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GLACIAL LAKE OUTBURST FLOOD (GLOF)

'REDUCING RISKS AND ENSURING PREPAREDNESS'



THE REPORT ON THE INTERNATIONAL CONFERENCE

5 - 7 DECEMBER, HOTEL OLATHANG PARO, BHUTAN

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ACRONYMS

ADA	Austrian Development Agency
CBDRM	Community Based Disaster Risk Management
CPS	Cryosphere Monitoring Project
DDM	Department of Disaster Management
DGM	Department of Geology and Mines
DHMS	Department of Hydro-met Services
ELA	Equilibrium Line Altitude Sensitivity
EWS	Early Warning System
GDP	Gross Domestic Product
GEF	Global Environment Facility
GLOF	Glacier Lake Outburst Flood
GNH	Gross National Happiness
ICIMOD	International Center of Integrated Mountain Development
JAXA	Japan Aerospace Exploration Agency
JICA	Japan International Cooperation Agency
JST	Japan Science and Technology Agency
LDCF	Least Developed Countries Fund
NAPA	National Adaptation Programme of Action
NDRM	National Disaster Risk Management
NEC	National Environment Commission
NVE	Norwegian Water Resources & Energy Directorate
OECs	Emergency Operation Centers
RBA	Royal Bhutan Army
RGOB	Royal Government of Bhutan
SNC	Second National Communication
SOP	Standard Operating Procedure
UNDP	United Nations Development Programme
USA	United States of America
WWF	World Wildlife Fund

EXECUTIVE SUMMARY

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Climate change as a global phenomenon is already impacting millions of people all over the world, transforming their lives from a certainty to an uncertainty one. Changing landscapes, increasing temperature, rising sea levels, increased risk of drought, fire and flash floods, increased diseases and economic losses are all indications of climate change. The hardest hit in the world are the people living in the developing countries such as Bhutan, where we are most vulnerable. The glaciers in the Himalayas, the world's greatest repositories of snow and ice are retreating at a rapid pace leading to swelling of the glacier lakes and increasing risks of living in a fragile mountain ecosystem. Extreme weather events are more frequent and severe. Wind and thunder storms damaged more than 1,400 houses in the ten dzongkhags in 2011.

Bhutan Himalayas has 677 glaciers and 2,794 glacial lakes and over the last two centuries we have experienced more than 21 glacial lake outburst floods of which 4 outburst cases have been reported in the last forty years. The recent outburst of the Lugge Tso in 1994 caused destruction to both human lives and property. It damaged 1,700 acres of agriculture and pasture land, washed away five mills and 16 yaks, destroyed six tons of food grains, washed away houses, caused critical infrastructure damage and killed 22 people.

Today, Bhutan has 25 glacial lakes that have been identified potentially dangerous. Raphstreng and Thorthormi lakes have been assigned as the most dangerous lakes and the Pho Chhu sub-basin indicated as the most vulnerable valley in terms of Glacier Lake Outburst Floods (GLOF). Unless measures are put in place, these lakes could have far reaching impacts as the major revenue earning projects are all located downstream such as the Puna Tsangchu I and II, Mangde Chu, Daga Chu, Sunkosh Chu. Further, damage on the settlements, historical monuments and institutions cannot be ruled out.

Recognizing these vulnerabilities and the need to be more sensitive to the GLOF risks, United Nations Development Programme (UNDP) assisted the preparation of National Adaptation Programme of Action (NAPA), 2006, Bhutan implemented 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.**" Under the project, three components were identified and implemented by three separate agencies. Component I "Lowering of water level of Thorthormi Lake" was implemented by the Department of geology and Mines, Ministry of Economic Affairs. Component II, "Installation of GLOF Early Warning System (EWS) in Punakha-Wangdi Valley," was implemented by the Department of Hydro-met Services, Ministry of Economic Affairs and component III, "Strengthening of Disaster Management and Communities awareness," was implemented by the Department of Disaster Management, (DDM), Ministry of Home and Cultural Affairs.

The project was a successful one meeting the overall objectives under each component. The Thorthormi lake was reduced by 5 meters through a manual excavation of several outlet channels by involving 300 national workers. In the front of EWS, automatic monitoring stations have been installed - with siren towers and state of the art EWS control system. On the front of DDM, non-structural mitigation works have been initiated including community preparedness and awareness workshops.

While much has been done on the front of GLOF in Bhutan, the pertinent need to share experiences and knowledge, views and lessons learned from the melting glaciers called for a gathering of experts and scientists from around the globe and particularly from the SAARC countries.

From the 5th - 6th December, 2012, the Royal Government of Bhutan (RGOB) in collaboration with the United Nations Development Programme, Austrian Development Agency (ADA), and the World Wildlife Fund (WWF) convened an international conference on 'Glacial Lake Outburst Floods – Experiences from Bhutan' at Paro.

The conference aimed at sharing experiences and lessons from the implementation of the project and to apply measures in future interventions in Bhutan and other GLOF prone countries in the region and beyond. The conference also considered and deliberated on the recommendations and resolutions from similar past and ongoing initiatives such as the "Bhutan Climate Summit for a Living Himalayas" held in Bhutan in November 2011 and the "Regional Knowledge Sharing for Effective Risk Management of Hydro-meteorological hazards in the Hindu-Kush-Himalayan Region" held in Kathmandu in March 2012.

In addition, the conference also enhanced learning and knowledge sharing, enabling the replication of effective disaster risk reduction measures and adaptation to climate change both within Bhutan and in other countries facing climate change-induced GLOF risks.

More than 70 participants attended the conference with representatives from the Royal Government of Bhutan and other mountain and/or GLOF-prone countries such as Nepal, India, Japan, Austria, Norway and United States of America (USA). In addition, the conference saw participants from UNDP and USAID.



INAUGURAL SESSION

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PREFACE TO THE DELIBERATIONS

In keeping with the tradition of the Bhutanese society, the International conference commenced with a marching ceremony, a traditional Buddhist ritual of offerings and appeasement, invoking guardian deities and the spirits for a successful endeavor of the conference.

His Excellency, Lyonpo Khandu Wangchuk, Minister, Ministry of Economic Affairs and Minister In-charge of Foreign Affairs presided over as the chief guest at the opening ceremony. Other key guests included Dasho Sonam Tshering, Secretary and Project Chairman (GLOF), Ministry of Economic Affairs, Dasho Namgay Wangchuk, Director General, Department of Disaster Management, Ministry of Home and Cultural Affairs, Ms. Claire Van der Vaeren, UN Resident Coordinator, Ms. Hideko Hadzialic, Dy. Resident Representative, Dasho Dzongda, Punakha, Dasho Dzongrab, Gasa, representatives from the Hydropower projects of Puna-tsangchu, participants from Austria, India, Japan, Nepal, Norway, USA, Bhutanese counterparts and members from the UNDP office in Bhutan.

In her welcome remarks Ms. Claire Van der Vaeren, UN Resident Coordinator, welcomed the delegates on behalf of the UN System in Bhutan. She extended her profound gratitude to the hundreds of courageous men and women from all over Bhutan who contributed to the arduous task of lowering the water level of Thorthormi Lake since 2009. The Resident Coordinator also expressed her gratitude to the Royal Bhutan Army for their contribution to the task in 2012.

She noted that Bhutan has made a renewed commitment to strengthen community-based disaster risk reduction measures, and congratulated the LDCF - GLOF project, which installed an early warning system and supported directly with the vulnerable communities of Punakha, Wangdue and Chamkhar valleys.

It was also pointed out that Climate change mitigation and adaptation issues are very complex, affecting agricultural productivity, biodiversity, water resource and health, to name a few sectors. She underscored that tackling such complexity requires policies that relate the international, regional, national and sub-national levels of intervention effectively, and there is also an urgent need to accelerate the translation of these policies into practical mitigation and adaptation interventions on the ground, and explore ways of sustaining the financing of climate change-related efforts over the long-run through varied and innovative modalities.

In his opening address, His Excellency Lyonpo Khandu Wangchuk, Minister, Ministry of Economic Affairs informed the gathering that in the pursuit of economic development and Gross Domestic Product (GDP), the world at large has achieved a high growth in the economic sphere benefitting mankind as a whole. Further, mankind has been able to explore all aspects of Mother Nature and as a result making attempts to make our presence felt even in other planets. Our pursuit through mining and deforestation has contributed towards Climate Change and mankind's over consumption only contributes more towards impacting our lives negatively. With more economic activities of Bhutan being driven by the Hydro power projects fed by the glacial lakes, Lyonpo reminded the gathering that more settlements along with economic hubs are sprouting along the river basins and unless we come up with relevant measures, these settlements are at risk.

His Excellency declared that "it's time for us to ponder over our development goals and questioned the basis of our sustainability." Touching on the philosophy of Gross National Happiness (GNH), he reminded the gathering that we need to find a balance between human well being and economic development. He also contended that GNH is intergenerational and that we should take prudent decisions thereby limiting exploitation of the resources that could benefit our future generations. Lyonpo declared that there is the urgent need for the global community to work together, share experiences and the rich knowledge and collectively move forward.

Two publications were launched after the key note address by His Excellency and Ms. Van de Vaeren.

- **"Standard Operating Procedure (SOP) for the GLOF Early Warning System Installed in the Punakha-Wangdue Valley."**

- “**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.**”

OBJECTIVES

Dasho Sonam Tshering, Secretary, Ministry of Economic Affairs welcomed the participants and said that he was inspired by the response to this conference. He outlined the intended outcomes and objectives of the International Conference as follows:

- Share lessons from the 1st NAPA follow up project in Bhutan – “**Reducing Climate Change-induced Risks and Vulnerabilities of GLOFs in Punakha-Wangdue and Chamkhar Valleys,**” funded by the Least Developed Countries Fund (LDCF) under the Global Environment Facility (GEF).
- Enhance learning and knowledge exchange, enabling the replication of effective disaster risk reduction measures and adaptation to climate change both within Bhutan and with other countries facing climate change-induced GLOF risks.
- Facilitate information sharing and cooperation through sharing of technical lessons from Bhutan with other GLOF-prone countries, based on experience of project implementing partners and an independent review conducted in mid-2012.
- Present regional and international experiences and best practices through invitation of international experts from other GLOF prone countries.
- Discuss linkages with regional initiatives.
- Provide avenue to discuss, share knowledge and experience in implementation of the GLOF mitigation works in providing inputs to improve future mitigation works in the respective institutions/organizations in the country and in the region.



PROCEEDINGS SUMMARY

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The two days conference on “Glacial Lake Outburst Flood (GLOF) ‘Reducing Risks and Ensuring Preparedness” got under way after the inaugural session and the launch of the publications by the chief guest. The panel discussions were divided into six sessions.

DAY I: 5th December, 2012

SESSION ONE: CLIMATE CHANGE ADAPTATION AND GLOF RISK REDUCTION IN THE REGION AND BEYOND: CURRENT DEVELOPMENTS AND OPORTUNITIES

The proceedings in the first session began under the broad theme “Climate Change Adaptation and GLOF Risk Reduction in the Region and Beyond: Current Developments and Opportunities.” The session was chaired by Dasho Sonam Tshering, Secretary, Ministry of Economic Affairs and Co-chaired by Professor Koichi Nishimura, Nagoya University, Japan. The session featured four eminent speakers.

The proceedings began with the presentation by Mr. Karma G. Chhopel, Chief Environment Officer, National Environment Commission (NEC) on the theme, **“Climate Change Adaptation in Bhutan and the NAPA process: Experience from Bhutan.”** He began by highlighting the economic status and the geophysical position of Bhutan. He stated that Bhutan being positioned in a fragile mountain ecosystem was vulnerable to the effects of Climate change. Based on the news clippings from around the world and from Asia, he pointed out that the glaciers have retreated by 20-30 meters annually especially in the Bhutan Himalayas leading to a rough estimation of about 500 meters retreat in the last 25 years. Globally he said that there has been an increase in the water levels, flood risks, flash floods and landslides, erratic river flows and a decrease in precipitation.

On Bhutan’s vulnerability to climate change, he said that our dependence on climate sensitive factors namely agriculture (with 70% of the population engaged in subsistence agriculture) and hydro-power and the low diversification of our economy has already impacted in terms of GLOF, land degradation, flash floods, droughts, wind and thunder storms and pests and diseases. He further stated that droughts, temperature rise, drying up water sources, longer intervals between rains, wind and thunder storms, pests and diseases are all recent experiences from around the twenty dzongkhags.

He emphasized that being aware of the GLOF risks, Bhutan signed the UNFCCC in 1992 and ratified it in 1995 and the KYOTO Protocol to the UNFCC in 2002. He further reiterated that institutional arrangements have been in place with NEC as the focal agency for Climate Change and that it has already prepared a National Adaptation Programme of Action (NAPA) to undertake vulnerability assessment and design adaptation plans and projects through multi-sectoral task force and working groups. He stressed that 55 adaptation activities have been identified to address climate hazards of which the Government considered on the artificial lowering of the Thorthormi lake, GLOF Hazard Zoning pilot scheme in Chamkhar Chhu basin and the Installation of Early warning System in the Pho Chhu Basin. He said that the first NAPA project was Reducing Climate Change-induced Risks & Vulnerabilities from GLOFs in the Punakha-Wangdue and Chamkhar Valleys in 2008.

As a long term adaptation priority based on the vulnerability and adaptation assessments in the Second National Communication (SNC), Karma highlighted on water resource management, diversification of energy mix, climate proofing of hydropower and infrastructure, agriculture diversification, awareness advocacy to cope with health risks and enhancing preparedness and understanding of GLOFs triggered by climate change.

Mr. Karma’s presentation was followed by **“An overview of GLOF risk reduction initiatives in Bhutan (including an overview of the project: Reducing Climate Change-induced risks and Vulnerabilities of GLOF implemented in Bhutan as a NAPA follow up project.”** It was presented by Mr. Dowchu Drukpa, Chief Seismologist, GLOF Project Manager, Department of Geology and Mines, Ministry of Economic Affairs.

Mr. Dowchu began by providing a historical perspective of the GLOF hazards, and said that 17 events

had occurred between the 19th and 20th century with 4 cases of outburst in the last 40 years. He also contended that of the 2,794 glacier lakes in Bhutan, 25 glacier lakes have been identified as being potentially dangerous especially in the Phochhu sub-basin that could pose significant threat and risk to over 70% of the settlements in the lower valleys. Besides, he impressed that infrastructures such as the Hydro-power plants and the newly set up air strip in the Chamkhar valley, the historical monuments and settlements across the border in India could also be impacted.

He also outlined on the various scientific studies that have been conducted in collaboration with international institutes over the last decade—particularly in the Pho Chhu sub-basin as a result of the 1994 Lugge Tso outburst. Due to the increased frequency of disaster occurrence in the country, Mr Dowchu elaborated that the government has initiated various policy and institutional interventions including the up-gradation of erstwhile Division of Disaster Management to Department of Disaster Management in 2008, Development of National Disaster Risk Management (NDRM) framework in 2008 and the Creation of Division of Glaciology under the Department of Geology and Mines in 2010 among others.

Focusing on the risk reduction programmes, he outlined on the GLOF hazard zonation and vulnerability mapping conducted in the three valleys of Chamkhar, Punakha and Wangdue. He also informed the participants that the mitigation works of the Raphstreng Tso initiated in 1996 has been successfully completed with the lowering of the water level by 5 meters in 2012. However, he cautioned that Raphstreng and Thorthormi are still two of the most dangerous glacier lakes in country and therefore require constant monitoring and vigilance.

On the Thorthormi lake GLOF risk mitigation undertaken in 2008, he shared that the lake has been successfully lowered by 5 meters reducing the risk as well as the impact on the environment. Highlighting on the other components of the project, he mentioned the installation of Early Warning Systems (EWS), identification and demarcation of safe evacuation sites, institutionalization of a Community Based Disaster Risk Management (CBDRM) and the advocacy and awareness campaigns carried thereof in the Pho Chhu and Punatsang Chhu valleys as a part of a comprehensive plan of the GLOF risk reduction initiative under the current GLOF Project.

Following Mr. Dowchu's presentation, Mr. Karma Tsering, Director, Department of Hydro-met Services (DHMS), Ministry of Economic Affairs presented on "**Sensitivity and response of Bhutanese glaciers to atmospheric warming**" that was based on his research study. In his presentation, Mr. Tsering emphasized that since clean-type glaciers are sensitive to climate change, the sustenance of clean water, ecosystem integrity, hydropower development, agriculture and food security are at a high risk besides the possibility of natural hazards like GLOF. He also contended that glacier change in terms of thickness and extent is poorly quantified and that there exists discrepancies in reported glacier mass balances due to differing approaches and methodologies being used. He also stated while there is a limited glacier related publications there seems to be none on field or modeling-based mass balance estimates for the Bhutan glaciers.

His research was based on Glacier Area Mapping, Equilibrium Line Altitude Sensitivity (ELA) perturbation model, Climate Input Data and Mass balance and Glacier Changes under current climate. Based on the study, he concluded that for all glaciers, the results of the ELA sensitivity tests are similar to that obtained using full energy balance model for ablation, that areas with higher accumulation rates are less sensitive to changes in temperature than areas with low accumulation rates and that the glacier ELA sensitivity to temperature increases from west to east. On the response to the glaciers under future climate scenarios he concluded that, even for a conservative warming of 1°C, minimum 25% of the glacierized area will be lost and that the present meltwater flux will decrease, after an initial melt spike, to 35% of today's value. He also contended that with the 2.5°C average projected temperature change for the next century over South Asia, these will result in the loss of more than half of the glacier area.

For Bhutan, Mr. Karma Tsering contended that the Bhutanese glacier area is considerably out of balance with the recent climatology and that even if no additional warming were to occur, the glaciers will decrease in order to reach a steady state and that the melt water flux are going to be significant. He suggested on the need to identify locations to prioritize and focus adaptation and mitigation interventions to glacier changes so as to safeguard water resources, sustain hydropower generation and reduce GLOF risk to lives and properties.

For possible researches in the future, he outlined the need to quantify uncertainties associated with differences in glacier area estimates, validate melt factors with observational data, accurately assess forms, magnitude (intensity, frequency and duration) and distribution pattern of precipitation and identify the likely debris-cover thickness at which albedo and insulating effects cancel each other out.

Dr. Mariam Jackson from the Norwegian Water Resources & Energy Directorate (NVE), Norway, followed next with the presentation on "**GLOF in Norway-More than 100 years of GLOF risk reduction.**" Presenting a brief background on GLOF, she informed that Norway had 2,000 glaciers of which GLOF had occurred from 12 different glaciers. The first known GLOF had occurred in 1736 from lake Demmenvatn on the North West side of the ice cap Hardangerjøkul. Two serious floods had also occurred in 1937 and 1938. As far as fatalities are concerned, she said that so far there has been 12 known fatalities.

She then zoomed in to lake Rembesdalskåka - Demmenvatnet where the earliest recorded flood was in 1736, subsequently occurring again in 1813, 1842, 1861, 1893, 1897, 1937, and 1938. From 1941 to 1954, GLOF had occurred almost annually ending only after a flood-relief tunnel had been completed in 1959. Touching upon other glacier lakes such as the Supphelle, Sisovatnet and Blamannsisen glacier lakes, she impressed upon the participants that GLOF occurred mainly because of the changes in the glaciers. These changes, she suggested were a result of warm and wet weather whereby without proper drainage under the glaciers, a large volume of water forced its way through the moraine causing floods.

Summing up on the long history of GLOFs and other related glacier hazards in Norway, she highlighted on the need to carry out mitigation works especially as the glaciers are located at a relatively short distance from the human settlements. She pointed out that building reservoirs upstream can not only benefit the hydropower plants but can also minimise damage from floods.

KEY COMMENTS/DISCUSSION POINTS

- Climate change is a global phenomenon. It has been fuelled by the consumerist attitude of human activities and the developmental activities thereof. Human well being, sustainability and the issue of resource use for future generations have been over shot by the ideology of development.
- Even with a conservative increase of 1°C, a minimum 25% of the glaciated area will be lost resulting in the decrease in the present meltwater flux. With the temperature projected change of 2.5°C for the next century over South Asia, more than half of the glacier area will be lost.
- 17 events had occurred between the 19th century and the 1970's and 4 cases of outburst in the last 40 years with 25 glacier lakes as being potentially dangerous. The impacts of climate change in Bhutan have been significantly felt with the formation of supra-glacial lakes, a result of the accelerated rate of retreating glaciers.
- Bhutan has already felt the impact of climate change in the form of land degradation, flash floods, droughts, wind and thunder storms, temperature rise and drying up of water sources, long intervals between rains and pests and diseases.
- The Government has drawn up various policies and institutional intervention measures. The Division of Disaster Management has been upgraded to the Department of Disaster Management in 2008. A National Disaster Risk Management (NDRM) framework has been drawn up in 2008 and the Division of Glaciology under the Department of Geology and Mines has been created in 2010.
- The Government of Bhutan has identified 55 adaptation activities to address climate hazards of which artificial lowering of the Thorthormi lake, GLOF Hazard Zoning pilot scheme in Chamkhar Chhu Basin and the Installation of Early warning System in the Pho Chhu Basin were few amongst others.
- As a long term adaptation priority Bhutan needs to emphasize on water resource management, diversification of energy, climate proofing of hydropower and infrastructure, agriculture diversification, awareness advocacy to cope with health risks and enhancing preparedness and understanding of GLOFs triggered by climate change.

- Not just Bhutan, even Europe and countries such as Norway has a long history of GLOFs and other related glacier hazards. Based on the experience of Norway, the best way of mitigating threats is to construct reservoirs upstream related to hydropower plants which can minimise risks.

Bhutan, Norway on track to mitigating GLOF

Norway and Bhutan, the two countries that are both vulnerable to threats from Glacier Lake Outburst Floods (GLOF) and after having had experienced glacial floods and learned lessons, are on track to mitigating possible flash floods from glaciers in the times to come.

One mitigation measure adopted by Norway, Dr. Miriam Jackson from the Norwegian Water Resources and Energy Directorate (NWRED) said, is the building of tunnels and drains down the lake and channeling water into the reservoirs used by the hydropower projects.

"Some of the mitigation measures actually went on primarily because it's also related to hydropower," she added.

And if a similar system can be emulated in Bhutan, Dr. Miriam Jackson explained that the situation in the two countries were different - in Bhutan, glaciers and hydropower projects are located far off from each other with settlements in between, while in Norway glaciers are close to human settlements, thus making it easy to build reservoirs near the glaciers.

However, what could be a similar between Norway and Bhutan, according to Dr. Miriam, are the experience of two countries knowing the existence of GLOF and the experiences in studying and specifically measuring glaciers and the possibilities of what might happen to glaciers in the future.

"Norway has several decades of experience in measuring glaciers which I think can be beneficial to Bhutan," Dr. Miriam Jackson said.

Bhutan's preparedness level against threats from GLOF presently depends on the basis of cases. The level of awareness, especially in the Punakha-Wangdi valley, seems to be quite high as compared to places in other valleys.

"In fact, there would be communities that don't even know such threats exist in their living space," the Director of the Department of Hydro-met Services (DHMS), Ministry of Economic Affairs in Bhutan, Karma Tshering said. The high-level preparedness in Punakha-Wangdi valleys has been attributed to 1994 GLOF, triggered by the outburst of the Lugge Tsho in Lunana.

"The incident has been an eye opener to Bhutan."

Conversely, the challenge in reducing risks from glacial floods, according to Karma Tshering, is the difficulty in monitoring glacial lakes as they are in some of the harshest, remotest and barren areas with very few people (few settlements) and setting up offices in such places have been a grueling task.

"We are also not really clear about the climate-dynamics; we still don't properly understand the glacial dynamics, the glacial processes that are happening, and what actually triggers the formation of glacial lakes," Karma Tshering said.

However, Thothormi Lake has been decreased by five meters recently, although the water level may rise up again next year.

Karma Tshering defines the construction of a conduit for water to flow freely as a major achievement as the water level has been brought down to more than five meters for its earlier height.

"So as much as water may accumulate in the lake, there is the outlet through which water can move out freely and safely," he said, adding that even if the lake's water level rises it won't reach the level that was originally there before the inception of the project.

"Having an efficient early-warning system that runs 24x7, community awareness and education so that people don't remain complacent, and access to media are few solutions Bhutan needs to adapt," Karma Tshering said.

But Dr. Miriam Jackson of NWRED in Norway, on the other hand, thinks that Bhutan has already made a very good start on the solution front.

"Looking at the areas downstream, if Bhutan has a GLOF, letting the communities know what areas are affected downstream and by not building in areas that are vulnerable are the solutions," she said. However, it is good to deal with the problem if possible rather than having an early warning system.

Norway experienced GLOF recently in 2004.

"The recent GLOF caused a lot of damages. Even though we have a lot of experiences, we can still be taken by surprise. There were many smaller events that signal Norway to be aware even if it has a lot of experiences" Dr. Miriam Jackson said.

SESSION TWO: GLOF RISK REDUCTION IN THE HIMALAYAS-MONITORING, COMMUNITY PREPAREDNESS AND EARLY WARNING SYSTEM

Session two was chaired by Dr. Alton Byers, Director, The Mountain Institute, USA and co-chaired by Dr. Mariam Jackson from the Norwegian Water Resources & Energy Directorate (NVE), Norway.

The afternoon session of Day I began with a presentation by Dr. Takeo Tadono, Associate Senior Researcher, Japan Aerospace Exploration Agency (JAXA) Japan. He presented on "**Development of Glacial Lake Inventory in Bhutan Himalayas using ALOS 'DAICHI'**". It was a project undertaken through Japan International Cooperation Agency (JICA) and Japan Science and Technology Agency (JST) Bhutan GLOF Project 2009-2011 based on Satellite Group or Remote Sensing Group to analyze glacial lake expansion history using terrain information derived from satellite data. The study included terrain analysis for the past GLOFs, base map analysis using ASTER onboard NASA's Terra satellite collaboration with Process Study Group, extract precise terrain information and validation using PRISM onboard latest Japanese satellite ALOS, development of glacial lake inventory based on multi-temporal satellite imageries, application of flood analysis generation of a hazard map collaboration with Assessment Group, and provisions of training and systems for remote sensing.

Dr. Takeo Tadono's presentation was followed by a presentation by Mr. Pradeep Mool, ICIMOD, Nepal. With his presentation themed "**Glacial lakes and GLOF Monitoring in the Himalayas**," Mr. Mool, touched on past GLOF events in the Hindu Kush region. He said that out of the 56 GLOF events, 4 occurred in Bhutan, 29 in China, 14 in Nepal and 9 in Pakistan. He further informed the participants that based on the report of ISRO, 16th May, 2011, 75% of the Himalayan glaciers are retreating leading to the formation of glacial lakes especially at elevations above 4000 meters.

He also focused on the trans-boundary issues of glacial lakes and shared on the GLOF events from China/Tibet that had its impact in Nepal causing damage to farmland, livestock and infrastructure such as bridges and hydro power plants. Reiterating the need to identify potential glacial lakes, he said that criteria such as the size and growth in area, increase in water level, its position vis a vis the moraines and associated glacier, and the socio-economic vulnerability assessment along the downstream areas need to be considered. Citing example from Nepal, he presented the participants with a list of 21 potentially dangerous glacial lakes as identified by the ICIMOD.

GLOF risk assessments carried out in the three glacial lakes of Tsho Rolpa, Imja and Thulagi were also presented along with the downstream vulnerability assessment on the settlements such as Dingboche in case of a flood on infrastructure, land and people. Summing up his presentation Mr. Mool shared on the various regional programs on GLOF risk management happening between countries such as Afghanistan, Bhutan, China, India, Myanmar, Nepal and Pakistan. He also stressed on the need to collaborate between the nations within the regions and also with others to exchange views from each other and share lessons learned.

Karma Dupchu was the third presenter and he made a presentation on "**Glacier Lake Outburst Flood (GLOF) Early Warning System: Preparedness for Eventuality**." His presentation was based on the implementation of one of the components under the project "**Reducing Climate Change-Induced Risks and Vulnerabilities from Glacier Lake Outburst Flood in the Punakha-Wangdu and Chamkhar Valleys**". The main outcome of the projects that included lowering the water level of Thorthormi lake, installation of GLOF Early Warning System, and strengthening of the Disaster Management and Communities Awareness were also touched upon.

He highlighted on the main components of the EWS that included Automatic Monitoring Stations, communication system, siren towers and the Standard Operation Procedures (SOP). He stated that the Early Warning Systems are important to provide a real time early warning system and to inform people of the approaching floods so that lives could be saved and property damages reduced. He further mentioned that system consists of 5 water level stations and 3 sirens in Lunana and 1 water level station and 14 sirens in the Punakha-Wangdi valley. He also said that the project also installed two Automatic Weather Stations (AWS) at Lunana and Dangsa to collect weather information as there is limited stations in the northern boundary. Besides, automatic monitoring stations have been installed in four lakes and

one on the confluence of Thanza. In the front of communications, a control center has been located at Wangdi with the state of art technology manned 24 hours a day. Emphasizing that it is ultimately people that needs to be educated and made aware of GLOF, mock drills and awareness on GLOF and EWS have been carried out for vulnerable communities residing along the valley together with the Department of Disaster Management.

Summing up his presentation, he said that while lessons learnt from this project especially in terms of knowledge and skills are useful and can be replicated in other projects, there still remain challenges. He said that limited accessibility and remoteness of the project sites, lack of technical capacity, lack of access to communication system and scarcity of funds needs to be addressed.

Dr. Jiro Komori from Teikyo Heisei University, Japan made his presentation on "**Temporospatial record and future hazardous of Himalayan GLOF-inferred.**" He started off by posing questions on what amount of fear should we have in GLOF and how do we prepare ourselves with such catastrophes and how often and where will GLOF occur in the future?

Those pertinent questions were answered by presenting a sketch of the latest GLOFs that had occurred in Bhutan and in Nepal. From Bhutan, the 1994 Lugge Tsho GLOF and the 2009 minor flood from supraglacial lakes on Tshojo Glacier were presented while from Nepal he discussed the GLOF from the Sabai Tsho and floods in the eastern Annapurna. He said that the source of the Tshojo glacier GLOF that discharged 5 million m³ of water was not from the moraine dammed lake but had its origin in the supra glacial lakes.

Further he also presented a list of floods that have occurred in Bhutan numbering to 21, 16 in Nepal and 9 in Sikkim. Of the 21 floods in Bhutan, he mentioned that 76% had occurred before the 1970's while there seems to be no GLOF record in the western half of Nepal. Sequences from the Satellite images were presented indicating that these floods occurred from glacier ice avalanche. From these floods he concluded that the behavior of hanging glacier and supraglacial lakes should be a concern as a source of flood as with glacier lakes. The lakes have some topographical and sedimentological characteristics in common.

KEY COMMENTS

There is a strong need for the regional countries to collaborate, exchange views and share lessons learned on GLOF as the lakes are located in the region and the impacts of GLOFs are also felt in the neighboring countries as a result.

- At least four lakes in Bhutan are being monitored throughout the day with a control room based at Wangdiphodrang. EWS and automatic monitoring stations are also in place in upstream Punakha along the Phochhu and in the lakes together with siren towers placed at strategic locations for maximum sound projections.
- The challenges posed by EWS are many including limited technical capacity and scarcity of funds. EWS in itself will not save lives and properties from GLOF and there is the need for all partners, communities and the line agencies to work together.
- The behavior of the hanging glaciers and the supraglacial lakes should be a concern as a source of flood as with other glacier lakes. The lakes have some topographical, and sedimentological characteristics in common.



SESSION THREE: LESSONS ON GLOF EARLY WARNING SYSTEM AND COMMUNITY PREPAREDNESS: RECOMMENDATIONS AND WAY FORWARD

The last session for Day I was chaired by Dacho Namgay Wangchuk, Director General, Department of Disaster Management, MoHCA and co-chaired by Mr. Pradeep Mool, ICIMOD, Nepal.

The session began with a group discussion on the lessons learned especially from the Early Warning System and Community Preparedness and based on the presentations made by the panelists in the morning and afternoon. The members were divided into four groups to deliberate upon and come up with recommendations. Each group had a chair to facilitate the discussion and a rapporteur to present the findings.

The lessons learned from the past experience in EWS and Community preparedness were based on two broad questions:

- 1. What are some of the lessons (positive and negative) and best practices from your past experience in implementing GLOF/disaster early warning systems and community preparedness programs?**

On the positive benefits accrued from EWS and community preparedness, the following were outlined by the working groups:

- The community members in the hazard zone especially in the Punakha-Wangdi and Chamkhar valleys have been sensitized on GLOF and early warning systems contributing to an increase in their knowledge level. This has been possible due to extensive awareness creation and through the mock drills on GLOF-EWS. The members felt that the confidence level of the communities in GLOF and EWS has increased drastically. The local community members are now beginning to take initiative in GLOF related activities and bear ownership.
- The community backup manual EWS has helped in trouble shooting whenever there were minor complications in the system. Further, the manual on SOP has enabled people at the control center to relay information through proper channels.
- EWS equipments such as the water level sensors and automatic weather stations purchased from a single vendor, has been able to minimize to a large extent the issues of coordination and integration.
- The other benefit of EWS is enabling the relevant organization such as the Department of Hydro-met Services to collect climate and water resources data.
- There is proper coordination between relevant departments including the Department of Disaster Management, Department of geology and Mines, and Department of Hydro-met services. This coordination has proved useful especially in coordination and in the resource utilization.
- 17 sirens which are strategically located in Lunana and Punakha-Wangdue valley to signal of the impending danger as a result of GLOF are found economical. The sirens can also be used to warn the hydro-power plants downstream such as the Punatsangchu I and II, and Sunkosh hydro project in case of GLOF. These would give them enough time to respond positively to GLOF threat.
- Hazard zonation maps along the vulnerable communities especially in the Punakha-Wangdi valleys have proved useful in sensitizing the people on safe places for future settlements.

On the Negative aspects, the following were outlined by the group members:

- False alarms due to technical glitches even without an outbreak could inhibit people from taking siren warnings seriously in the actual event. Further, the location of sirens in the vicinity of the Hydropower plant construction sites are found inaudible due to many construction activities. The noise from the drilling machines, the blasting that occur frequently and the movement of the heavy machineries at the construction sites makes the siren inaudible.
- While the EWS systems have been set up with assistance from the LDCF funding, the sustainability issue to operate and maintain would arise at the end of the project duration.

Meeting even the recurrent costs in terms of satellite communication is expensive and unsustainable.

- EWS system that is placed in the Punakha-Wangdi valley relies only on water level sensor with no alternatives. Therefore, in the event of malfunction of the water level sensor, EWS will not react when there is GLOF. Similarly the communication system is provided via satellite lacking other means of reliable communication backups.
- While on paper, the actual hazard mapping has been carried out smoothly segregating into Red "Most dangerous" Yellow "Intermediate" and Green "Safe" zones, the actual implementation of the plans at the ground level is very challenging.
- Setting up EWS in the Punakha-Wangdi valley has been found expensive incurring huge amount of money vis a vis the possibility of GLOF occurrence.
- Mapping, recording and incorporating of the local knowledge on GLOF is important and there is no indication of any study undertaken on this area.

2. What are some of the indigenous methods of EWS and how can these be utilized?

- The locals have a rich experience in predicting floods. One important local knowledge is that the houses in the olden times were all constructed at a higher level and away from the river banks. This is with the perception that they can avoid damages in case of flood and other natural disasters.
- The locals also talk of a peculiar smell of mud preceding a flood event.
- They are also aware that the domestic animals behave peculiarly during such events since they could feel the vibration and hear the oncoming flood noise from far away distance.
- We could also make use of the available local expertise and the resources in designing the EWS. This could reduce the cost and in the long run be more sustainable. The locals would also have better trust in the system and thereby create a sense of ownership.

RECOMMENDATIONS

The recommendations made were in the following areas:

- Since the sirens are found inaudible because of the ongoing construction works and also sound similar in nature, it is recommended to use unique sounds such as pistol signals. Using pistol signals could be better to alarm the people and the communities. Installing CCTV's with the water level stations besides the sirens could also help in the visual validation of the flood. Besides adopting a standard warning system of sound/colors in the country could also enable in alerting people of an oncoming flood.
- Since, the method of communication is based on only one system which is satellite communication, it is recommended to have in place more than one so that there is a reliable backup system.
- While hazard mapping of the communities at risk especially in the Punakha Wangdi valley has been successfully carried it has been impeded in its full enforcement on the ground. To successfully implement and adhere to the zonation map, support from relevant organizations including the Local government and other stake holders is necessary.
- Since the current EWS is based on a single sensor system which is the water level sensor, it is recommended to use a combination of sensors like earthquake and vibration sensor to ensure that the EWS is triggered appropriately.
- Pre-disaster planning and mitigation should be given equal priority to that of relief efforts after GLOF has occurred.
- While the system is in place and to an extent advocacy on GLOF EWS has been carried out, it is

important to train few focal persons from each community on GLOF EWS.

- While, the local communities have been engaged in the setting up of EWS, it has been limited to only certain phases of the project implementation. Therefore, it is recommended to engage the communities right from the inception design and through all phases of the project.
- We have to strategize sustainable methods of maintaining the EWS in collaboration with the stakeholders like hydropower plants, which is lacking at the moment.
- EWS system should not be looked as a mere tool to warn the communities during times of floods but also make it as an avenue to educate people on hydro-met services, on disaster management and achieving other development plans.
- There is the fear that once the project is over, the responsible agencies would have less contact with the community level. It is recommended that there is in place a good mechanism to communicate and advice the communities periodically.
- For warnings to be more effective in case of GLOF, it is suggested that besides broadcast media, we should also make use of other social network services and SMS through mobile services as practiced in Bangladesh.
- While the EWS system is relatively new, there are chances that they could mal-function if regular maintenance is not carried out. Therefore, it is suggested to have in place a regular maintenance arrangement.
- The frequency of mock drills in the communities, schools and institutions should be carried out regularly for better preparedness during the event of GLOF.



DAY II: 6th December, 2012

SESSION IV: GLOF RISK MITIGATION: EXPERIENCES IN IMPLEMENTING STRUCTURAL AND NON-STRUCTURAL MEASURES

The first session for Day II, Session IV was chaired by Mr. Sonam Yangley, Director General, Department of Geology and Mines (DGM), Ministry of Economic Affairs and co-chaired by Dr. Diethard Leber, University of Vienna, Austria.

Prof. Koichi Nishimura, Nagoya University, Japan, presented his study on "**The Study on GLOFs in the Bhutan Himalayas.**" His presentation was based on a project spread over a three year period particularly to evaluate GLOFs hazard level in Bhutan with focus on the Mangdechu valley for which the GLOF hazard level was believed to be high but yet information for mitigation was lacking. Bathymetric surveys, geophysical explorations and meteorological observations were conducted in the Zanam region at the headwaters of the Mangde-Chhu River basin, to evaluate the potential risk of GLOFs and the possible amount of flood water discharge in the case of a GLOF. Field surveys and satellite data analysis was carried out to provide a complete hazard map in the region.

The analysis was based on the ALOS mosaic images. The study included triggering of GLOF, moraine stability, hydrological survey and behavior of the glacier. Mr. Nishimura's team conducted a geophysical exploration, breach simulation, flood simulation, hazard mapping, landslide inventory, active fault mapping and Early Warning System. Besides, the team also conducted trainings on technology transfer focusing on satellite data analysis, landslide data mapping, flood simulation and hazard mapping. The study while finding no immediate threat however cautioned that we need to be prepared.

His presentation was followed by a presentation by Mr. Karma Toeb, Department of Geology and Mines on "**GLOF Risk Mitigation: Artificial lowering of the water at the Thorthormi Tsho.**" He said that the threat posed by Thorthormi is real. The lake has been rapidly expanding in size to about 3.42 km² and could release about 53 million cubic meters of water. Hence, he felt that it was pertinent to carry out mitigation works that included artificial lowering, hazard zonation and installation of EWS. He opined that during the engineering and safety study in 2008, the project looked at three options to lower the lake level including by siphoning, pumping and manual construction of spillway.

The third option of manual construction of a spillway was considered based on several factors including unknown rate of recharge into the lake, extreme weather conditions at the site and also based on lessons learnt from the Raphstreng Tso mitigation in the late 1990s. Mr Karma presented that the artificial lowering of the Thorthormi lake started in 2008 with a fund of US \$ 4.23 million co-financed by the Royal Government of Bhutan (RGOB), and spread over a four year period. The goal was to lower the lake by 5 meters. The total fund allocated for the mitigation work at the lake was US\$ 2.7 million. Mr Karma presented that after 4 years of hard work and sacrifice, the project has successfully lowered the lake level by 5m. This, he pointed out resulted in release of 17 million cubic meters of water over the last 4 years. He further clarified the project has been able to minimize the risk of outburst from the lake and moreover, even if an outburst occurs from the lake in future, damage downstream will be minimized to a large extent as a result of the measures undertaken by the current project.

Summing up his presentation, he outlined the constraints faced in carrying out the project. He pointed out the unpredictable weather system, high altitude sickness and emergency evacuation, difficulties in the transportation of materials, managing a large force of workers, planning and financial difficulties and finally achieving the desired goals. He also suggested recommendations on the lines of requiring a detailed scientific information, more technology based approach to avoid large work force management issues, multiple drilling machines combined with silent explosives, avoiding wet working conditions, use of fuel efficient stoves and if possible to maintain same working team members.

Mr. Chencho Tshering made a presentation on "**GLOF Risk Reduction: Experience on Implementing Non-Structural Mitigation Measures in Bhutan.**" He touched upon the Disaster Management Strategy and on the National Disaster Management Bill, 2011. He mentioned that the National Disaster Management

Bill, 2011 is important to build a sustainable and a decentralized disaster management mechanism at both the National and the Local Government and to establish Critical Disaster Management Institutions in the country. Further, he said that the Bill could also enable in mainstreaming disaster risk reductions into all national plans and policies.

He then presented on the non-structural mitigation measures undertaken by the department of disaster management such as community preparedness, GLOF hazard mapping along the Punakha-wangdue and Chamkhar valleys, vulnerability assessment in case of GLOF, hazard zone demarcation, identification of GLOF Safe evacuation site and possible routes especially for the communities that fall under the red zone, alternate community based early warning system where they have identified about 31 vulnerable communities starting from Lunana in the north to Lhamoizingkha in the south. He also highlighted on the trainings conducted for capacity development and for creating awareness. The trainings focused on Community Based Disaster Risk Management Planning Process, school preparedness and response planning, mock drills and mainstreaming DRR into plans, policies and developmental activities.

Lastly he delved into the lessons learnt from the mock drills and the challenges faced. He said that the communities lacked knowledge about safe evacuation sites, lacked coordination, lacked ownership of the EWS equipment and that the sirens sounded similar to the warning sounds of the PHPA construction sites. He said that some best practices to be included were for a "Bottom Up" and a "Participatory Approach" especially in designing disaster management plans for the gewog and chiwog levels as carried out by the DRM. He said that the overall challenges that DRM faced was in term of budget constraints in implementing the prioritized preparedness and mitigation activities and inadequate resources for setting up Emergency Operation Centers (OECs) and Search and Rescue equipment and trainings.

"Hazard Zonation and contingency planning: A standard tool for reducing flood risk in European Alps" followed next by Dr. Diethard Leber from the Department of Environmental geosciences, University of Vienna, Austria. He focused on the Geo-hazard assessment and risk management. He based the phases of disaster management into three categories which includes Preparedness, Response and Recovery. Using the Buddhist Wheel of life as an example, Dr. Leber said that preparedness level is the phase of planning activities with a long-term view of the risk management aiming at the reduction of vulnerability, hazard potential and hazard exposure. On Response, he said that it is the phase of reacting to an ongoing or an impending disaster while on Recovery, he said that it is the phase of restoring the affected area to its previous state in terms of conditions of life, infrastructure, communication and social organization.

He also highlighted on the common procedures involved in hazard assessment such as maintaining data base, field mapping, observation and back calculation of past events and estimating future events.

Dr. Alton Byers, Director, The Mountain Institute, USA shared on "**An Introduction to the High Mountain Glacial Watershed Program: Recent Results from Imja Glacial Lake, Sagarmatha (Everest) National Park, Nepal.**" He shared the Peruvian-Nepal collaboration whose goals were to strengthen scientific, social, and institutional capacity for managing dangerous glacial lakes in Peru and implement community-based, participatory glacial lake risk reduction project in Nepal. The field work at the Imja lake in Nepal carried out using GPR survey and bathymetric survey were also shared with the results. The study found out that the lake is growing and growing fast and that the best way of minimizing risk is by building a 60 meters high dam that could reduce the risk by 89%. Finally he shared the process forward in the risk management process that included besides others to develop glacial lake management handbook, undertake case studies of the glacial lake and develop adaptation options based on the recommendations through community consultation, develop GIS data base for vulnerability analysis.

KEY DISCUSSIONS

- Carrying out mitigation works in the high altitude areas due to unpredictable weather system poses many challenges such as, altitude sickness, emergency evacuation, transporting materials, managing a large work force, planning and financial difficulties and finally achieving the desired goals.
- For future projects, we need to look at acquiring a detailed scientific information, more Hi-tech approach to avoid management issues, use of multiple drilling machines combined with

silent explosives, avoiding wet working conditions, use of fuel efficient stoves and maintaining the same team members.

- Mitigation measures are important including community preparedness, GLOF hazard mapping, vulnerability assessment, hazard zone demarcation, and identification of GLOF safe evacuation sites, alternate community based early learning warning systems and identifying vulnerable communities.
- Risk management process should be continued and the way forward is building dams that could minimize risk.

SESSION V: PERSPECTIVES ON REGIONAL AND GLOBAL INFORMATION SHARING COOPERATION

This session was chaired by Prof. Hermann Haeusler, University of Vienna, Austria and co-chaired by Karma Tshering, Director, Department of Hydro-met Services, Ministry of Economic Affairs.

Karma L Rapten, UNDP, presented on the findings of technical review and social impact assessment carried out by UNDP under the project. It covered the technical and social assessment focusing on best practices and formulating recommendations for an exit strategy which increases sustainability, enables up-scaling and replication of the project. Some of the best practices and key findings were presented including detailed engineering mitigation plan based on comprehensive site investigation, health and safety management, labor based approach and limited negative environmental impact. The study recommended high-tech approach in boulder clearing, armoring and slope stabilization, seepage monitoring and fuel wood management and multi-disciplinary team, visual check, alert and alarm levels and community engagement.

Dr. Dorothea Stumm, from ICIMOD, Nepal made a presentation on "**Information sharing and cooperation on cryospheric research in the Hindu Kush Himalayas**". She presented an overview of the past glacial lakes projects undertaken by ICIMOD from 1987 till 2011. It centered round the Bhutan and Nepal and the Hindu Kush Himalayan regions. Based on the Cryosphere Monitoring Project (CPS), she outlined that the basic objective was improving knowledge and sharing experience based on its five components of In-situ glacier monitoring and capacity building. She highlighted that ICIMOD as the Cryosphere Knowledge hub disseminates information shared through the local communities, government bodies, scientists and donors, trainings, through reports and leaflets, interactive CDs, articles, sponsorship of studies through a masters course in glaciology in Kathmandu University and development of a web portal.

Professor Hermann Haeusler, University of Vienna, Austria followed with talk on "**Information Sharing and Cooperation on GLOF Risk Reduction in the Tien-Shan: The 2012 Bishkek Example**," based on the ADC project 1998-2003. It focused on the Austrian Alps, Swedish Alps and the Tien Shan during the last fifty years. Under the Bishkek workshop 2012, a case study was carried out on lake Bishkek in Central Asia. It included excursions for mapping the geo hazard assessment of Baitik flooded area, undertaking field work to study the socio-economic implications of the 2003 and 2012 floods from Ala Archa National Park and carry out the risk management processes and continuous situation analysis. Based on the study, lessons learned were presented. He said that there was a limited cooperation and coordination between countries in the Central Asia and that there were also restrictions in cooperation between national institutions. Besides, he said that capacities of the national experts were also limited and that the universities did not have any courses that focused on geo-hazard assessments. As a way forward he pointed out the possible solutions that included drawing up an international charter for major disasters, international cooperation and setting up of Information & Learning Management System (for different levels of decision makers & different stakeholders at governmental and regional level), use of social media such as twitter, facebook that could promote interactive knowledge exchange and enhancement of socio-economic studies through GIS, implementation of hazard zonation plan and intensivate cooperation between Bhutanese DRR team, experts and communities.

Reshma Thekkethil, from the Bureau for Crisis Prevention and Recovery, UNDP, New Delhi through her presentation on "**Strengthening capacity in accounting Loss and Damages**," presented the worldwide catastrophes that occurred between 1984 and 2011 before sharing the losses and damages arising out of GLOF and disaster focusing on the Climate Change conferences held at Cancun and Durban and UNFCCC first global expert meeting in Tokyo in March 2012. She outlined that the dismal state of databases – lack of baseline data and inability to update it, lack of systematic assessment of disaster impacts and the lack of systems to capture changing climate are some of the challenges. She suggested that the way forward is setting up disaster databases, improve post-disaster damage and needs assessments and have systematic ways of capturing climate change/variability impacts in disaster risk management and development sectors. Added to these, she said that there is the need to develop institutions at the global, regional, national and sub-national levels for loss and damage assessments, enhance capacities to capture, analyze, disseminate and apply disaster loss and climate data and prioritize resource mobilization and allocation for risk reduction and adaptation.

KEY DISCUSSIONS

- High-tech approach with a multi-disciplinary team is important along with a comprehensive site investigation, community involvement in mitigation works and limiting negative impact on the environment.
- International cooperation and setting up of Information and Learning Management System for different levels of decision makers and different stakeholders at governmental and regional level is imperative.
- There is the need to set up a disaster databases, improve post-disaster damage and needs assessments and have systematic ways of capturing climate change/variability impacts in disaster risk management and development sectors.
- Develop institutions at the global, regional, national and sub-national levels for loss and damage assessments, enhance capacities to capture, analyze, disseminate and apply disaster loss and climate data and prioritize resource mobilization and allocation for risk reduction and adaptation.

SESSION VI: RECOMMENDATIONS ON GLOF RISK MITIGATION (STRUCTURAL AND NON-STRUCTURAL MEASURES) AND INFORMATION SHARING.

The last session was chaired by Mr. Yeshi Dorji, Geo-Technical Advisor, Druk Green Power Corporation and co-chaired by Dr. Dorothea Stumm, ICIMOD,. The participants were divided into four groups and assigned with the task of coming up with recommendations on the following four questions: What are some of the lessons (positive and negative) and best practices in implementing GLOF Risk Mitigation (both structural and non-structural measures)?

POSITIVE

The positive lessons and some of the best practices in implementing GLOF (both structural and non-structural measures) were

- The project has been carried out following strict environmental guidelines that was cleared by the NEC. There was a minimum negative impact on the environment.
- A multi-disciplinary team was engaged during the project to provide their expertise in different fields and to avoid any untoward incidents. The teams engaged were Department of Geology and Mines, Department of Hydro-met Services, Department of Disaster Management and Department of Roads (DoR).
- The basic goal of the project in mitigating GLOF risks has been achieved by lowering the water level by 5 meters. The mitigation of 5 meters was carried out gradually spread over a period of four years. This strategy ensured the stability of the moraine dam at the opening which otherwise could have resulted in weakening the moraine dam if carried out at one go.
- The EWS systems along the Phochhu river sub-basin have been completed to increase the awareness level on GLOF and EWS to the vulnerable communities.
- The project has been able to generate information and documents such as the 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, Standard operating Procedures and brochure on Early Warning System, pamphlets on do's and don'ts during GLOF event.
- Because of the project, the other benefit was in the capacity building of doctors in terms of addressing high altitude sickness. . The doctors from Bhutan were sent to Switzerland to get trained on high altitude sickness care.
- The local communities have benefitted economically by way of involving them as work force in the project as well as indirect benefits to the local communities through business opportunities.
- The other benefit was the managers and the supervisors have now gained the expertise to manage a huge work force especially working in high altitude and difficult terrain.

NEGATIVE

Some of the negative lessons learned from the project were as follows:

- While the water level has been reduced by 5 meters, it is still not confirmed that the risk has been completely mitigated.
- The glacier lakes at high altitude are the main source of river systems in Bhutan. Therefore, draining out water from these lakes without proper study would lead to scarcity of water resources in the future.

- Due to the location of the project sites at high altitude and accessible only during the summer, the wet weather conditions inhibited the efficiency of the work force and often made the workers sick. The wet working conditions were further aggravated by water seepage and lack of proper piping system.
- The project was heavily depended on human labor. Employment of new technique and mechanized lowering process would have been a better alternative in terms of achieving the targets faster and from the safety aspects.
- The location of the project site at the high altitude lessened the number of working months in a year to four months only (May to August). The other times of the year remained inaccessible due to snow.
- The other disadvantage was lack of emergency medical provisions like gammo bags and health care professionals especially prior to 2010.
- Due to the presence of a huge number of work force including animals used in transportation, there were severe degradation of the grazing lands. The large working population also had a huge impact on fuel wood and proper management of waste.
- The primary focus of the scientific study was on lowering the lake missing out on other important aspects like accelerating glacier melting and retreat and scouring effects.

1. What kinds of techniques and approaches have been deployed to engender community ownership of disaster risk reduction and management programs?

Some of the techniques and approaches that had been deployed to engender community ownership of disaster risk reduction and management programs were as follows:

- There was the involvement of various-stake holders like the local government administration, hydro-electric power projects and communities during the planning and implementation process of the project.
- Adequate number of awareness programs was carried out to the community members so as to instill a sense of ownership besides the mock drills.
- The communities have been empowered through the formation of a Community Based Disaster Risk Management (CBDRM) committee.

2. What are some of the methods used to integrate traditional and modern knowledge/know-how on GLOF risk reduction? Share best practices.

Some of the traditional and modern knowledge integrated in the GLOF reduction processes were:

- Religious ceremonies involving a local lama were performed on a daily basis at the project site to appease the deities and ensure safe conduct of the mitigation works.
- A religious personality is also included as a member of the multi-disciplinary task force to provide religious perspectives.
- A religious monument (Chorten/stupa) was also built at the project site for the well being and psychological support of the workers.
- Explosives were not used so as not to displease the local guardian deities and the deity of the lake as well.
- Lowering of the lake was carried out manually using locally available equipment such as spades, spikes, crowbars etc.
- A medical team consisting of both modern and traditional health care professionals was engaged to provide the workers with their choice of treatment.

- An animated clip known as "Ap Churi" had been broadcast over BBS television to sensitize and educate people on flood issues.

3. What are some of the issues with regard to information sharing and knowledge management on GLOF in the region? What are some of your recommendations in this regard?

Some of the issues with regard to information sharing and knowledge management on GLOF in the region were:

- There is a lack of information sharing on GLOF and other floods in the region.
- There is also a lack of proper national data base exclusively for GLOF and flood aspects.
- Countries are being very protective as far as sharing water datas/information are concerned.
- Hazard zonation maps are not updated regularly.
- Hydro-power stake holders should provide substantial support in mitigation of potentially dangerous lakes and setting up of EWS for their own safety.
- There is also a limited medium of communication that could be shared in social networks such as face book, websites, twitter and others.

RECOMMENDATIONS

The recommendations that came out as a result of group discussions on the questions 1 to 4 were:

- Before future mitigation projects are carried out, there is the need to carry out a detailed scientific study and have in place a strong data-base and information. Besides, modern technologies and hi-tech equipment should be used/explored.
- To conserve water, a dam could have been constructed downstream, rather than letting the water flow as was the case with Thorthormi lake.
- Local people should have been considered and engaged meaningfully right from the start to give them a better perspective on all aspect of the mitigation project.
- A diverse inter-disciplinary team could have been used including local and international experts.
- An eco-friendly approach could have been used thereby integrating conservation in the project.
- There is the strong need to brief the stakeholders on the various policies for sustainability in the future and the need to reassess previous works in greater detail to provide better information.
- The barrier between Raphsteng and Thorthormi lakes need to be monitored regularly.
- There is the need to develop capacity especially in the health professionals on high altitude medicine and remote emergency care.
- As GLOF is becoming more pertinent, related subject and curricula such as glaciology and disaster management need to be introduced in the education curriculum at all levels.
- There should be a better understanding of GLOF trigger factors such as earthquakes and glacial hydrology to study monsoon flow and glacier flow.
- The hazard zonation maps should be reassessed based on the use of high resolution ALOS sat images.
- Regional agencies such as ICIMOD should take lead in the integration and coordination of different studies and data base both at the national and regional levels. Besides, to enable trans-boundary knowledge sharing and management regional web portals could be developed.

CLOSING SESSION

CLOSING SESSION

The closing session was presided over by Dasho Sonam Tshering, Ms. Claire, Director General Namgay Wangchu and Director General Sonam Yangley.

Mr. Karma Tshering briefly touched upon the proceedings and the outcome of the two day International conference. He reiterated on the pertinent fact of the retreat of the glaciers in the Himalayas by 20-30% that had led to a rough estimation of 500 meters retreat in the last 25 years. He also stressed that GLOF as a global phenomenon had to be tackled together and the need of the hour was to collectively carry out further scientific researches, share knowledge and expertise, strengthen capacity, develop awareness and shift our focus to developing adaptation and mitigation interventions especially to the glacier changes so that lives could be protected and minimize losses and damages. He also highlighted some of the limitations on the mitigation works carried out at Thorthormi that came out clear from the group discussions. He suggested that lessons from the artificial lowering of the Thorthormi lake could be considered for upcoming projects in Bhutan and in the region.

Dasho Sonam Tshering, Secretary, in his closing remarks stated that over the last two days, we have been able to understand the threat and risks of GLOF in the Himalayan region and had the opportunity to learn from and listen to experts on the science behind GLOF and the different measures and policy options available for GLOF risk mitigation and adaptation. He said that the key consideration for us now is to ensure that all these research findings, lessons and best practices get translated into actions on-the-ground that will benefit the poor and vulnerable communities.

He reminded the gathering that the completion of the GLOF project in Bhutan is just the beginning of a long and arduous journey in mitigating climate-related risks in the Himalayas and important to build partnerships among experts and institutions in such gatherings.

He reminded that the focus should now be in moving forward to integrate or mainstream climate change mitigation and adaptation into government policies and systems so that it becomes our core business, especially as we are now faced with diminishing resources and aid.

Dasho thanked the high level expertise from all over the world and said that their advice and recommendations would go a long way in our upcoming projects. The secretary also thanked the donors and the organizers.

This was followed by the closing remarks by Deputy Resident Representative, UNDP. She thanked the delegates and said that the conference was a success. The conference allowed the experts on different disciplines to exchange their most updated researches and network to each other for future collaboration. She recapped some take-away points, and also outlined that henceforth, priority should be given to the importance of pre-disaster planning and development of sound warning system to be familiarized by communities, including learning from the experiences from the Tsunami in Japan, to supporting the elderly, women and the children during times of disasters. She said that it's important for us to continue investing in capacity development.

Representing the participants, Environmental Officer, Wangdue, Dzongkhag, noted that the conference was knowledgeable and gained more knowledge about the GLOFs and the challenges faced by people in other countries. He said that he is now better equipped and encouraged to work actively with the community in his work place.

Dr. Mariam Jackson, on behalf of the international participants, also noted that the conference was a big success. She thanked the organizers who had put in their efforts in organizing the conference. She noted that while the data on the GLOFs were different, it was however very useful as a scientific approach. She said that the disagreements and the differing views provided all of them with the opportunity to exchange further and learn from each other. She said that the conference provided with an opportunity for all of them to broaden their contacts for future use and references.

Sonam Yangley, Director General and GLOF Project Director, proposed the vote of thanks. He opined that the GLOF projects had been successful in lowering the water level, establishing EWS and creating awareness all of which had been possible with support from the dzongdags, the health ministry, the

ministry of works and human settlement, the Royal Bhutan Army (RBA) and the Central monastic body. He also thanked the organizers and the participants for sharing their expertise and their knowledge. He finally concluded that the recommendations from the conference would be useful to tackle the issue of GLOF in Bhutan and beyond.

ANNEXES TO THE REPORT

ON GLACIAL LAKE OUTBURST FLOOD (GLOF)

'REDUCING RISKS AND ENSURING PREPAREDNESS'

Annex I

CLIMATE CHANGE ADAPTATION AND GLOF RISK REDUCTION IN THE REGION AND BEYOND: CURRENT DEVELOPMENTS AND OPPORTUNITIES

Annex II

GLOF RISK REDUCTION IN THE HIMALAYAS-MONITORING, COMMUNITY PREPAREDNESS AND EARLY WARNING SYSTEM

Annex III

LESSONS ON GLOF EARLY WARNING SYSTEM AND COMMUNITY PREPAREDNESS: RECOMMENDATIONS
AND WAY FORWARD

Annex IV

GLOF RISK MITIGATION: EXPERIENCES IN IMPLEMENTING STRUCTURAL AND NON-STRUCTURAL MEASURES

Annex V

PERSPECTIVES ON REGIONAL AND GLOBAL INFORMATION SHARING COOPERATION

Annex VI

RECOMMENDATIONS ON GLOF RISK MITIGATION (STRUCTURAL AND NON-STRUCTURAL MEASURES)
AND INFORMATION SHARING.

Annex VII

Welcome remarks by Claire Van der Vaeren, Resident Coordinator, UN System in Bhutan

WELCOME REMARKS BY CLAIRE VAN DER VAEREN, RESIDENT COORDINATOR

UN SYSTEM IN BHUTAN

International Conference on Glacier Lake Outburst Flood (GLOF)

'Reducing Risks and Ensuring Preparedness'

5th December 2012

Hotel Olathang, Paro Bhutan

Hon'ble Chief Guest, Lyonpo Khandu Wangchuk, Minister, Ministry of Economic Affairs and Minister In-charge of Foreign Affairs, Royal Government of Bhutan;

Dasho Sonam Tshering, Secretary, Ministry of Economic Affairs and Chair of the Project Board;

Excellencies, Dashos, Aums;

Representatives of multilateral and bilateral agencies in Bhutan;

UN colleagues;

Other distinguished guests;

Ladies and gentlemen,

On behalf of the United Nations in Bhutan, I would like to join Dasho Sonam Tshering in welcoming you to this International Conference on Glacial Lake Outburst Floods. It is very heartening to see senior government officials, eminent experts, development partners, civil society representatives and other professionals gathered at this forum. I take this opportunity to thank all the participants present here today, especially those who have travelled from other countries to be here today.

First of all, let me express my profound gratitude to the hundreds of courageous men and women from all over Bhutan who contributed to the arduous task of lowering the water level of Thorthormi Lake since 2009. I would also like to express my gratitude to the Royal Bhutan Army for their contribution to the task in 2012. Without their courage and commitment, reducing the lake water level by 5 meters would not have been possible.

The Project – "Reducing Climate Change-induced Risks and Vulnerabilities of GLOF in the Punakha, Wangdue and Chamkar Valleys" is the first on-the-ground adaptation project supported by the GEF / LDC Fund, which stemmed from the National Adaptation Programme of Action (NAPA) process. The implementation of this project has not been an easy task. It has entailed hard manual labour in very harsh conditions in high altitude areas. It has also required multifaceted coordination among different sectors and agencies at national and local levels. I believe there will be opportunities to learn more about the challenges and lessons of the project in the next two days of this Conference.

Ladies and gentlemen,

Climate change is posing an unprecedented challenge to humankind today. We need to recognize that this is not a distant threat but one which has already begun to unfold; indeed a threat that Bhutan and other countries in this region are experiencing first hand. The wide-ranging impacts of climate change are undermining the very survival and sustainability of our development efforts. It is sadly ironic that these impacts are felt mostly in countries which account for the least greenhouse gas emissions. These countries also happen to have high poverty incidence and limited financial and technical resources to adapt to the impacts of climate change.

Bhutan is a typical example of this scenario. Although a net negative emitter of greenhouse gases, a substantial portion of Bhutanese communities are at significant risk from climate-induced disasters. The glaciers in Bhutan are retreating at an alarming rate causing threats of GLOFs to hundreds of communities living downstream. The melting of glaciers may also result in reduction of freshwater available for people's livelihood as well as hydropower generation as Bhutan's main source of revenue. While Bhutan has made a bold commitment to remaining carbon neutral, the efforts of the Royal Government to explore other renewable options such as biomass, solar and wind energy is a move in the right direction given the

uncertainty of water availability and hydropower development in the long run.

Bhutan is on track to achieve the Millennium Development Goals. However, natural hazards, such as GLOFs can easily erode the development gains, compromising achievements already made and sustaining them beyond 2015. It is critical for Bhutan to be well prepared to adapt and mitigate such disasters so that the negative impact on development results is minimized. The Disaster Management Bill which is before Parliament is expected once enacted, to contribute significantly to strengthening the country's preparedness.

As we noted, less developed nations and communities are likely to face the brunt of climate change impacts. This enhanced vulnerability and low adaptive capacity at community level underscores the need to formulate coordinated and comprehensive risk mitigation and preparedness strategies.

Bhutan has made a renewed commitment to strengthen community-based disaster risk reduction measures. Some progress has already been made. I am happy to note that, the LDCF - GLOF project has installed an early warning system and also worked directly with the vulnerable communities of Punakha, Wangdue and Chamkhar valleys.

Ladies and gentlemen,

Climate change mitigation and adaptation issues are very complex, affecting agricultural productivity, biodiversity, water resource and health, to name a few sectors. Tackling such complexity requires policies that relate the international, regional, national and sub-national levels of intervention effectively. Looking at climate change from a development perspective, it is important that we continue to mainstream climate change into national policies, plans and programs in a holistic manner. There is also an urgent need to accelerate the translation of these policies into practical mitigation and adaptation interventions on the ground, and explore ways of sustaining the financing of climate change-related efforts over the long-run through varied and innovative modalities.

It is equally important that we learn from the results and lessons of GLOF and other similar projects implemented in Bhutan and other countries, feed these experiences into the design of policies, and upscale interventions. Knowledge sharing and management should be further enhanced, and partnerships and networks built to find practical solutions to problems. This two-day conference is also an opportunity to foster such cooperation among countries that face the risk of GLOF. The recommendations of the "Bhutan Climate Summit for a Living Himalayas" held in Bhutan in November last year and the "Framework of Cooperation" that resulted from it can contribute to the operationalization of practical measures for collaboration that build on existing knowledge and institutions.

As Climate Change Adaptation and Disaster Risk Reduction are closely linked, there is an opportunity for Bhutan and other countries in the Himalayan region to bring the GLOF agenda within the realm of Priorities of Action under the Hyogo Framework for Action. The UN Secretary-General has asked the UN International Strategy for Disaster Reduction to lead the development of a successor to the Hyogo Framework for Action by 2015. Disaster risk reduction and resilience, with a stronger focus on preparedness, requires more central consideration in the post-2015 global development agenda if the objectives of sustainable development are to be achieved.

In closing, let me also take a moment to congratulate the Departments of Geology and Mines and Hydromet Services under the Ministry of Economic Affairs and the Department of Disaster Management under the Ministry of Home and Cultural Affairs for their hard work in achieving the intended results under the project and for organizing this conference. The project, has among others, greatly reduced the threat of GLOFs in the vulnerable communities of the Punakha-Wangdue valley.

Our deepest appreciation also goes to our co-financing partners - Austrian Development Agency (ADA) and the World Wildlife Fund (WWF) Bhutan in addition to the GEF/LDCF for supporting the project. This has been a very meaningful cooperation and we look forward to working with you in the future.

I wish you all fruitful deliberations.

Thank you and Tashi Delek !

Annex VIII

Closing remarks by Ms. Hideko Hadzalic, Deputy Resident Representative, UN System in Bhutan

CLOSING REMARKS BY MS. HIDEKO HADZIALIC, DEPUTY RESIDENT REPRESENTATIVE UNITED NATIONS DEVELOPMENT PROGRAMME

International Conference on Glacial Lake Outburst Floods

Olathang, Paro

06 December 2012

Hon'ble Chief Guest, Dasho Sonam Tshering

Distinguished Participants,

Colleagues,

Ladies and Gentlemen;

A very good afternoon to all!

I thank you all for inviting me to the closing session of the International Conference on Glacial Lake Outburst Floods. I am very pleased to note that the conference has been successfully convened in Bhutan, where the linkage between climate risk management and disaster risk reduction is a critical aspect in our quest for sustainable development. On behalf of UNDP, I would like to thank our partners - the Royal Government of Bhutan, Austrian Development Agency, World Wildlife Fund and Global Environment Facility for supporting the international conference, as well as technical experts from Austria, Nepal, Norway, Pakistan, India, Austria, Japan and the United States for enriching our discussions. Among others, such meetings serve as excellent platform to further our common agenda of reducing risks and securing livelihoods. After all, what we do, as development practitioners, ultimately benefits poor and vulnerable communities.

In the last two days, we have been able to understand the threat and risks of GLOF in the Himalayan region. There is a wealth of scientific information and indigenous knowledge on GLOF risk reduction around the region and beyond. We also had the opportunity to learn from and listen to experts on the science behind GLOF and the different measures and policy options available (eg. early warning system and community-based approach to DRR) for GLOF risk mitigation and adaptation. From whatever was presented in the conference, it appears that there is a wealth of scientific information and indigenous knowledge on GLOF risk reduction around the region and beyond. It is also evident that a lot of research and work on glacial lake outburst floods have been undertaken in the past few decades. Many more will probably follow. The key consideration for us now is to ensure that all these research findings, lessons and best practices get translated into actions on-the-ground that will benefit the poor and vulnerable communities.

As we celebrate the completion of the GLOF project in Bhutan, I would like to remind you all that this is just the beginning of a long and arduous journey in mitigating climate-related risks in the Himalayas. What we do in the Himalayas has a direct bearing on the more than 1.7 billion people in the sub-continent. It is important that we learn from each other's experiences and research activities. As you all know, the expertise is in this room. It is important to build partnerships among experts and institutions in such gatherings. I hope this two-day conference provided a good platform for networking and information sharing. GLOF risks calls for concerted efforts not only at national level but also at regional level. Mechanisms to facilitate sharing of information, knowledge, experience and expertise to effectively tackle the impending threats posed by climate change must be developed. I hope the experts and practitioners gathered here representing the fields of disaster management, climate change, environmental management, development planning, administrators and civil society actors have done just that. As noted by the UN RC in her opening remarks yesterday, a framework to promote greater regional cooperation would help reduce disaster risks not only in the respective countries but also in the region as impacts of climate change and disaster risks have a strong co-relation and are bound in a delicate cause and effect relationship.

While we have, over the last two days, discussed and deliberated extensively on reducing risks of GLOFs, this is just one aspect of disaster risk reduction. We must also look at ways and means to integrate this element into the overall DRR agenda. For a community-based disaster risk reduction and management programme to be effective, it is pertinent that we look at all kinds of hazards in a holistic and comprehensive

manner.

I am very happy to learn that the discussions were very rich and substantive, and that the same resulted in a collection of innovative ideas and knowledge (technical approaches on lake mitigation and setting up a robust early warning system) that could be used to address challenges in our efforts to reduce risks of climate-induced disasters. The focus moving forward should be to sustain these activities with the ultimate goal to integrate or mainstream climate change mitigation and adaptation into government policies and systems so that it becomes our core business, especially as we are now faced with diminishing resources and aid.

I am also hopeful that the recommendations from this conference will be useful to other countries, especially Nepal and Pakistan, who are embarking on similar initiatives. The UNDP will be happy to facilitate knowledge sharing and exchange of technical expertise among countries to promote south-south cooperation in the region.

Lastly, let me thank all the resource persons, experts and participants for coming all the way to Bhutan to attend this conference. We thank you very much for your contributions and look forward to working with you again in the future. I hope that that you had some time during the conference to explore bit of Bhutan.

I wish you all an enjoyable stay here in Bhutan and safe travel back home.

Thank you and Tashi Delek.

Annex IX

Conference participants list

Conference Participants List

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