Kinley Rabgay	Teacher
6	Ms. Nim Dem	Teacher
7	Tshering Norbu	ADMO
8	Dechen Lhendup	ADEO
9	Tenzin Tshewang	GAO, Samadingkha Gewog
10	Nakphel	Mangi Ap
11	Langa Dem	Shop Keeper
12	Lhaden	Shop Keeper
13	Phub Dem	Shop Keeper

Table 8 Multi-disciplinary team members and Gasa *Dzongkhag* Officials met during the Gasa-Lunana-Gasa site visit

No.	Name	Designation/ Occupation
1	Karma Toeb	Team leader, Head of Glaciology Division, DGM
2	Phuntshok	Assistant Forest Officer, JDNP representative
3	Jigme Jamtsho	Engineer, DoR, MoWHS
4	Major Sonam Tshering	RBA, Tencholing
5	Major Leki Wangdi	Security member, RBA, Tencholing

6	Dr. Suresh Chandra Mothey	Doctor, MoH, Gasa *Dzongkhag*
7	Lalit Kumar Chhetri	Senior Surveyor, DGM
8	Phuntsho	Store-in-charge, DGM
9	Tashi Wangdi	Lama, Monastic Body, Thimphu
10	Samten	Engineering Geologist, DGM
11	Nidup Dorji	Project Accountant, DGM
12	Hari Prasas Gurung	Support staff, DGM
13	Dorji Tenzin	GAO, Laya
13	Sherab	GAO, Lhedi-Lunana
14	Dasho Sonam Jigme	Dzongda, Gasa *Dzongkhag*
15	Dasho Chewang Jurmi	Dzongrab, Gasa *Dzongkhag*

Trekking Crew members of Gasa-Lunana-Gasa trek

1	Pema Wangchuk	Owner Adventure Bhutan Travels (ABT)
2	Tezin	Guide
3	Sangay (Tolong)	Cook
4	Dorji	Ass. Cook
5	Laya Dorji	Horseman
6	Karma Tshering	Horseman
7	Gasa Dorji	Horseman
8	Rinchen	Horseman

Appendix 5 Interview Transcripts

27th August 2012
Punakha *Dzongkhag*
Dasho Dzongdag's Office,
Punakha

The Review Team was accompanied by Chencho and Karma Dupchu, the two project managers from DDM and DHMS respectively.

Having arrived in Dasho's Office around 2:30pm, Chencho opened the meeting with the introduction of the purpose of the meeting with Dasho Dzongdag and his officers. Punakha being located in the lower basin of the PhoChhu, the highest impact of the GLOF would be felt by many communities living alongside the PhoChhu river- to name a few, the communities are Wolathang, Samdingkha and Khuruthang.

The Review Team's mandate being review of Technical and Social Impacts of the methodology applied in the implementation of the Project, following were the points of discussion which were guided by an open ended questionnaire:

A. GLOF experience and expectation and impact of Project

1. Dasho Dzongdag was appreciative of the GLOF Mitigation Project; said that it had generated information, which is power in modern day world;
2. The ongoing mitigation work has reduced risk from the Pho Chhu side;
3. A recent flash flood, on June 28th, from the Mo Chhu reinforced the perceived need to have EWS on Mochhu side too. Mo Chu has repeatedly flooded and is considered a real threat.
4. In times of flood, loss of lives is not as worry-some as the public properties as people have time (about 7 hours in case of GLOF from Lunana) to evacuate but evacuating the public properties like the Dzong, and the Training Institute at Khuruthang and other government structures like the PHPA are impossible;
5. Managing disaster is a bottom up approach in Bhutan: *Chiwog-Gewog-Dzongkhag-*Central Government (National Levels);
6. Expectation of the local communities different from those compared to the civil servants, the local people want/demand hard structures as mitigation measures for the disasters-something like a "wall" whereas the civil servants expect their capacities to be built.

B. Hazard Zonation and red/yellow zones

7. Zonation of the areas along the river basin had been done as "red," "yellow," and "blue";
8. No new constructions are allowed in the red zone but there have been few outstanding cases who still built their houses in the red zone. Such cases were allowed to do so at their own risk and government would not be responsible for insurance of such structures;
9. Gups are helpless (as elected leaders) to prevent some people from building their houses in the red zone; some people believe that man-made calculations are not reliable. In principle no permits are issued for construction within the red zone, but people will continue to construct on their land.
10. Structures like the Emergency Operation Center (EOC) is in Khuruthang as a pilot project, this serves as an evacuation center for the locality;

C. EWS and trainings/awareness

11. EWS is in place; sometimes, use of mobile phones for warning fails as there is traffic in transmitting messages, especially in times of emergencies;
12. Giving vouchers for mobile phones to focal persons along the river basin for flood warning worked well, however their phones needed updating;
13. In terms of raising awareness and generating information, audio visual aids were found to be more effective;
14. Trainings were given to the households living alongside the river basin before, but there is a constant need of refresher trainings as settlements keep increasing;
15. The *Dzongkhag* Disaster Management Committee was initially headed by the DEO, but now the Admin. Officer has taken over. There is flexibility in member composition, but all sector heads are taking part.
16. Eleven *gewog*s have been trained on CB-DRM by DDM; people/communities made capable to write their own Community Disaster Management Plans based on the local knowledge;
17. There are different groups designated to manage disasters, example-"Search and Rescue" and "First Aid Group;"
18. Awareness on safe constructions like the quality control in constructions in order to withstand disasters have been raised;
19. Information level of the GLOFs have gone high after the mitigation project started at Lunana; Economic development not hampered by the Hazard Zonation as lives have continued as normal and businesses are still continued;
20. EWS has made people more relaxed (more peace of mind) as they know they will be warned/informed when the flood will be coming; Communities are empowered with knowledge on GLOF hazard;
21. When an exercise on the EWS was conducted by the Hon.PM in one of the meetings, people knew what to do and what the siren was for;
22. But the *Dzongkhag* is still waiting for mock drill/training from DDM for the GLOF; schools do drills for earthquakes;
23. At present there is little local engagement in the maintenance of the EWS (local bye-laws lacking): would be good to involve local communities to enhance sense of ownership
24. False alarms cause some anxiety; it is essential to limit these as much as possible.
25. Participation of women not so open; geographical differences, concerns differ with topography even though in the same *Dzongkhag*; *chiwogs* close to river have clearly more concern for GLOF than those located higher up;
26. Agriculture lands left fallow are mostly due to shortage of labour and not because they are in the red zones;
27. CB-DRM skills amongst the civil servants and the DMC not sustainable as they get transferred to other *Dzongkhags* and come from varied backgrounds in different *Dzongkhags*;
28. There is a National SAR Team consisting of 20 members who is supposed to act as national trainers;

D. Key Lessons from the Project:

29. Re-aligning of the roads at higher levels might slowly motivate people to shift their houses away from the red and the yellow zones; Now about 90% of the roads fall partially in the red zone.
30. The most important aspect of GLOF project management should be good documentation, the need of the moment;

31. Mitigation works are concentrated at PhoChhu and negligible intervention at the MoChhu without a single EWS Unit along its side is a growing concern as it has impending dangers like flash floods/GLOFs too;
32. Fear of Punakha Valley and the *Dzongkhag* Administration is that flood mitigation need not be concentrated only to PhoChhu as it could also come from other rivers like MoChhu and/or flash floods as a collection of smaller streams joining the main river;
33. Well informed about the risks from GLOF. Now that the people are aware, they are made equally accountable for mitigating the risks;
34. Cooperation and coordination much improved to save lives and properties in times of emergencies;
35. *Dzongkhag* people trained as trainers of CB-DRM ToT but when they get transferred, there is no continuity of the skills;
36. Needs more trainings on SAR and need to have proper equipment in place;
37. Very less knowledge on how and what is happening at source at Lunana Lake Mitigation Project.

E. Recommendations:

38. DGM/DDM should have more long term study on Glacial Lakes; Project should continue for more years for a holistic study;
39. Continue the work; people up stream should be able to inform the people downstream;
40. Focus more on prevention than build structures like EWS or river training works;
41. Make it illegal to build structures along the red zones;
42. Budget allocation for DM at *Dzongkhag* level to plan, implement and monitor the impacts of disasters;
43. 11 FYP does not emphasize GLOFs as planning is done per the village needs and they do not see GLOFs as impending dangers;
44. Essential to continue with/refresh awareness raising activities;
45. Documentation has been lagging behind; project needs to focus more on dissemination of progress reports/activities.

28th August 2012
Wangdue *Dzongkhag* Office (Temporary)
Wangdue Phodrang

Officials present: *Dzongkhag* Disaster Management Committee

Serial No.	Name	Designation
1	Sahadev Thapa	Dy.Chief Planning Officer
2	Kul Bahadur Gurung	*Dzongkhag* Livestock Officer
3	Lhapchu	*Dzongkhag* Engineer
4	Tika Ram Bhandari	Junior Engineer
5	Chhimi Tshering	Asst.Land Record Officer
6	Tshewang Penjor	*Dzongkhag* Education Officer
7	Yeshey Dorji	RO
8	Pelden Wangchuk	ICT Officer
9.	Dorji	*Gewog* Administrative Officer
10.	Wangchuk Tempa	Administrative Officer
11.	Dorji Wangdi	*Dzongkhag* Environment Officer

Wangdue *Dzongkhag* Disaster Management Committee are all male officers. Dasho Dzongdag, Dzongrab and the Thrompon had gone to receive the newly appointed lady Dasho Dzongdag of Tsirang. From the people who attended this meeting, only the planning officer had full knowledge of the disaster management component as the rest of the officers were newly transferred here, and they expressed the need to be familiarized and trained by DDM for disaster management with a focus on GLOF. This situation called for measures to be taken for sustainability in the future. Points of discussion guided by the questionnaire were as follows:

A. GLOF experience, expectation and impact of the Project

1. The *Dzongkhag* administration lost all documents in the Dzong fire including the *chiwog* CB-DRM plans: need for new set of CB-DRM documents and maps was expressed;
2. Repeated awareness raising to the people living in the red and yellow zones was found necessary;
3. DRM has become a real theme in the *Dzongkhag*: before it was more ad-hoc base. CB-DRM is now infused into planning.
4. CB-DRM trainings and sensitization to all the *gewog*s have been happening and knowledge about disaster resilience has been developed amongst the local people;
5. CB-DRM Manual was translated to Dzongkha about two years back and now there is increased knowledge of disaster management amongst the public; contents of the manual were found quite satisfactory.

B. Hazard zonation and red/yellow zones:

6. The only person in the group who had knowledge of GLOF as a disaster informed the floor that he knew about the hazard zonation done in the Punatsangchhu basin and that the colour codifications were “red,” “yellow,” and “blue” and the fact that there are some areas under the red and the yellow zones worry them a lot;
7. Community members were taken around and the pegs used to demarcate the zones were shown to them;
8. There are still some houses in the red zones; haven’t been able to stop some people from constructing in the red zones;

9. After the cadastral survey, those land owners whose lands were in the red zones were allocated compensation lands to safer zones;
10. Experience of floods of 1994, Cyclone Aila and the most recent flood in June have compelled residents and communities of Wangdue to develop the habit of making people look out of their windows every morning to gauge the water levels;
11. It was only after the 1994 flood that all sorts of interventions came about to mitigate impacts of GLOF and the project intervention started sometime in 2008;
12. Main impact of the project was the raised level of knowledge amongst the people and they are more at peace now than before as they have faith that the project is doing something up there to help reduce the impacts of GLOF; It has also helped in the socio-economic planning of development projects;
13. Now people are aware about the EWS structures in place which will forewarn the downstream population if at all there is a flood coming from Lunana and that it takes about 7 hours before it reaches Punakha/Wangdue.
14. However, once there was a false alarm from the EWS equipment based along the river basins. That alerted and scared everyone but later found that it was not for the real flood. Such incidents are unwelcome as it creates unnecessary fear and panic among the people;
15. But generally, people are aware where to go for safety if sirens start and what the siren would warn about;
16. Negative impact of the Project is that people are not happy when they're asked to resettle elsewhere from red zones or not allowed to build new houses in the red zones as they have attachment to their land and houses and also believe that it might take at least another 50 years or more before another such flood comes; restrictions have a negative economic impact;
17. Communication/ transportation infrastructure like the bridges over Punatsangchhu, if damaged, could cause great danger to the local people of Wangdue. Wangdue is known for "varieties" of hazards;

C. EWS Training and awareness

18. Need more and strengthened input for awareness raising and trainings; sustaining the activities will not be a problem as it is within the civil service; Some incentives should be kept in place in order to sustain the management of EWS structures in place;
19. Eleven *gewog*s from the total of fifteen have been already trained on CB-DRM; Wangdue being one of the six *Dzongkhags* which are the pilot *Dzongkhags* for CB-DRM;
20. Much needs to be done for medical response to emergencies; training only few won't help, have to have the whole community ready to face disasters;
21. Wangdue BHU (Gr.1) located in red zone is a great concern to the *Dzongkhag* Authority; vulnerability assessment of medical facilities going on at the moment; Health emergency plan is being developed;
22. DDM budget allocation for disaster management needs to be reviewed as it is felt that some places get more importance than others; there should not be concentration of attention to any particular place like that;
23. Procurement of equipment like rafts and boats for emergencies should not be based on bidding rules as the low bidders supply low quality goods thereby leading to more disaster impacts;
24. Expressed need for drills as part of preparation for disaster and that drills should be a regular program with an assigned focal person; test of the EWS should be done well before it is found defunct when the real need arises;

D. Key Lessons from the Project/GLOF:

25. Awareness level raised amongst the people for GLOF as a key output; this leads to reduced level of vulnerability and enhances preparedness. Translates abstract effect of climate change into concrete actions in the *Dzongkhag*;
26. There's need for more ICT knowledge development to manage disasters;
27. Most recently, there is a Program called ECP (Environment, Climate Change and Poverty) which has come as a result of mitigating disasters taking on board the environmental and poverty reduction issues;
28. There is no gender biased representation in meetings deliberately; whoever is available comes and attends the trainings/workshops for disaster; But mostly, women are shy to come forward and attend public meetings/trainings as they are held up by household work;
29. Re alignment of roads to higher levels might motivate people to move their houses together with it;
30. Need to collaborate closely with RBA, as they are essential in times of disaster.

E. Recommendations:

31. Project activities should be streamlined in the FYPs; replication of activities should be done in other GLOF zones like Chamkhar Valley;
32. There should be proper communication in place for more information generation and not do it as part of the ToR only;
33. There should be uniformity in the Focal Persons for disaster and not have people from varied backgrounds like Env. Officer in one *Dzongkhag*, planning officer in another and livestock in the third and so on; It would be more advisable to have FPs from the same technical background;
34. The focal person's post should be decided by the central government and not left to the *Dzongkhags* to decide;
35. Desuups are very efficient to manage disaster as they are trained to do so; contributed a lot during the Dzong fire;
36. To enhance sense of ownership of communities, it requires the provision of a certain incentive for those who take care and are accountable for maintenance of the EWS.

28th August 2012Bajothang Higher Secondary School (Yellow/Red Zone)
Wangdue Phodrang

Officials Present:

Serial No.	Name	Designation
1	Shankaraj Sharma	Principal
2	Tshewang Jamtsho	Vice Principal (Disaster Focal Person)
3	Bholanath	Teacher
4	Ugyen	Teacher
Project Officials		
5.	Karma Dupchu	Project Manager, DHMS
6.	Chencho Tshering	Project Manager, DDM

Interview in this school was an open ended one without the use of the questionnaire. Principal was very accommodating and welcomed the team for the discussion. Following were the minutes of the meeting:

1. The School has a strength of 742 students and 22 teachers and the location is a little above the river Sunkosh banks on the side of the Bajothang town;
2. It was learned that there were School Programs for senior and junior students separately for mitigating disaster;
3. The school has a School Disaster Management Club started early 2012 with 42 members and there is a representative from each class as Wangdue is prone to many hazards like windstorm, fire and GLOFs;
4. GLOF awareness program was also raised among the students; they were aware that there is a Lhakhang (monastery) nearby which is demarcated as the evacuation place for the school and ;
5. Drills for earthquake like the “Duck, hold and cover” were being conducted at least twice a year;
6. Awareness materials and curriculum developed as part of “ Safe School Initiative” and it is being taught and used for raising awareness amongst the school children; knowledge on the lakes and danger zones are taught to the students;
7. The school also has an equipment storage facility donated by the SDF for emergency kits/equipment like few pairs of helmets, fire extinguishers and First Aid Kits; however the school is in need of more equipment to develop disaster resilience and preparedness;
8. The School has a School Disaster Management Plan, covering key disasters, including GLOF.
9. The School intends to organize a GLOF mock drill later this year to raise awareness and preparedness of the students;
10. As a whole, it was learned that the students of this school have good exposure to the knowledge of disaster management trainings and lessons.

Recommendations:

1. Disaster management trainings with a focus on GLOF is necessary for the teachers;
2. New findings on the impending dangers should be shared with the school as they are first hand stakeholder in the river basin;
3. Additional info material for curriculum development and awareness programmes is welcomed by the school.

August 28th, 15.00-17.00
Punatshangchu Hydropower Authority (PHPA), Lobesa
10 staff (see name list in Appendix 4)

Open-ended interview on PHPA's involvement, concerns and management steps to deal with a potential GLOF from the upper basins.

- PHPA I will be about 1200MW and PHPA II 1021MW.
- The 1994 GLOF event has made the staff aware that they have a great responsibility for their staff, many of whom work in or below the river bed and are thus exposed and vulnerable to any flood event. It also requires special attention in the design phase, to be able to accommodate and withstand the negative impacts of a GLOF.
- PHPA supports the EWS installation with a financial contribution of about Nu20million.
- PHPA has its own Disaster Management Plan, aimed at safeguarding the lives of 7 to 8,000 staff. A vulnerability assessment has been carried out as base for the DM Plan, taking into account risks as fire, slope instability and earthquakes.
- In its control room PHPA has a separate communication line with Lunana (satellite phone with flood warning staff up there)
- Apart from Pho Chu, the staff expressed certain concern with the Mochu upper basin, as potential origin of flash floods.
- PHPA I: dam construction is now on-going, with the base of the foundation 70m below present river level. In total about 4 years need to be worked below river level, of which 1 year has passed. The EWS therefore is essential.
- The dam is designed to handle a probable maximum flood + a maximum GLOF combined, estimated to be around 4,500 m^3/sec. The dam is over dimensioned and designed to accommodate 15,000m^3/sec. The dam has sluices to lower the lake level to accommodate an incoming flood surge wave.
- These 7 sluices or gates have a combined discharge capacity of 15,000m^3/sec, equalling the worst case scenario input. Facilities will be in place to take care of logs and debris (floating material). To minimize the negative impact of the sediment load of a flood, the inlet gates of the de-silting chambers will be closed and the turbines shut down in time.
- The team expressed to have no worries about the water volume. The sediment accumulated will be washed out yearly, as usual for a run-of-the-river scheme.
- The highway downstream will be submerged after the sluices are opened: but this would have happened anyway, dam or no dam….
- Investment for PHPAI is about 8,900 crores and for PHPAII 7,000 crores, combined about 16,000 crores, which amounts to about USD$3 billion.
- A concern was raised regarding the Wangdue bridge over Punatshanchu. The Executive Engineers indicated to have spoken with the Swiss architect/designer of the bridge, who stated that the bridge is designed for a maximum flood of 4,000m^3/sec and a flood wave height of maximum 7-8m. A worst case scenario flood would therefore be an immediate threat to the bridge. The EE did not think that additional mitigation works at the base of the arch of the bridge would be of any use.
- The staff of PHPAI and II is given awareness training on disasters, including floods/GLOF risk. The red zone has been delimited in collaboration with the Project, and there are only temporary structures in the red zone as of now. Staff has participated in the *Dzongkhag* DRM training.
- Post-Construction, the staff feel confident and see no direct vulnerability. During construction they will need 3-4 hours to mobilize all staff and evacuate staff and equipment.

- The present coffer dam is designed for 2,400 m^3/sec. After Aila, the design was adjusted to be able to deal with higher flood levels, which caused some delay in the overall project. A GLOF therefore could lead to water entering the present construction site….
- Initial dimension of the coffer dam was 1,900 m^3/sec, but was raised to 2,400 m^3/sec to have an increased margin (Aila was about 1,900 m^3/sec).
- Every month mock drills are organized to prepare staff for emergencies.
- As extra precaution, PHPA has decided to equip the flood warning staff upstream in Lunana with a satellite phone during the construction phase.
- Apart from the DM plan for both sites, the contractors at these sites have their own focal points for emergencies and have an own alert/alarm system with sirens inside.
- PHPA feels comfortable with the EWS as it is now. The hazard zonation was initially felt as an issue, but after demarcation on the ground (pegging) it is in agreement.
- Training of unskilled labourers is rather complicated: awareness is not easy to create, also because there is a high turn-over of staff.
- Basochu project will be damaged in case of a GLOF. It is located in a turn of the river, in a narrow section and the switch yard might be flooded/undercut by a flood of large dimensions. This is a point of worry.
- Most essential for PHPA is the EWS. There is a clear need to continue support and collaboration with DHMS and DDM to ensure that the EWS will be a lasting infrastructure.
- For PHPA I 118 land-for-land compensation cases were treated. Land owners were offered employment opportunities, free electricity to a certain maximum limit (1ac → 10,000 units). 8HH were resettled, in total 22HH had land and livelihoods affected by PHPAI, For PHPAII only 1 house will be submerged.
- Aila has been a clear learning point. To come with a robust design of the dam phase one has to be informed of the highest possible flood peak volume. Aila superseded the initial maximum flood expectation and the project had to go back to the drawing table…
- PHPA expressed the need for seismic and landslide hazard zonation from DGM. In fact these should be available before the project is initiated…
- There is a fourfold information/alert-alarm system in place:
    - Chief Engineer to EEs at site
    - Security staff to staff at site
    - Contractors to their supervisors at site
    - Labour officers to their site staff

Date: 29/8/2012

Dzongkhag: Punakha
Gewog: Toewang
Chiwog: Wangkha-Esukha, Village: Samadingkha

Disaster Management Focal Point: Tshogpa
Others: DDM and DHMS Project Managers.
Number of community members present at meeting: 8males / 5 females

A GLOF experience and expectation and impact of Project

1. GLOF is very uncertain by nature. We do not know if it'll come in winter or summer. It is also very destructive. But now we're relying on the government intervention of mitigating the problems through lowering the project. Now that the government has done some river training, we're hopeful that it'll protect us as the river is flowing straight now.
2. There was some plantation done as part of the project to save the river sides but because the soil is sandy and they had planted it in summer, the trees died down.
3. As we're uneducated, our main fear is if floods come before the end of the project.
4. Our fields, houses and properties which are along the river basin are dear to us but we have no choice other than to live here as we cannot go anywhere else.
5. At the beginning of the project, we were glad that our government is doing something good to save us and that even if floods came, there is enough time to save ourselves although we may not be able to save our cattle and properties.
6. We're ready to go up to safer places if the floods come in winter as there's plenty ofplaces to run to but we're concerned if it comes in summer, we do not have much place to run to and so the government should find an evacuation site. In summer, everyone would have planted their fields and some areas are locked/fenced by the owners.
7. As positive impact of the project, we are confident that at least there will be time to prepare and run to safer places if the floods come as we heard that there are sirens placed in different places along the river.
8. About the impact of the project lasting for years, we feel that the machineries will be there even after the project and we like to request the government to keep them as they are for our benefit.

B Hazard zonation and red/yellow zone

9. We heard that colour coding is done for different areas as they are written on stones/boulders and trees.
10. We know and agree that no one should live in red zones but we have no choice but to live there as all our livelihoods revolve around those areas with accessibility to all facilities like roads and electricity.
11. The hazard zonation has not caused us any loss of economic opportunities as we still live there without any choice of shifting.

C EWS and training/awareness

12. We have felt safe after the project started as we know that government is doing something very good for us only. Now we know that we will be informed when the floods come. At least we are relaxed that there is time to prepare for evacuation.
13. We attended a training with the DDM officials who come and gave training to us.

14. Regarding the sirens, we're told that there will be some noise from the machinery planted nearby out villages but since we have not heard the sound even once before, it would be a great help if we could have some training before the actual floods come. Sometimes, the machinery things do not work when we need it the most and it may be very tragic and too late then.
16. We have not had a drill for the siren yet but we would like to request for one in the future soon.
17. Yes, we have local by-laws in place to take care of community properties and we are ready to take care of such structures like we do to lhakhangs and chortens; all we need is the handing over of the responsibility.
18. Regarding the participation of women in the GLOF Project, our women are shy and do not take part in projects of this nature but they are active members of women's organizations and they are fully aware of their rights as women. They are quite powerful at homes.
19. The community members took part in the trainings and because the trainings were participatory in nature, most of them were very active in drawing the maps for demarcation of hazard zones of the *chiwog*.
20. There are two NFE centres in our village, with seven students in one and twelve in the other.

D. Key Lessons/E. Recommendations:

21. Those who are working in the project right now should be maintained as they are doing good job. Grateful for EWS structures in place and measures should be taken to ensure everything runs well when needed.
22. We learnt that adequate measures should be taken from now itself in order to avoid catastrophic events in the future. Depth of the lake should be lowered to such an extent that there will not be any GLOF in the near future.
23. We're happy that this time there is plenty of mitigation work going on. One of the respondents said "I*n 1994 flood, I lost about 1.5 acres of land to the flood. The officers from Dzongkhag came and measured the area of the land that was damaged but I never got any compensation for that*."
24. The river water had come up to the old bridge grounds and had entered the shops that were standing there. There were lot of debris like sand and logs on the river bank.

Interview Minutes (*Chiwog* level meeting)
Date: 29/8/2012
Dzongkhag:Punakha *Gewog*:Toewang
Chiwog: Tamidamchhu, Village: Tsachuphu Kewana
People present: 12
Disaster Management Focal Point: School Teacher
Others… *MangiAp* and Community members
Number of community members present at meeting: 07 males / 05 females

A GLOF experience and expectation and impact of Project

1. We heard that there are big mountains of snow which fall into the lake and when it melts, increases the water level of the lake which in turn will flow down in big volumes with the possibility of taking our fields away.
2. We have the knowledge that it is dangerous and we do not get peaceful sleep. There were times we would get up in the middle of the night and monitor the water levels whenever we heard big sounds from the river. As we are just next to the river, it is our constant worry that we might be taken away any time.
   What would be your main fear if a GLOF would happen in your chiwog?
3. Our main fear is for the school as it is located just at the river bank and the river here gets splashed back by the rocks on the other side. There is also an easy entrance for the river a little above the school premises and if the river gets flooded, water might come directly to our school ground and flood us.
4. It would be a great help to get some assistance to train the river in that area. It would not cost much but would give us a great protection.
   What do you consider to be most vulnerable in your chiwog?
5. School. We do not mind if we lose trees and other lands but we are worried about the safety of our children in school.
   What were your expectations at the start of the project?
6. We were relaxed that the project would be lowering the water level at Thorthormi lake and that it would save us. We heard that the government is doing a great work up there and have lowered the lake by about 4-5 meters.
   How do feel now, after 4 years of project? Has it lived up to your expectations?
7. Yes, the project has given us the sense of security and we are fortunate that the machine (EWS) is there to alert us but we also heard that sometimes the warning systems do not work, especially in times of big floods and so we worry what will happen to us then.
   Because of our location, we feel as though we are like "frogs under the boulders which have no choice but to die."
   What has been the impact of the project after 4 years (both in positive/negative sense and with examples if possible)
8. Positive lessons: Some of us are trained and we will be training some more people in the near future on the actions in situations of flooding.
   Do you think this impact will last?
9. Cannot say but we are hopeful that our government will do good whatever they do for us.

B Hazard zonation and red/yellow zone

Do you think there is good knowledge and awareness of the "red zone" in your chiwog?

10. We were not told about that yet.
    Do you agree that no one should live in the red zone?
11. NA.
    Do people still live in the red zone?
12. There is no house in the red zone in this area, our house are all a little upstream but our school is located very near to the river, so in future, we feel that the location of schools should be very well planned and placed in safe places.
    Does the hazard zonation cause problems? Less economic opportunities?

13. Although not much to our properties, our school will be affected and since the road is right by the river side, if that gets washed away by the flood, our villages will be cut off.

C. EWS and training/awareness

Has there been a change in the sense of safety in your chiwog through the activities of the Project?

14. Our worries have lessened after the mitigation project started. We would like to know and get trained on what to do if there is a GLOF. We haven't heard the sound of the alert system, so it would be nice if we get drill/training for that.

Have you participated in any trainings related to GLOF/disaster management?

15. Not yet. (But the Mangap had attended the gewog level CB-DRM).

Are you confident that everyone knows what to do if the sirens start?

16. We will run to the upper safer areas if we hear the siren. (Not sure about the exact place).

Have you taken part in drills? Apart from schools?

17. *NO*

Are there local by-laws how to maintain/take care of the EWS hardware? Fencing? Responsibility?

18. Mangap: We have it in the gewog plan/LG that any government structure if entrusted to our care, we are required to take up the responsibility and take care of them. We just need the handing taking over formally. We'll make sure that no one throws stones to structure and the cattle do not enter the fenced area.

How would you describe engagement of women in the GLOF Project?
(Women participation / gender sensitivity / inclusiveness of process/Pro-active steps of the project for women engagement)

19. *Our women have not been taking active roles so far but if needs arise, then they'll do.*

How would you describe the community engagement (role of chiwog administration)? Is there a difference between this chiwog and other chiwogs regarding community commitment, and if so, what are causal factors behind this?

20. The villagers are co-operative and very forthcoming.

How has the community participation been in trainings? Is there good use of pictures, so that all can take part? What were the factors of hindrance (if there were any) for community participation?

21. The permanent residents of the village/community are not involved fully in the trainings by DDM. Because the school staff are only temporarily here for just about 4-5 years, it would be good if DDM could include the villagers fully for any trainings related to managing the floods/disasters.

Is there a NFE centre in your area and have they been trained by the project?

22. There was a NFE till 2010 but now it is no more there. (None of the participants of the meeting had attended NFE).

What would you consider to be the key lessons learnt from the GLOF Project and why?

23. We learnt that the lake is very dangerous and wide and it is melting fast. We learnt to stay vigilant and plan where and what to do if the floods come.

Do you have recommendations for future work on GLOF based on your experiences?

24. Jalarongchu and Sechhu keep disturbing/scaring us. IF they join together, there will be a big flood and it might also cause an equivalent problem to that of GLOF from Thorthormi Lake.

Would you have recommendations for an exit strategy of the GLOF Project, as it is nearing its project end, in order to enhance sustainability of the project impact?

25. We need funds to develop the evacuation site which is located above the road and near the upper village. It is a flat land and because it is located quite higher than the riverbanks, we are hopeful that it will be safe.

What questions did you miss in this interview, or what information would you like to add?

26. From ancestral knowledge, we heard that Phochu flood comes in an interval of every 30 years. Heard that there were lots of wild animals at Wolathang before.
Flood of 1994 and before might have come until the school ground as one can find lots of sand and gravels in the school premises.

Date: 30/8/2012
Dzongkhag: Punakha
Kuruthang Institute of Electrical Engineering (KIEE), Khuruthang Town

Interview at Khuruthang Institute of Electrical Engineering, which started its operation in 2005. It is located in the red zone of the Khuruthang town with a strength of 120 trainees (with 65F and 55M) and 32 faculty staff. In any normal working day, the campus houses about 208 people with the principal, teachers and trainees.

As an open interview, the following were the points discussed:

1. The Institute experienced flood after 4 years of opening it and it was a great learning experience after which the mitigation work, in the form of the protection wall started.
2. The protection wall costs about Nu. 30 Million and is more expensive than the cost of the whole institute. DDM helped the institute rebuild the wall as it was destroyed by Cyclone Aila in 2009. The building of the wall is still on-going. DDM facilitated the mobilization of funds for the construction of the wall.
3. At the time of Aila, river had flooded upto the road point of Khuru. Hotel Damchen which is adjacent to this Institute was flooded and had sand heaped up to 24 inches high.
4. At that time, trainees of this institute were evacuated to Khuruthang Middle Secondary School, which is located a little above the road and has fairly enough elevation to act as an emergency evacuation ground.
5. As part of building capacity to be disaster resilient, DDM trained some of the student of this institute as part of CB-DRM along with some business community members in 2010. The focus of this training was mitigating GLOFs.
6. Trainers from IDRC and Japanese trainers also trained the students here on Search and Rescue skills using a car jack to lift heavy objects.
7. Awareness of hazard zonation was eminent with majority of the group present there.
8. However, expectations for better communication from DDM's side were expressed. And it was felt that CB-DRM training was found necessary annually and not leave it as a one-time event. Especially in Institutes like this, the students keep changing every year affecting the continuity of the knowledge/skills.
9. Significant outcome of this meeting was that potential was seen for DHMS and DDM to liaise with IEE as part of ensuring sustainability of management of the EWS stations.
10. School Focal Persons to coordinate with DDM and prepare their own DM Plan in the near future.

Additional Note: The present situation at KIEE is causing some worry. A protection wall has been erected along Pho Chhu to protect the Institute, but the wall is yet incomplete. The upstream section is missing and therefore the actual vulnerability of the Institute is now higher, as water can now enter the compound, but will be more or less trapped in the compound by the wall. Completion of a wall in the upstream section is therefore needed. The wall built seems very solid, but to be over-dimensioned for the task at hand. A simpler, and cheaper construction could be as effective as the present reinforced structure.

Figure 27. *The unfinished protection wall*

Appendix 6 Consultation meetings with key stakeholders in Thimphu

August 23rd 2012 09.00-10.00am
UNDP CO
Karma Rapten, Assistant Resident Representative, Head of Environment and Disaster Management Unit, UNDP Bhutan Country Office

Discussion points:
- Logistical arrangements for meetings with stakeholders in Thimphu
- Suggestions and feedback to updated programme
- Guidance for approach of assignment: focus on learning, key lessons and impact and sustainability. Reliance on project-managers for further guidance on ToR and specific expectations.
- Gathering information and documents for processing necessary permits: health certificate, road permit, work permit, trekking permit, army permit and Park permit.
- Arrangement to meet trekking agency to prepare for the trek to Lunana.

August 23rd 2012 10.00-10.30am
Department of Geology and Mines (DGM), Ministry of Economic Affairs (MoEA)
Sonam Yangley, Director General DGM, Project Director GLOF Project

Discussion points:
- UNDP-GEF has showcased the GLOF Project regionally and globally as an example and it is at the same time the first ever approved LDCF project. There is therefore a certain pressure and responsibility to deliver and live up to the raised expectation level.
- A future project is being discussed, linked to the second NAPA, in which landslide zonation and mitigation is prioritized, and in which DGM will be again playing an important implementing role.
- The DG referred to how the Lunana valley has changed after the 1994 GLOF from a green valley to the present valley floor dominated by bare GLOF deposits dominating the valley floor.
- The DG expressed his satisfaction with the coordination from UNDP and the overall collaboration with the other line Departments, which has been without major management issues and overall in a harmonious spirit.

August 23rd 2012 10.30-12.00am
Department of Geology and Mines (DGM), Ministry of Economic Affairs (MoEA)
Project Team: Dowchu Drukpa, Project Manager for DGM
Phuntsho Tshering, Dy PM for DGM
Karma Dupchu, Project Manager for the Department of Hydromet Services (DHMS)
Sangay Tenzin, Dy PM for DHMS
Chencho Tshering, Project Manager for the department of Disaster Risk Management (DDM)

Discussion points:
- Welcome/Mutual introduction of Project Team Members and Review Team
- Word of thanks for:
  - Expressed confidence in us as consultants

- Logistical support to get us here both

- ToR: overall expectation and focus (output 2 and 3: lake lowering and EWS)
- Feedback on the updated programme (missing stakeholders?): some amendments were made to the initial schedule.
- Separate meetings with all members/institutions on their key responsibilities/output areas and experience with the project implementation
- Additional meetings with other stakeholders
- The intention is to be of best assistance to help to draw key lessons, extract and document best practices, identify main constraints and how the project team has adapted to these issues, and to contemplate how to replicate and scale-up and make interventions as sustainable as possible (exit strategy and recommendations for other GLOF hazard areas)
- The review team aims to be open, frank and constructive, and learning by listening. They expect the project team to be frank: often best learning comes from failures and mistakes, and it is understood very well how complex the management of this project is, with very challenging conditions. So share please what went wrong, why, when, how and how the project team dealt with it or is still struggling…
- The review team requested all relevant documents, additional to what one can access on the project's website: technical report 2011, Annual Project Reports (APRs), Project Inception Report (IR), Project Implementation Review (PIR), Mid-Term Review etc.
- The review team plans to do as much as possible together, although the members have their specific technical domains: it is thought to be adding fresh perspectives and also be more interesting for the ones being interviewed. Technical and social approaches and impacts are interrelated and should be regarded in a holistic, integrated matter.
- Based on the meetings with the stakeholders the coming days the review team will draft structured interviews for the various meetings with *Dzongkhag* and geog administrations and communities and other stakeholders.
- For clarification: this is not a final evaluation with the usual focus on targets + indicators etc. (relevance, effectiveness, efficiency, results and sustainability).
- Explanation why the Chamkhar basin is not part of the assignment, as the review team will not go there for site visits.
- In the initial project document DHMS was not there as a full partner and the EWS was under the mandate of DGM.
- During the Inception Workshop this was amended and DHMS became responsible and additional funds were mobilized from hydropower projects for the EWS.
- It was complicated to determine the hardware requirements for a EWS, as there are very few examples to learn from. The procurement and compilation of the tender specifications were time-intensive and it was decided to go for a turn-key component, which did not exist under exiting procurement rules.
- Communication module of the EWS is the critical part of the EWS and this required careful weighing of options and priorities.
- The lower region system is operational since 2 years, the lower region since a year.
- The importance of the project was stressed as it brings together, through its set-up, the technical line Departments of DGM, DHMS and DDM. There is now an improved collaboration between the Departments, beyond their technical scope and responsibility. This will be a lasting impact it is felt and seen as a very positive output of the project.

August 23rd 2012 14.00-16.00am

Department of Hydromet Services (DHMS), Ministry of Economic Affairs (MoEA)
Karma Tshering, Director DHMS
Karma Dupchu, Project Manager for DHMS
Sangay Tenzin, Dy PM for DHMS

Discussion points:

- Compilation of bidding documents for the procurement of the hard- and software of the EWS were a big task. It was decided not to hire a consultant, but to do it with own staff. This proved to be an excellent learning experience, although it took about 2 months to finalize the bidding documents.
- The EWS equipment is pre-calibrated at the fabric, which eases installation later in the field.
- The equipment has to pass three separate tests:
  - Factory acceptance test
  - Site acceptance test (after installation on-site), and
  - Overall system acceptance test, aimed at checking appropriate internal communication of the system, through all its respective system elements, integrating hardware and controlling software.
- The turn-key system comes with a 2-year warranty, which is important to avail technical support and guidance when the system is going through its "infancy", with normal "teething problems". Considered to be a "best practice" to replicate for future system development.
- DHMS staff went to the supplier's facility to be instructed on the equipment. After this the supplier provided technical supervision, on-site, while the DHMS staff installed the respective system elements. This proved a very good procedure to build skills and confidence of the DHMS staff and to ensure future independence. The lower system was installed with supervision of the supplier, but the in the upper region system elements were installed independently by DHMS staff.
- The EWS contains the following components:
  - The Data Collection Platform (DCP), consisting of a data logger, power system, solar panel and regulator, Iridium antenna and modem, mast with lightning protection and fencing enclosure,
  - Stream Gauge Stations, consisting of a stream gauge and Dual Orifice Constant Flow Bubbler
  - Hydromet Stations, consisting of a stream gauge and Dual Orifice Constant Flow Bubbler, added with rain gauge, tipping bucket and total precipitation gauge, temperature/relative humidity sensor, wind sensor, solar radiation sensor and atmospheric pressure sensor,
  - Siren Stations,
  - The ESW Control Centre, with system control software, data base and related website.
- The terrain conditions, certainly in the upper region, pose a constraint for installation and maintenance of the system elements, in particular the siren towers.
- There are several communication options for linking the EWS elements: High-Frequency (HF) or Very-High Frequency (VHF) radio, or satellite link-up. Although technically it would be feasible to use HF or VHF for the upper or lower region independently, it was preferred to make use of satellite communication. This ensures a reliable communication platform, not perturbed by atmospheric problems and without the need for repeater stations for extended line of sight (ELOS) communication, taking into account the considerable distance between the upper region and the lower regions and the EWS control room in particular (over 100km).

- Before 1994 GLOF event flood warning was under Telecom, and developed into a flood warning network based on wireless, before Hydromet as a Division became responsible in 2002.
- The existing flood warning system functions as a back-up system and was already equipped with satellite phones.
- The initial project design was built upon a DGM assessment and comprised of a relatively limited system. This has now been upgraded by DHMS to a much more comprehensive system.
- The present EWS is intended not only to warn, but also to collect and monitor hydro-meteorological data. It includes 6 water level measurement stations and 2 automatic weather stations.
- Tarina Tsho is considered to be another hazardous lake, but its outburst flood would not be detected by the lowest sensor of the Upper Region. It will be detected first by the sensor at Danza, upstream from Punakha, reducing the lead time to react.
- Tshojo glacier has produced recurrent floods (most likely related to en-glacial lake/water outbursts, called a **jökulhlaup,** any large and abrupt release of water from a subglacial or proglacial lake/reservoir (http://en.wikipedia.org/wiki/J%C3%B6kulhlaup), often occurring as episodic releases. A recent outburst was reported in April 2009.
- The Japanese-DGM project recently has finalized an updated glacial lake inventory, as follow-up to the ICIMOD publication of 2001.

Challenges:

- Limited technical assistance available from UNDP, which would have helped at the initial stage of design of the EWS. TA was not incorporated in the original project document, and through the late joining of DHMS to the GLOF Project this was felt as a challenge, although it provided a steep learning curve for the DHMS staff.
- The extreme weather conditions, especially in the Lunana region, proved to be a serious constraint for the EWS installation and monitoring and maintenance work in snow and icy conditions.
- There have been problems with the chosen site at Thorthormi Tsho: last winter the sensor tube got blocked by ice formation and caused a malfunction and false alarm, which inevitably causes a certain degree of panic and fear with the Lunana community.
- It is reported that some of the households in the upper region still prefer to live in tents in summer since the 1994 GLOF.
- The DDM training on community based disaster risk management planning (CB-DRM) was carried out later and ideally should have taken place directly after installation of the EWS components within the community. Sequencing should be refined.
- There is no support from the project for DHMS staff in training or maintenance. This is related to the fact earlier mentioned that DHMS joined the project after start. Support is only to hardware. Training/capacity building for DHMS staff therefore had to be incorporated in the turn-key tender for the EWS equipment. Some of the additional financing for the EWS by PHPA has been used for training purposes.
- To mobilize the communities without the possibility to offer incentives has turned out to be difficult.

Sustainability:

- DHMS is confident they are able to maintain the EWS up and running as it is their core mandate to ensure continuous flood warning and meteorological data collection.

- They see more risk for DDM and DGM to maintain their impact as they will have no, or limited dedicated funds for this.
- At the end of the project fund balance is needed for payment of the annual subscription fee to Iridium for satellite services and to maintain the EWS (costs for spare parts and maintenance/monitoring work).
- The present data base, as part of the EWS, is designed to ne expanded nation-wide, but one needs the same, or compatible equipment (compatible with the present SUTRON hardware/software).
- JICA has committed itself to fund the set-up of two more EWS (Chamkhar and Mangdechu basins).
- As part of the second NAPA it is foreseen to upgrade the existing hydromet equipment to state-of-the-art, and link the system with the now developed EWS.
- As stated earlier, there is certainly a clearly improved collaboration between the technical line Departments of DDM, DGM and DHMS.
- As of now, most of the direct consultations with the *Dzongkhag* administration are through DDM. There is a need to think of a continued link with the *Dzongkhags* and geogs after project end. The present Project Board composition, with the Dasho Dzongdas, could serve as an example.
- It is envisaged that hydropower projects in future will support the EWS (in continuation of their present support).
- There is some concern about the engineering structures built by local contractors, if they will be of sufficient quality to endure the harsh climatic conditions and if the contracting quality is sufficient.
- False alarms are an issue, but are restricted mainly to the upper region.
- Planned mock drills of the EWS, through testing the sirens and related evacuation plans, in close collaboration with DDM, should be carried out to build awareness of the communities.

August 23rd 2012 16.00-17.20am
Department of geology and Mines (DGM), Ministry of Economic Affairs (MoEA)
Dowchu Drukpa, Project Manager for DGM

Discussion points:

- The 1994 GLOF was a catastrophe that triggered RGoB's interest, a real eye-opener.
- Concrete activities started with the GOI funded lowering of Rapsthreng Tsho (1997-1999?). At that time MoHCA was the lead agency, but the project was hampered though a series of problems related to audit and managerial issues.
- The Austro-Bhutanese Project, a DGM scientific collaboration with the University of Vienna, between 2000 and 2004, resulted in addition knowledge development in the Lunana region, with focus on Thorthormi Tsho.
- Another scientific collaboration has been the long-term relation with the University of Nagoya and their scientists (glaciologists) since 2000 until now.
- Apart from routine monitoring of the glaciers and glacial lakes, DGM was involved with the ICIMOD study of 2001, an inventory of glacial lakes and related GLOF hazard in the Hindukush Himalayas (Mool et al., 2001). This inventory was Remote Sensing based, without field verification and/or ground truthing.
- The 2008 SATREPS project (JST and JICA) was a follow-up activity to undertake an update of the inventory. For this study 14 of the 25 lakes identified as potentially hazardous were visited. "Glacial lake outburst floods in the Bhutan Himalayas', under the cooperation of JST, JICA andDGM." See Kuensel:

http://www.kuenselonline.com/2011/?p=29947. In this inventory apparently one lake is named as hazardous: Thorthormi Tsho.

- In 2009 it was proposed to have a separate Glaciology Division, which was established in 2010, headed by Karma Toeb and under him 4 staff members.
- In 2007 DGM was involved with the pre-project phase and in 2008 the Project Document was accepted. Initially DDM and DHMS were not involved, which meant that DGM had to cover all thematic areas and it proved challenging to do so. DGM relied partly on the earlier work of the Austrian project and went to Norway to visit the NGI and the national flood warning system.
- The Honourable Secretary of MoEA suggested to have the EWS under DoE during the Inception Workshop. This resulted from a perceived need for a more comprehensive EWS in place compared to the initial design prepared by DGM.
- As this change did not involve any budget implications the funding agencies were in agreement, also as it broadened the stakeholder base and resulted in the closer involvement of the PHPA projects.
- The project has since the joining of DHMS three project managers and one project director, which has worked out quite fine. It is only more complicated to call for PMT meetings with 3 PMs. In addition, it ensures a close collaboration between the three line Departments, which is now already having a positive impact on the relation, beyond the GLOF project work.
- There is relative little interaction with DDM. Only at the start, when DGM realized that mitigation work could trigger a GLOF there was more collaboration to set up a back-up warning system.
- The Disaster Bill is funded through the project and can be considered as a key output for the project under DDM. The final draft is being discussed in parliament, but the process has been very slow. DGM has been involved in drafting of the DRM Framework and the related Bill.
- The Secretary of MoEA has been very proactive and influential and is respected as being a decisive chairperson for the project board.
- Initially there were some issues with UNDP related to fund release, but UNDP has been very understanding and flexible, considering the specific requirements, nature and challenges of the project.

August 24th 2012 9.00-10.00am

Department of Disaster Management (DDM), Ministry of Home and Cultural Affairs (MoHCA)

Director General Namgay Wangchuk

Discussion points:

- A crucial role for the project is being played by DDM in Punakha, Wangdue and Bumthang in creating awareness and through advocacy of disaster risk management (DRM).
- Based upon the GLOF hazard zonation provided by DGM, DDM has focused on the identification of vulnerable communities and areas at risk. The zonation maps are discussed with the public and with wooden pegs the red and yellow zones are demarcated in 21 vulnerable communities. The pegs are partially replaced by iron poles.
- The *Dzongkhag* administration plays a crucial role through their engagement in Training of Trainers (ToT) on community based DRM (CB-DRM). After the initial ToT at Dzonkhag level these CB-DRM planning meetings are rolled out to all communities. First the geog administration staff is trained, after which all chiogs are included one by one in

the CB-DRM planning. The chiog plans are consolidated in geog CB-DRM plans and compiled at *Dzongkhag* level into a *Dzongkhag* CD DRM plan.

- DDM intends to carry out a review of the planning system in the pilot *Dzongkhags*. Is it worth it? Is the CB-DRM planning cost-effective? Should it be as comprehensive as it is, or limited to certain geogs only?

Challenges:

- There is a clear need to continue support to community based institutions. It will be cost-effective and enhance sustainability of the impact related to awareness level, local capacity and preparedness.
- At present, there is no legislature related to recovery and resettling and/or compensation related to disasters.
- The hazard zonations and the red zone with its inherent restrictions, have direct consequences for spatial planning and infrastructure development, with a distinction between already existing infrastructure and newly planned.
- The legal back-up for DRM is now still poor without passed Bill / regulations: “there are not yet legal teeth to bite with…”
- Coordination with the decentralized administrations is difficult without legal back-up. There is no permanent DDM staff based at *Dzongkhag* level, so DDM has to rely on the *Dzongkhag* focal person, which is sometimes challenging, as could be of any sector, and have to their DRM work additional to their technical mandate.
- There is no institutionalized link between the *Dzongkhag* Environmental Committee (DEC) and the *Dzongkhag* Disaster Management Committee (DDMC).

Sustainability:

- Linkage to decentralization and local government is essential to support sustainable impact.

August 24th 2012 11.00-12.00am

Gross National Happiness Commission (GHNC), Tashigo Dzong

Ms Tandin Wangmo, GEF Focal Person

Discussion points:

- UNDP acts as GEF agency and links with GNHC for coordination
- Fund requests, releases and fund flow are managed by UNDP CO. UNDP involves GNHC for AWP preparation and Annual Reviews as GNHC is a member of the Project Board.
- GNHC is pleased with the impressive implementation so far, and the project is taken as a good example.
- A one year extension was granted, due to unavoidable delays in implementation (Ayla impact, Gasa road wash out, early snow fall etc.).
- The project is perceived to have a tangible positive impact on communities in the region.
- The Project is the first under the LDC Fund to be supported and linked to the 1st NAPA.
- Overall, there has been good support from and coordination by UNDP.

Challenges:

- Some issues arose initially over fund releases, partly related to the project design with 3 line Departments having shared responsibilities. As a result the 2nd NAPA now calls for “one house one roof” to simplify project management.

Sustainability:

- What will be the sustainability of the project impact?
- How will the EWS be managed post-project?
- How will DGM continue to monitor the lake(s)?
- How to prioritize other lakes in future?
- GLOF hazard as a theme needs to be part of the 11th FYP from a national level.

August 24th 2012 12.00-13.00am
World Wide Fund for Nature Bhutan Programme
Vijay Moktan, Director Conservation Program
Phurba, Focal Person, Climate Change

Discussion points:

- WWF has contributed small funding support through co-financing of the GLOF Project.
- The visibility of WWF is considerable, although the actual support to the project is minimal (ca. USD$30,000). There is no actual involvement of WWF staff in the project.
- The GLOF Project is considered by WWF as very timely in the context of global and regional climate chance and the contribution it can make to avoid catastrophes. The project contributes to social and psychological security, but it is understood that mitigation of the GLOF hazard is not easy.
- GLOF hazard is a threat beyond Bhutan, as the flood waters will reach India and Bangladesh, and therefore WWF encourages efforts along the entire river basin, even in India.
- WWF has a regional collaboration with WWF India and WWF Nepal, where WWF Nepal focuses more on issues related to the middle river section and WWF India targets the downstream river section.
- WWF's concerns with climate change are linked to impacts on water and biodiversity. WWF presently has a focus on the Protected Areas in the North of Bhutan and hopes to contribute towards climate resilience of the PA network.
- WWF is carrying out a climate change vulnerability assessment incorporating livelihoods, biodiversity and water in the PA's.
- In another activity WWF works on regional wetlands through the "Regional Saving Wetlands Sky High Project".
- WWF is supporting the joining of Bhutan to the Ramsar Convention on wetlands conservation, with site work in 3 locations.
- Outcomes of the Climate Summit 2011 support the GLOF theme through the Road Map document. WWF is engaged with regional collaboration with SAARC and the McArthur Foundation.

August 24th 2012 14.00-15.00pm
Ministry of Economic Affairs
Dasho Sonam Tshering, Secretary MoEA

Discussion points:

- The first project year has been very much about learning and assessing. The second year focused on the start of the mitigation works. The third year was influenced

considerably by the death of 3 labourers and led to more stringent screening of labourers and project staff.

- The cyclone Ayla, in May 2009, caused more weather associated delay and last year the team had to return early because of onset of winter.
- A definite challenge is created by the remoteness and associated problems. Also the sheer size of the labour force, with 300+ labourers in the first year, complicates project management considerably. One should try to bring down the volume of the labour force.
- A recent study by NORAD, through NWI, on climate change impacts on water resources for Bhutan, indicates that if present trends continue, there will be a large problem in about 50 years (rapid decrease in water resource availability). With the existing and developing dependency on hydropower generation, this has serious consequences for the Bhutanese economy.
- There is a commitment from JICA to continue with GLOF related work in the Chamkharchu and Mangdechu river basins.
- The 1994 GLOF had a peak flow discharge of about 2,500m^3, the peak maximum flood the project is foreseeing is about 13,000m^3, taking into account a possible 53 million m^3 in the worst-case scenario originating from Lunana.
- The budget of the project has clear limitations, but as it was understood that the EWS should be comprehensive to get a maximum lead time downstream, additional budget was allocated by PHPA projects.
- The creation of a Project Steering Committee (PSC) has been very supportive, uniting the three line Departments, all accountable to the same PSC.
- There has been good flexibility to divert funds between the 3 components and outcome areas, through a very accommodating attitude of the multiple donors.
- There has been full support by RGoB regarding rules with for instance procurement dispensations to overcome bottlenecks in tender procedures.
- There have been no real difficulties within the management, only “force majeure” events.
- After completion of the project it is advisable to compile a good document reflecting the learning through the project.
- The use of a helicopter has been discussed but was found to be difficult because of high costs, weather uncertainty and the high cost of transporting rations.
- The hazard zonation entails enforcement issues as citizens want to avail maximum economic opportunity from their land in strategic locations close to the river bed. Relocation is often not an option and one therefore has to rely on a robust EWS.
- To make the EWS effective, it is essential to conduct mock drills to train and make aware the vulnerable communities along the river.

- **Challenges:**
- To organize resources to accommodate the large number of labourers: food rations, tools, transport, competition from the local Cordyceps season that complicated availability of local labour, combined with a decreased efficiency of people at altitude.
- Medical facilities for all project staff and labourers have improved over time, but the project has gone through a steep learning curve.

August 24th 2012 15.00-16.00pm
Austrian Coordination Office
Mrs. Christine Jantscher

Discussion Points:

- Has recently joined ACO in Bhutan, therefore has had little interaction with the GLOF Project so far.

- Participated in the recent PSC and some of the discussions were related to what phasing out entails: what to do with equipment brought to Lunana and possible environmental impact.
- She had the impression that the awareness raising component is successful.
- There is apparently a good collaboration within the project between the line Departments.
- The ACO contribution in total amounts to Euro 600,000 for the 3 year period.
- There will not be any future fund support from ACO, but ACO is open for TA/scientific support, building on the existing knowledge on GLOF research and the institutional linkage (DGM-University of Vienna).

August 24th 2012 16.20-16.45pm
National Environment Commission (NEC)
Thinley Namgyel, Chief of Climate Change Division

Discussion points:
- In the 1st NAPA, GLOF appeared as a clear priority, linked to climate change adaptation and mainstreaming into national policy, while mitigating an immediate risk.
- He was partially involved in the project design phase and is member of the Technical Advisory Steering Team (TAST), convening about once a year.
- Within 1st NAPA priority was given based on the risk assessment from the Austrian study, potential downstream impact, the cultural heritage at risk, the vulnerability of the upstarting hydropower projects, and agricultural land at risk.
- Initially the EWS component had a limited scope, but now has become more comprehensive.
- Funds for the 2nd NAPA are loans, which makes them less suited for adaptation work.
- The excavation works at Thorthormi Tsho have a “primitive” look, very low-tech. Considers it wiser to assess if it were possible to apply more high-tech approaches to lower labour staff size.
- There is concern about the environmental impact of the project. An EIA was done and a management plan is there, for which the monitoring is done by the Park management.
- One could think of a central mess, with cooking facilities at one central site, instead of having them spread all over camp. This could involve fuel-efficient stoves etc.
- At Damji, it is recommended to see the Park HQ, where the Park manager resides. A park ranger would be on site to meet.
- At policy level it is of interest to assess the new Japanese Inventory and its implications.
- JICA has committed further GLOF related activities in 2 more basins: Chamkharchu and Mangdechu, as there are more hazardous glacial lakes up there and upcoming hydropower projects downstream.
- In the 11th FYP DHMS and DGM have to put GLOF related activities strongly on the agenda to enable mainstreaming and continued RGoB support and budget.
- The recent SAARC Climate Summit as produced some background documents on climate change and GLOF for Bhutan.