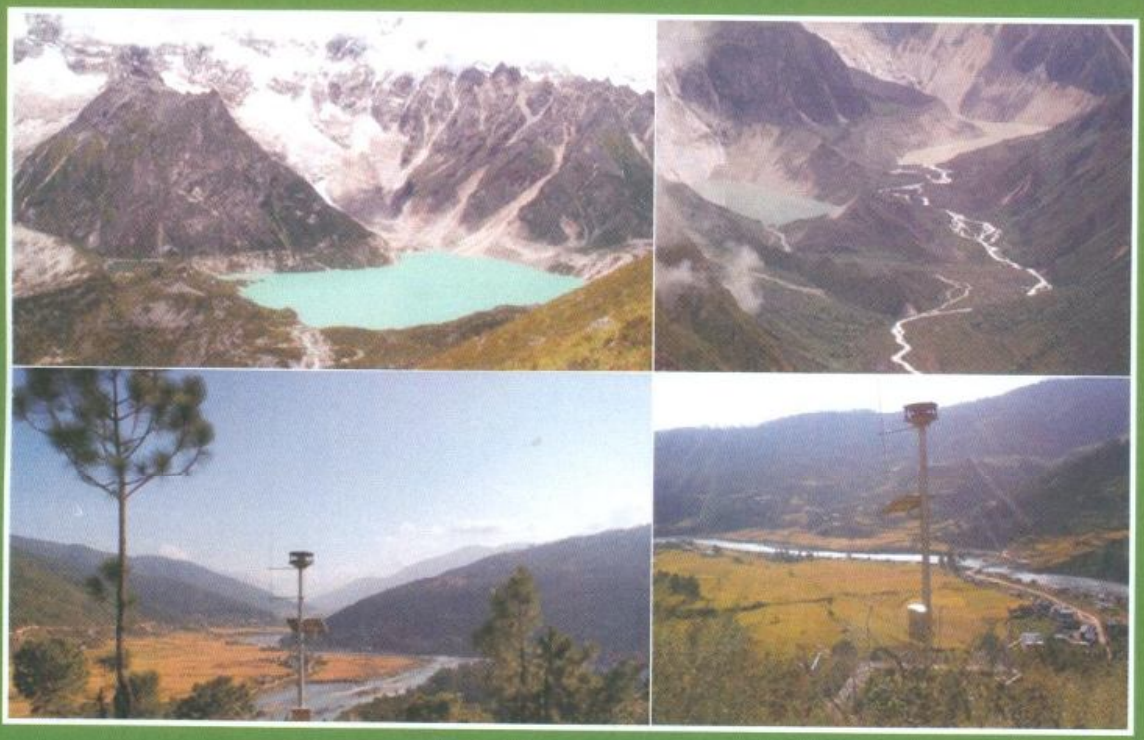
GLOF Early Warning System in the Punakha Wangdue Valley

Project Implementation Procedures followed and Lessons Learnt

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



Department of Hydro-met Services
Ministry of Economic Affair
Thimphu: Bhutan

Forward

This report was prepared to properly document the implementation procedures followed while implementing the project component for future reference. The development of document was initiated by the Department of Hydro-met Services, Ministry of Economic Affairs as per the decision and directive of the 13th Project Board (PB) meeting held on 18th January 2013. All the procedures, problems and lessons learnt complied in this report were produced by the GLOF Early Warning System Project Management, Hydrology Division, Department of Hydro-met Services, Ministry of Economic Affairs.

Special thanks go to the Hydrology Division, Department of Hydro-met Services particularly Mr. Karma Dupchu, Chief, Hydrology Division/Project Manager, GLOF EWS, Mr. Sangay Tenzin, Engineer (Dy. Project Manager) GLOF EWS and other staff for coming up with this report. To all others who were directly or indirectly involved in the project implementation, your contributions have ensured its success.

The Department of Hydro-met Services, Ministry of Economic Affairs is immensely grateful to the United Nations Development Program (UNDP), Global Environment Facilities (GEF), Austrian Development Agency/ACO and Puntsangchhu Hydropower Project Authority (PHPA I & II) for their financial support.

(Karma Tsering)
Director

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Acronyms

ACO	Austrian Coordination Office for Development Cooperation
AWLS	Automatic Water Level Station
AWS	Automated Weather Station
BGAN	Broadband Global Area Network
DCP	Data Collection Platform
DDM	Department of Disaster Management
DGM	Department of Geology and Mines
DHMS	Department of Hydro-met Services
DLAC	Dzongkhag Land Acquisition Committee
DOE	Department of Energy
DoR	Department of Roads
EI	Expression Interest
EIA	Environmental Impact Assessment
ELOS	Extended Line Of Sight
EOC	Emergency Operation Center
EWS	Early Warning System
FAT	Factory Acceptance Testing
FP	Focal Person/Point
FWS	Flood Warning Section
FYP	Five Year Plan
GAO	Gewog Administrative Officer
GDMC	Gewog Disaster Management Committee
GEF	Global Environment Facility
GLOF	Glacial Lake Outburst Flood
GNHC	Gross National Happiness Commission
GSM	Global System for Mobile Communication
HD	Hydrology Division
HF	High-Frequency
HMSD	Hydro-met Services Division
IP	Implementing Partner
JICA	Japan International Cooperation Agency
JST	Japan Science and Technology Agency
LDCF	Least Developed Countries Fund
MD	Meteorology Division
MoEA	Ministry of Economic Affairs
MoHCA	Ministry of Home and Cultural Affairs
MTR	Mid-Term Review
NAPA	National Adaptation Programme of Action
NEC	National Environment Commission
PB	Project Board
PHPA	Punatsangchhu Hydropower Project Authority
PM	Project Manager
RGoB	Royal Government of Bhutan
SAT	Site Acceptance Testing
SIA	Social Impact Assessment
SOP	Standard Operation Procedures
TA/DA	Travel Allowance/Daily Allowance
ToR	Terms of Reference
UNDP	United Nation Development Program
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction

Glossary

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

Chapter 1
Introduction

1.1 Background

The project **"Reducing Climate Change-Induced Risks and Vulnerabilities from Glacier Lake Outburst Flood in the Punakha-Wangdu and Chamkhar Valleys**" was funded by UNDP-GEF under LDC funding.

The project has three main components:

a. Lowering of water level of Thorthormi lake
b. Installation of GLOF Early Warning System (EWS) in the Punakha-Wangdue Valley, and
c. Strengthening of Disaster Management and Communities Awareness

The 2nd component **"Installation of GLOF Early Warning System"** was handed over to the Department of Energy (DoE), Ministry of Economic Affairs (MoEA) for implementation as per the directive of 1st Project Board (PB) meeting held on 23rd July 2009 to establish a comprehensive early warning system for the Punatsangchhu basin that not only cater to the needs of the people in Punakha-Wangdue valley but also to hydropower projects and other infrastructures downstream by combining with flood warning program implemented by the Hydro-met Services Division, Department of Energy, MoEA.

As per the original project document, the component 1 and 2 were to be implemented by the Department of Geology and Mines (DGM) and 3rd component to be implemented by the Department of Disaster Management (DDM), Ministry of Home and Cultural Affairs.

GLOF early warning component of the project was formally transferred to the Department of Energy (DoE), MoEA based on a request letter submitted to the Gross National Happiness Commission (GNHC) by DGM vide letter DGM/63C/2009/4456 dated 14 January 2009. The early warning component of the project was formally implemented by the Hydro-met Services Division (HMSD), Department of Energy (DoE), MOEA with effect from January 2009.

1.2 Fund Allocation

An amount of US$ 847,787.00 was allocated for the installation of GLOF early warning system component from the GEF/UNDP with co-financing from Austrian Development Agency (ADA). In addition, the government mobilized around USD 0.380 million (Ngultrum 20.00 million) from the hydropower Authorities (Phunatsangchhu Hydropower Project Authority (PHPA-I and II) as co-finance to establish comprehensive of the early warning system.

1.3 Organization of Report

The documentation of the "Installation of GLOF Early Warning System in the Punakha-Wangdue Valley" report consists of eight chapters followed by annexes.

a. Chapter 1: Introduction and Background.

Chapter 1 describes the project background, project funding and a summary of different chapters.

b. Chapter 2: Project Preparatory Phase

Chapter 2 describes about the project site assessment, procedures followed for land acquisition and environment clearance for the project.

c. Chapter 3: Tendering and Award of Work

Chapter 3 deccribes about the tendering procedure followed for the project including problems and lesssons learnt.

d. Chaper 4: Project Implementation

Chaper 4 describes about the project implemenation processes followed such as handing over of the project sites to the Contractor, award of work, project inception report and meeting, civil work construction, manufacturing and testing of equipment, Factory Acceptance Test (FAT), transportation and shipment of equipment, challenges and lessons learned.

e. Chapter 5: Installation and Integration of System

Chapter 5 contains all the procedues followed during the installation of equipment in Punakha-Wangdue, Lunana region, system integration and trainings, final acceptance testing, challenges and lessons learnt.

f. Chapter 6: Operation of GLOF EWS

Chaper 6 describes about the operation and maintenances aspect of the GLOF EWS upon taken over from the Contractor, development of Standard Operating Procedures (SoP), Education and Awarness of GLOF EWS installed and mock drill and problems.

g. Chapter 7: Sharing and Dessimination

Chapter 7 decsribes about the sharing of expereinces and showcasing the system installed with line agencies and international organizations by site visits to the GLOF EWS sites and through international GLOF conference.

h. Chapter 8: Follow up Actions and Conclusion

Last chapter 8 describes about the project follow up activities and conclusions.

1.4 Profile of GLOF Early Warning System

A GLOF EWS installed in the Punakha-Wangdue is composed of 6 remote Automatic Water Level Monitoring Stations and Automatic Weather Stations (AWS) and 17 Sirens to warn vulnerable communities along the river valley downstream. Iridium satellite communication is used to transmit data from remote stations to control room for operation and monitoring of GLOF in real time and as well as activation of sirens to issue warnings in the event of GLOFs. Control station operators can view the latest data from any of the 23 stations using custom developed software by Sutron. The schematic diagram of the present GLOF EWS in Punakha-Wangdue Valley is shown in the **Figure 1.**

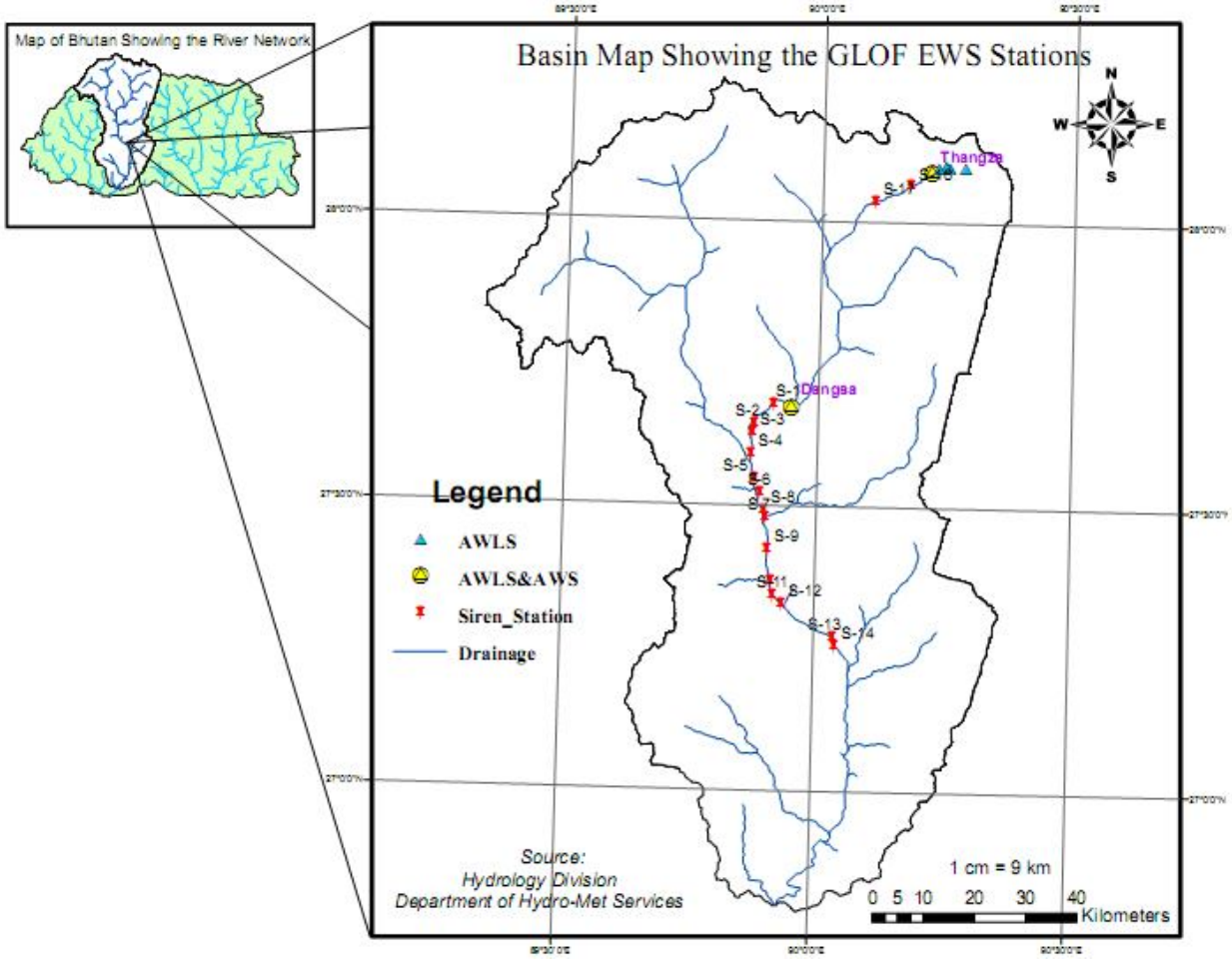


Figure 1: Punatsangchhu Basins Map showing location of GLOF EWS sites

Chapter 2
Project Preparatory Phase

2.1 Site Assessment

Earlier Site Assessment of GLOF Early Warning System in Punakha-Wangdi valley was carried out by the Department of Geology and Mines (DGM). The study identified the location of sensors, sirens and control room including the mode of communication. Two alternative sensor locations were identified at about 3 km upstream of Wolathang Community School in the so-called "Punakha Gorge" in line with sites proposed by the Austrian team in 2002. Four siren locations were identified at Samdingkha, Punakha, Khuruthang and Bajothang with alternatives sites to alert and warn people in the event of GLOF. Study proposed that the main control station be located at Khuruthang, Punakha.

Based on the directive received from the GLOF Project Board (PB) to set up a comprehensive early warning system for the Punatsangchhu basin, the Department of Energy (DoE) carried out "Re-assessment of GLOF-EWS sites in the Punakha-Wangdue valley" considering the following objectives:

a. To design comprehensive GLOF EWS incorporating real time hydro-meteorological data collection and retrieval system.
b. To reduce human and material losses in vulnerable communities in the Punakha-Wangdi Valley through GLOF early warnings

2.2 Site Assessment in Punakha-Wangdue Valley

Re-survey of GLOF EWS sites in the Punakha-Wangdue valley were carried out by DoE in collaboration with the Department of Geology and Mines (DGM) in September 2008. The field assessment report was presented to the 2nd Project Board (PB) meeting held on 16 February 2009, Thimphu.

The study identified:

a. Two sensor locations: one at Dangsa upstream of Wolathang and recommended that other sensors should be located at Thanza, Lunana to have more lead time for warning.
b. 14 Sirens locations were identified along Punakha-Wangdi valley with alternatives sites to alert and warn people in the event of GLOF starting from Wolathang community school upstream Punakha to Kamichhu, Punatsangchhu –II Power house site downstream;
c. Proposed different mode communication system for the transmission of data from sensors to Control station, from Control Station to Sirens for warning.

Study also proposed the preliminary design and difference communication options for GLOF EWS to be installed.

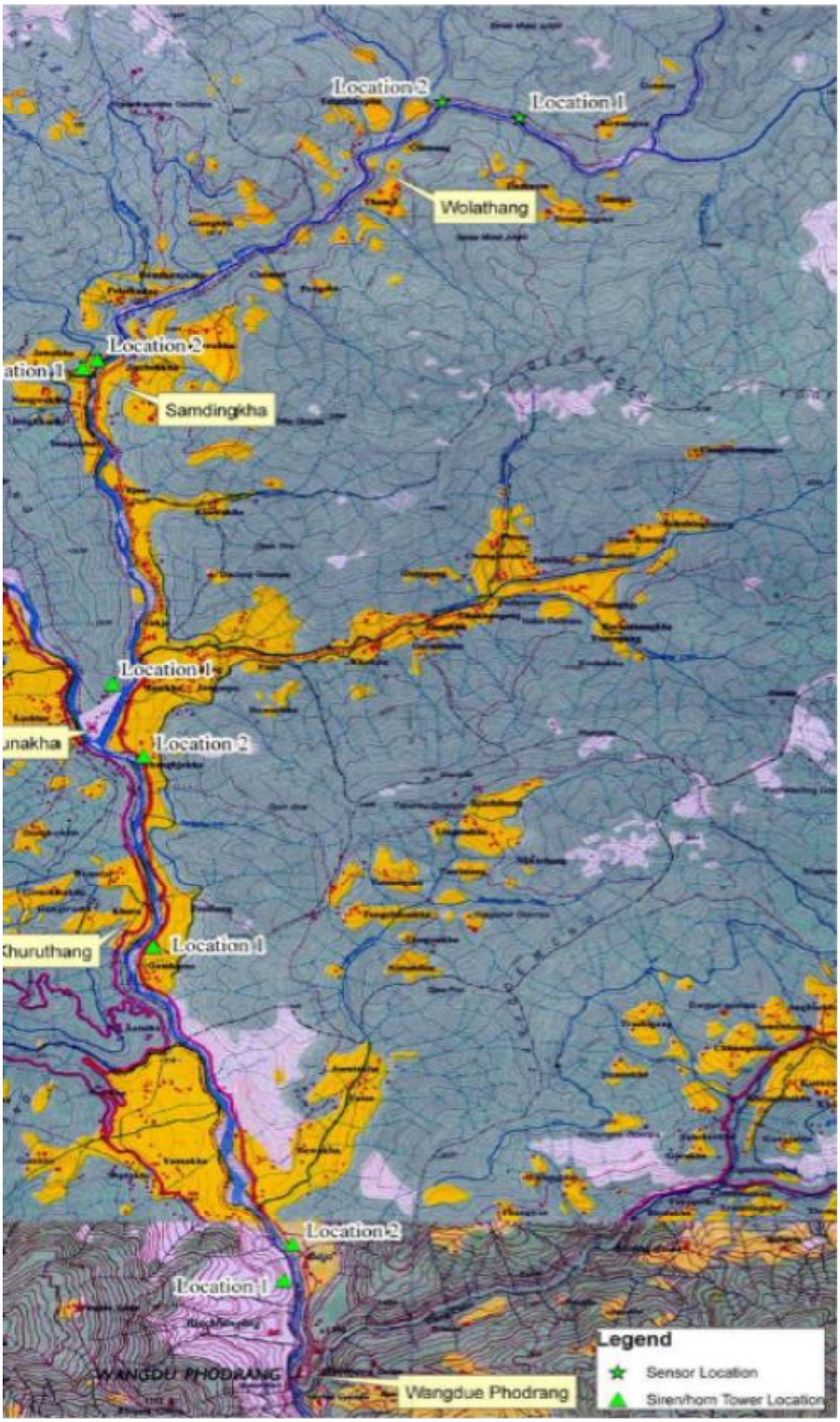


Figure 2: Map showing the DGM Proposed Pilot GLOF EWS sites in the Punakha-Wangdue valley (Source: DGM, MoEA)

Photo 1: Site Assessment Team from HMSD (DoE), DGM and from Punakha Dzongkhag, September 2009

Photo 2: Site Assessment Team from HMSD (DoE), DGM and Local people upstream of Phochu, Punakha Dzongkhag (September 2009)

2.3 Site Assessment in Lunana

Lunana project sites have very limited access. Places are accessible only during summer months. DoE deputed a team of engineers to carry out the site assessment study to identify location of sensors, sirens and communication system in Lunana from 6 July to 7 August 2009. Team identified location of sensors sites, siren towers and communication system for GLOF EWS.

Photo 3: Location of Sensors and Sirens in Lunana Areas

2.4 Control Room

The Department of Geology and Mines (DGM) in their earlier preliminary site assessment report proposed to set up GLOF EWS control room at Khuruthang, Punakha. However, the Department of Energy proposed and decided to set up GLOF EWS Control Room at Wangdue Flood Warning Office due to existent of acquired land and infrastructures. The Flood Warning Office, Wangdue was also the control room for the Manual GLOF early warning system operated by the erstwhile Hydro-met Services Division (HMSD), DoE. Water level status from Thanza, Lunana are transmitted (as per the schedule 8 times daily) by staff stationed through wireless directly to Wangdue Flood Warning Office with Dobani flood Warning Station at Sankosh as back up. These offices are equipped with HF wireless set, telephone line and access to electricity. Location of Wangdue Office very near to the Bhutan Telecom Transmission/Receiver tower and availability of residential quarters for staff within office compound were other reasons for selection of Control Room location at Wangdue.

Photo 4: Wangude Flood Warning Office

2.5 Land Acquisition

After completion of site survey and re-assessment, the project management followed-up with National Land Commission Secretariat (NLCS) for acquisition of land for the project at various locations in the Punakha-Wangdue valley. As per the directives of the National Land Commission Secretariat (NLCS), DOE then followed with Dzongkhag Land Acquisition Committee (DLAC) of the Punakha and Wangdue Dzongkhag administration. Site visit to sensors and siren sites by DLAC in the Punakha and Wangude Dzongkha completed in January 2010. However, the land acquisition got delayed as Land Recorder Officer of the Wangdue Dzongkha Administration was fully engaged with land acquisition process of Punatsangchhu Hydropower projects.

After completing all the formalities with the respective Dzongkhags, NLCS issued the "Approval for Lease of GRF Land for Development Activity" vide letters given below:

a. No.NLCS/Lease(01)/10/2106 dated 14th January, 2010 for lands under Punakha Dzongkhag.
b. No. NLCS/Lease(03)/10/2153 dated 25th January, 2010 for lands under Wangdue Dzongkhag.

Based on the land commission letter the 30 years "Agreement Deed for Lease of Forest Land-Non Planation" was signed between DoE and the Forestry Division, Wangdue, Department Forests and Park Services, Ministry of Agriculture and Forests on 1st April 2010.

2.6 Environment Clearance

In parallel to land acquisition, the department also processed for the Environment Clearance for installation of siren towers and sensors for GLOF EWS in the Punakha-Wangdue from the National Environment Commission (NEC). After review of the required documents submitted, Environment Clearance for the project was issued by the National Environment Commission (NEC) on 24 July 2009.

Since the validity of the clearance issued was expired during the implementation of the project due to delay in tendering process as well as due to bad weather conditions in Lunana, the Environment Clearance of the project was renewed by NCE till 31 December 2012.

2.7 Lessons Learnt

a. It is very important to identify and engaged relevant agencies including the local government starting from the formulation and designing of project for the timely implementation of the project. The handing over of the GLOF EWS component of the project to the Department of Energy at the project implementation stage clearly indicates that no proper consultations were done during the formulating of the project. Engagement of DoE during the project preparatory phase would have completed studies as such as site assessments, land acquisition of the project component much earlier.

b. Land acquisition and Environment Clearance are pre-requisites for this kind of project, where the formalities have to be completed before the starts of the project implementation. Since these processes take long time, it is important to initiate dialogue with relevant agencies from the beginning. And also prepare and submit the required documents to relevant agencies on time.

c. With good support and cooperation received from national and local government organizations as well as from the relevant line agencies, the Project Management could complete the all the formalities within the required time frame.

Chapter 3
Tendering and Award of Work

3.1 Expression of Interest (EoI)

Considering the complexity of the project and limited technical capacity within DoE to implement the project, DoE decided to implement the GLOF EWS system by recruiting National/International firm on Turnkey Contract. DoE invited the "Expression of Interest (EoI)" from interested Firms on 17 May 2009.

The following five (5) Firms submitted EoI in June 2009.

a. M/s Visala, Finland
b. M/s USD Enterprise, Bhutan;
c. M/s Ugyen Trading House, Bhutan Joint Venture (JV) with M/s Motorola Singapore;
d. M/s Marubeni Corporation, Japan;
e. M/s The Friendship, India joint venture with Endress + Hauser [India] Pvt. Ltd. and Sai Technologies, India.

EOI was opened on 19 June, 2009. The screening and evaluation of firms were done by the Technical Committee nominated from the relevant agencies on 26 June 2009.

Considering that only five firms have shown interest and all firms offered similar technology and communication system, the meeting discussed and agreed that all the firms will be asked to submit the technical proposal to ensure competitions.

3.2 Preparation of Tender Document

The new Procurement Rules and Regulations of Bhutan 2009 was enforced by the Ministry of Finance from 1 April 2009. Since there was no standard bidding document for turn-key/EPC, the tendering process of the project was delayed. Standard Bidding Documents were available only for the Work, Supply and Consultancy Services. Several round of discussions were held with the Procurement Section of the Ministry and as well as with the Public Policy and Procurement Division (PPPD), Ministry of Finance.

With no options and recommendations provided by the Public Procurement and Policy Division (PPPD), Ministry of Finance (MoF), the project management, DoE prepared and developed a Turnkey Tender Document by modifying the Standard Bidding Document of Work for the project component and was submitted to the Ministry of Finance (MoF) for endorsement as there was no standard bidding document for turn-key/EPC contract. Modified tender document for Turn-key work was endorsed by the Public Procurement and Policy Division (PPPD), Ministry of Finance (MoF) on 1st September 2009.

Other great challenges and difficulty faced by the project management was to come up with detailed technical specifications of equipment and realistic cost estimate of the system because of the following:

a. Complex nature of the project/system that had to consider number of components such as remote monitoring stations (hydrological, meteorological monitoring equipment), Control Operation Room, communication system, public warning sirens, SCADA system etc. that required multi-disciplinary experts to integrated the system.
b. Limited technical capacity of staff within the Division/Department and
c. Lack of Firms and experts within Bhutan dealing with early warning system and equipment.

Therefore, a special approval was sought from the Project Board (PB) to float the Tender without "Technical Sanction".

3.3 Bidding Process

After endorsement of the Modified Bidding Document of the project by the Ministry of Finance (MoF) and endorsement by the PB to float the tender, invitations for the bids were sent to all the five selected Firms for submission of bids to carry out the Installation of GLOF EWS in the Punakha-Wangdue Valley on turn-key basis on 25 September 2009.

The Bidding Documents were sold to all the five Firms who have submitted EoI, however, only three Bidders viz. (M/s Ugyen Trading House, Thimphu, M/s USD Enterprise, Thimphu and M/s The Friendship, India) submitted the bids on time.

3.3.1 Pre-bid Meeting

As per the requirement of the Bidding Document, the Pre-bid meeting was held on 12 October 2009 to clarify bidders on the scope of work and other issues. Based on the request of the Bidders the deadline for the submission of Bids was extended to 23rd November 2009 from 12th November 2009.

In pursuant to ITB Sub-Clause 10.2 of the Bidding Document, the project mangement issued three (3) Addendums/Clarifications based on the queries submitted by the Bidders.

3.3.2 Opening of Technical Bids

Since this was a turn-key project, evaluations of bids were conducted in two stages, where total weightage for the technical proposal was (60%) and financial was (40%). Upon submission of Bids by the Firms, Technical Bids were opened on 23rd November 2009 in presence of Bid Opening Committee members. The opening was chaired Mr. Yeshi Wangdi, Offtg. Secretary, Ministry of Economic Affairs.

3.3.3 Evaluation and Presentation of Technical Bids

With the approval from the Ministry, Technical Evaluation of the bids was carried out by the multi-disciplinary Technical Bid Evaluation Committee members nominated from different agencies at Paro from 28 November 2009 to 2 December 2009. The Evaluation Tender Committee also sought number of clarifications from the bidders.

The Technical Evaluation report was presented to the Ministerial Tender Committee (MTC) on 30 December 2009.

Photo 5: Technical Evaluation Team at Paro during the Technical Bids Evaluation 28 November-2 December 2009

3.3.4 Evaluation and Presentation of Financial Bids

All the three Firms were qualified in the technical evaluation scores. The minimum technical score required to qualify was **70 Points.** The financial bids for all three bidders were opened on 5th January 2010. The financial bid opening was chaired by Mr. Sonam P Wangdi, Offtg. Secretary, Ministry of Economic Affairs and was attended by the bid opening members nominated from other department of the Ministry.

Upon completion of Evaluation of Financial Bids, the Final Evaluation Report was presented to the Ministry Tender Committee (MTC) on 26 January 2010. The meeting was chaired by Dasho Sonam Tshering, Secretary, Ministry of Economic Affairs with members from line agencies and UNDP.

3.3.5 Problems with Tender Evaluation Result

All three bids were technically qualified and their financial bids were opened and the results of evaluation are given in table below.

Final Evaluation Score [Technical (60%) + Financial (40%)] table showing ranking of the bids:

Criteria	Bidder I	Bidder-II	Bidder-III
Weighted Score (60%)-Technical	42.09	46.10	50.48
Weighted Score (40%)-Financial	36.55	40.00	14.65
Total weighted Score (100%)	**78.64**	**86.10**	**65.13**

Table showing ranking of the bids along with total weighted scored and Bid Price

Name of Bidder	Total Weighted Scored (100%)	Bid Price (Nu.)	Rank
Bidder-II	86.10	48,058,368.00	1st
Bidder-I	78.64	52,600,000.00	2nd
Bidder-III	65.13	13,12,02,433.60	3rd

However, as per Clause 4.5 of the Instructions to the Bidders, in order to qualify for award of the Contract, the substantially responsive bidders should meet the minimum qualifying criteria. Therefore, the substantially responsive lowest bids in the order of above ranking were evaluated against the following minimum qualifying criteria.

4.5 (a) Average annual volume of work done in any one of the last 5 years: Nu. 60 million;
4.5 (b) Satisfactory completion of 1 (one) number of similar works/supplies in last 5 years;
4.5 (c) Availability of critical equipment for the work:
4.5(e) Liquid assets and/or credit facilities from a reputed financial institute: Nu.9.0 million.

All the Bidders fulfilled above minimum criteria by adding the figures for each of the partners of JV/C/A.

However ITB 4.6 states that ***"…. for a JV/C/A to qualify, each of its partners must meet at least twenty five percent (25%) of minimum criteria 4.5 (a)) for an individual Bidder, and the partner in charge at least forty percent (40%) of those minimum criteria. Failure to comply with this requirement shall result in rejection of the JV/C/A's Bid"***.

Bidder-I and Bidder-II did not fulfill the minimum criteria of the Average annual volume of work done in any one of the last 5 years (Nu. 60 million) i.e. 25% as an individual Bidder and forty percent (40%) of those minimum criteria as lead partner of JV/A/C. Only Bidder-III met above minimum criteria as individual bidder and as a lead partner but bid price was found to be almost 3 times more than lowest bidder (Bidder-II) and 2 times more than 2nd lowest bidder (Bidder-I).

Since the ITB 4.6 clearly states that *"….Failure to comply with this requirement shall result in rejection of the JV/C/A's Bid"*, the Tender Committee was left no room but to abide by the clause and directed the Department of Energy to negotiate bid price directly with the 3rd Lowest Bidder (highest) (Bidder-III) to the acceptable bid price based on the available committed fund of the project component of around Nu. 50.00 million only.

3.3.6 Negotiation with 3rd Lowers Bidder (Highest)

Based on the MTC directive, the department negotiation team negotiated with the 3rd Lowest Bidder (Highest) on 28 January 2010. **Nu.115,689,702.24** (reduced from original bid price Nu. 131,202,433.60) was negotiated price offered by the 3rd Lowest Bidder.

3.3.7 Presentation of Negotiation Results

The negotiation team presented the negotiation result to the Ministry Tender Committee (MTC) on 12th February 2010. The negotiated bid price offered by the 3rd Lowest Bidder **Nu.115,689,702.24** (reduced from original bid price Nu. 131,202,433.60) was quite high that exceeded way beyond the availability of fund of the project component and was more than 2 times that of the lowest bidder (Bidder-II), the MTC could not take decision to award the Contract to Bidder-III.

After extensive discussion on the issues whether to go for re-tendering or some other process, the MTC decided put up the issue to the Ministry of Finance for seeking the relaxation on ITB clause 4.6 so as to enable the DoE to award the work to the first lowest evaluated bidder (Bidder-II) owing to the following reasons:

a. Based on technical and financial evaluation result, Bidder –II ranked 1st followed by Bidder-I and Bidder-III, except they do not met the provision of ITB 4.6 i.e. *at least twenty five percent (25%) of minimum criteria 4.5 (a)) for an individual Bidder, and the partner in charge at least forty percent (40%) of those minimum criteria.*
b. Since the Bidding Document allows even individual foreign company/Firm to bid for the turn-key project, ITB clause 4.6 could have no relevance if the individual foreign companies have submitted the bid on their own. Although, Bidder-I and Bidder-II does not met the minimum criteria as per the ITB 4.6 as an individual but their partner/s does fulfill individually as lead partner if they have submitted the bid individually.
c. Bidder I and II do not meet the minimum criteria as per ITB 4.6 as an individual but their partners fulfill if considered as lead partners.
d. Since there was no standard bidding document for the turn-key project and bidding document was prepared by just modification of standard work document, some provision of document were overlooked while preparing the document.
e. Some of the likely implications that would have on the project if we go for retendering were:
    I. The bid price would go up beyond available committed fund of the project component of Nu. 50.00 million. Thus more or additional fund have to be secured.

    II. There was some un-certainty whether relevant international firms dealing with hydro-meteorological and communication equipment will bid for the tender again considering the amount of fund available for the project is small.

    III. Re-tendering may further delay the already delayed implementation of this project component. This was because as per the project document 'Installation of GLOF EWS component was to be implemented prior to other to components implemented by DGM and DDM. This was because the Department of Disaster Management (DDM) component to disseminate EWS outputs and results to communities to create awareness could be implemented only upon installation and commission of EWS system.

    IV. Unlike other project this component was related to disaster to warn communities and infrastructures downstream. Considering the number of mega hydropower

projects that were coming up in the downstream of Punatsangchhu, the EWS system needed to be operational at the earliest.

V. If we re-tender, we would have to do away with ITB 4,6

Given the above reasons and implications that would have on the project, the Ministerial Tender Committee (MTC) submitted a letter to the Ministry of Finance seeking approval for awarding the work to the first lowest bidder, bidder – II at their quoted bid price of Nu. 48,058,368.00 on 16 February 2010.

The Ministry of Finance vide letter no. MoF/PPPD-10/2009/2010/0465 dated 2nd March 2010 informed Clause 4.6 may be ignored and work be awarded to the Bidder obtaining the highest total weighted score (Technical + Financial).

3.4 Awarding of Work

In pursuant to the approval letter from the Ministry of Finance and directives of the Ministerial Tender Committee (Minutes of the meeting of Ministerial Tender Committee dated 12 February 2010) the turkey work was awarded to Bidder-II based on technical and financial evaluation result.

a. Turkey work was awarded to M/s USD Enterprise, Joint Venture (JV) with M/s Sutron Corporation, USA at a Contract Price of Nu**. 48,058,368.00** based on endorsement of the Project Board in the 7th Project Board Meeting held on 16 March 2010.

b. The Contract Agreement between the Department of Energy (DoE) Ministry of Economic Affairs and M/s USD Enterprise signed on 29 March 2010 and work order issued on the same day.

c. Supply, installation, testing and commissioning of the GLOF EWS in the Punakha-Wangdi Valley had to be completed by the Contractor within 15 Months from the issue of work order (29 March 2010) i.e. April 2010 to June 2011.

3.5 Challenges and Lessons Learned

The following are some of challenges and lessons learnt:

a. Limited Technical Capacity and Complexity of Project

One of the challenges faced by the project management of the department was lack of technical capacity within to implement the project due to complex nature of the project. It was very difficult to frame and come up with realistic cost estimate and technical specifications for the equipment. This was because, GLOF EWS have lots of components such as hydro-meteorological, electro-mechanical and communication equipment, and "rates" for most of the equipment are not available in Bhutan Schedule of Rate (BSR) as well as in the Bhutanese markets.

There was no good example of existing GLOF EWS system that was operational in the region as well as around the world.

b. Change in Procurement Rules and Regulations

New Procurement Rules and Regulation 2009 was enforced from 1 April 2009, but there was no standard bidding document for turn-key/EPC contract (Standard Bidding Documents available only for- Work, Supply and Consultancy Services). Adoption or enforcement of new rules and regulations also hindered and delayed the tendering process, thus implementation of the project.

c. Clauses and Provisions

Although the modification of the Bidding Document served the purpose to initiate the tendering process of the project, however, one clause of the bidding document (ITB 4.6 clearly states that *"….Failure to comply with this requirement shall result in rejection of the JV/C/A's Bid")* had led to futile exercises.

However, under the dynamic leadership and prompt decision of MTC and approval from the Ministry of Finance enabled the department to award work without resorting to re-tendering considering the importance and the urgency of the project.

It is very important to thoroughly review and understand the clauses and provisions of bidding documents before tendering.

Chapter 4
Project Implementation

4.1 Handing Over of Sites

After the award of the work, the first meeting between the Department of Energy (Employer) and the Contractor (M/s USD Enterprise JV with M/s Sutron Corporation was held on 24 May 2010 in Thimphu.

Project sites (Sensor site at Dangsa, Control Station and Siren stations) along the Punakha-Wangdue valley were handed over to the Contractor between 25-26 May 2010. Due to nature of the project sites, Lunana area sites were handed over to the Contractor only in between 6 July to 7 August 2010.

Photo 6: Dangsa Automatic Water Level Monitoring Station Site, upstream of Tame Damchhu Village under the Punakha-Dzongkha (May 2010)

Photo 7: Siren towers location field survey with Contactor (May 2010)

Photo 8: Siren Tower locations field survey with Contactor (May 2010)

4.2 Project Inception Report

Based on the information collected, the Contractor prepared detailed design of the GLOF EWS system and submitted the Draft Project Inception Report to the Department of Energy for review and comments on 27 May 2010. After incorporation of DoE comments, the Final Inception Report was presented to the department and other project stakeholders meeting was held on 17 August 2010. The presentation meeting was chaired by the Secretary/Chairman Project Board Ministry of Economic Affairs, other Board members from UNDP, ACO and other line agencies.

Photo 9: Project Inception Meeting (17 August 2010)

4.3 Civil Work

The construction of all the civil works were done by the local company based on the design approved by the Employer with technical back stopping provided by Sutron Corporation, USA.

4.3.1 Civil Work in Punakha-Wangdue Valley

Civil work in the Punakha-Wangdu valley started soon after the award of work by the Contractor from June 2010. Materials for the civil construction were transported by dedicated pick up vehicle procured for the project by local contractor that was suitable for narrow and unpaved farm roads.

Photo 10: Transportation of materials to sites during the monsoon by pick-up Van (August 2010)

By end of September 2010, almost all the civil work in the lower region of Punakha-Wangdue were completed except for those siren sites in the Punatsangchhu-I and Punatsangchhu-II Hydropower Project sites, where we had to relocated to new sites identified by the projects. Civil works were supervised by dedicated site engineer deployed by the project management office.

Photo 11: Progress of civil work at Dangsa for Automatic Water Level Site above Tamedamchhu, Punakha (August 2010)

Photo 12: Progress of civil work at Samdingkha Siren Station (August 2010)

The contractor completed all the civil works and erections of 14 sirens towers in the lower valley by the end of December 2010.

4.3.2 Civil Works in Lunana Region

Contractor deputed workforce for civil work in Lunana from 9th June 2010. Team completed excavations of foundation for the structures to be installed in Lunana area from 20 June 2010 till 25th September 2010. However, heavy rainfall in July 2010 washed away most of foot paths and bridges in between Gasa and Laya. This natural disaster hampered the transportation of construction materials to Lunana sites by the Contractor as roads and foot paths were damaged by the flood. Roads and bridges were re-opened only by the end of August 2010. All the laboures were called back from Lunana as construction materials got struck at Gasa.

Since not much progress of work in Lunana region in 2010, Contractor had to carry out the civil work and installation of equipment simultaneously in 2011 season including the transportation of construction materials and GLOF EWS equipment.

4.4 Manufacturing and Testing of Equipment

All the equipment and accessories for the project was supplied by M/s Sutron Corporation based at Virginia, USA. Soon after the award of work, Sutron Corporation manufactured and assembled the GLOF EWS equipment as per the specifications designed for Bhutan project.

4.5 Factory Acceptance Test (FAT)

Upon completion of manufacturing, assembly and testing of the GLOF EWS system equipment at the factory site, M/s Sutron Corporation invited the Department of Energy (Employer) representatives to attend the Factory Acceptance Test (FAT) at their Company Office in Virginia, USA. The representatives (two members) of DoE visited USA from 20-25 September 2010. The main objective of the Factory Acceptance Test (FAT) was to ensure quality of equipment to be delivered that were conformed to the technical specification requirement of the bidding document.

During the FAT, Employer representatives together with Sutron professionals reviewed, checked and verified technical specifications of all equipment for the various components of the system. Team also verified and checked electrical circuits/wiring of stations/equipments as per the wiring diagram and voltage of electrical circuit of all the assembled equipment. The tests were performed for all the components of GLOF Early Warning System as given below.

a. 6 Automatic Water Level Station (AWLS) – 4 in the lakes, one at confluence, Thanza, Lunana and one at Dangsa, Punakha;
b. 2 Automatic Weather Stations (AWS) - one at Thanza, Lunana and another at Dangsa, Punakha.
c. 17 Siren Stations- 3 in Lunana area and 14 in Punakha-Wangdue Valley and
d. Control station hardware and software.

Photo 13: Testing and inspection of AWS/AWLS setup at Sutron, USA (September 2010)

Photo 14: Testing of Sirens' hardware and software. And also Control Software and hardware at Sutron, USA (September, 2010)

Photo 15: Visited Iridium Control Facility at Leesburg, Virginia and Sutron Corporation, HQ, Sterling, Virginia, USA (September 2010)

The procedures and test results of all the stations were recorded in the FAT Forms, which were duly signed by the representatives of DoE and Sutron after completion of each test.

A wrap-up de-briefing meeting was held on 24 September 2010 with the Sutron project team. The meeting discussed and provided necessary items for modification including the system configuration of the software. Upon completion of all the test and wrap-up meeting, the team signoff the Factory Acceptance Test (FAT) Form.

4.6 Transportation and Shipment of Equipment

4.6.1 Shipment of equipment from USA to Bhutan

After modification of software and configuration of system based on the FAT, M/s Sutron shipped GLOF EWS equipment from USA to Bhutan on 24 November 2010 via Calcutta. Due to large size of consignments, shipment was made till Calcutta from USA as Durkair was not

willing to lift consignment from Bangkok/Calcutta. From Calcutta all the equipment were transported by land (trucks) to Phuntsholling then to Thimphu, which again took some times.

Photo 16: Storage of Project Consignments upon arrival at Thimphu (November 2010)

A joint verification and inspection of consignments was done by the Project Management at Thimphu on 29 November 2010. After that all the equipment were dispatched to the respective project sites in Bhutan.

4.6.2 Transportation of Equipment to Project Sites

Before arrival of experts from M/s Sutron Corporation, USA all the equipment and accessories were dispatched to respective sites by the local contractor.

Transportation of equipment and accessories to the project site in Punakha-Wangdue valley were done by vehicle as most of the sites were connected by farm roads during the implementation of the project.

However, the transportation equipment to Lunana project sites were done by mules/yaks and people. Transportation took lot of time as some of equipment and accessories were quite heavy that had to be carried by a group of people. Contractor did study various options to transport

equipment to Lunana even lifting by helicopter, but it was found to very expensive as helicopter services are not available in Bhutan.

The project faced serious problems in transportation of equipment to the project sites in Lunana as the transportation of goods coincided with monsoon with heavy rainfall that damaged foot paths and bridges between Gasa and Laya in 2010. Heavy snow fall in the month of May/June 2011 hindered the transportation and movement of workers as all mountain passes between Gasa and Lunana were blocked by snow.

4.7 Challenges and Lessons Learned

4.7.1 Remote Sites and Harsh Weather Conditions

Remoteness and harsh un-predictable weather condition of the project sites impeded the timely completion of the project. Cyclone Aila in 2009, heavy rainfall and flash flood that damaged foot paths and bridges between Gasa and Laya in 2010 and late snow fall on the passes between Laya and Lunana hampered the transportation of material and equipment as well as movement of labours to project sites in Lunana.

4.7.2 Shipment of Equipment

Shipment of equipment and accessories from manufacturing site (Country of Origin) to Bhutan faced challenges due to limited capacity of Druk air flights. For the project, Contractor planned to shipment all the equipment from Virginia USA directly to Paro, but later it was found that direct shipment was not possible and they have changed the shipment plan. All the consignments have to first shipped from USA to Calcutta, India and then on land by trucks to Phuntsholling and Thimphu.

4.7.3 Factory Acceptance Testing (FAT)

Sutron Corporation is a reputed global ISO certified company based at USA and the quality assurance is the company top priority. As per the company quality assurance requirement the following testing are mandatory before system are handed over to the Employer/Purchaser.

a. Factory Acceptance Testing (FAT)
b. Site Acceptance Testing (SAT)
c. Final Acceptance Testing

Factory Acceptance Testing (FAT) organized by Sutron Corporation at their manufacturing site was found to be very comprehensive and of high standard. During the FAT different experts performed tests of all the system components as per the technical specifications and requirement of system in presence of Employer representatives. Test results were jointly signed by the Company and Employer representatives in the prescribed FAT Form at the end of each test.

FAT provide last opportunity for the Employer to make any final changes and modification of the system and equipment requirements.

For the future projects, such testing procedures will be necessary to be incorporated in the Bidding Document.

Chapter 5
Installation and Testing of System

5.1 Installation of equipment in Punakha-Wangdue Valley

Installation of 14 Sirens in lower region of Punakha-Wangdeu valley, Automatic Water Level Station (AWLS) at Dangsa and setting up of Control Room were carried out from 17-28 January 2011. Sutron Corporation deputed following three experts for the installation of system in Bhutan.

a. Mr. Daren Tagg, Water Resources Engineer,
b. Mr. Cristian Martillio, Electrical Engineer and
c. Mr. Shashank Parab, Software Engineer

Prior to installation of equipment at the sites, a day long theoretical training workshop was organized in Thimphu during which experts briefed participants on various components and functions of the equipment and accessories. Participants were also briefed on the procedures to be followed during the installation of equipment in the field.

Installation was done as hands on training mode by engaging all the appropriate staff of the Hydro-met Services as well as the local contractor staff to build the in-house capacity under the supervision of M/s Sutron Corporation experts. Only the installation of Dangsa Automatic Water Level Station (AWLS) and one of the Siren station was done by Sutron experts. All the 13 remaining siren stations were installed by HMSD staff and local contractor staff under Sutron supervision.

Photo 17: Installation of AWLS at Dangsa, Tame Damchhu (January 2011)

Installation of automatic water level station at Dangsa, 14 Sirens and setting up of Control Room at Wangdue in the Punakha-Wangdue were carried out from January 17-27, 2011 and completed within 11 days as equipment for each site was assembled and packed into difference boxes prior to shipment from USA to Bhutan. Installation was made it simple and easy, it was just a matter of basic fitting various components of equipment and its accessories at each site.

Photo 18: Installation of Sirens in Punakha-Wangdeu valley (January 2011)

Sutron experts and Employer Representatives signed Site Acceptance Testing (SAT) Form after conducting tests for various components for each station as given below.

Table 1: SAT Performed for Stations

Station Type	Tests Performed
1. Water Level Monitoring Station	a. Test 1: Solar Panel and Battery b. Test 2: Dual Orifice CF Bubbler Water Level Sensor c. Test 3: Wind Speed and Direction Sensor d. Test 4: Air Temperature and Relative humidity e. Test 5: Tipping Bucket f. Test 6: Pressure sensor g. Test 7:Solar radiation h. Test 8: Communication
2. Siren station	a. Test 1: Solar Panel and Battery b. Test 2: Siren c. Test 3: Communication
3. Control Room/Centre	a. Test 1: Software installation test and work station b. Test 2: Additional Installation Services c. Test 3: Iridium Communication

Upon completion of installation, Site Acceptance Testing (SAT) for all the sites and control room was conducted. Site Acceptance Testing (SAT) for GLOF EWS on lower region was signed between Sutron and DHMS project management on 27th January 2011 taking ownership of above stations and Control Room. The GLOF EWS on lower region was operational thereafter.

Photo 19: Installation and Training at Control Centre, Wangdue (January 2011)

5.2 Installation in Lunana

Transportation of materials for civil work constructions in Lunana were hampered by the bad weather conditions in summer 2010. Contractor planned to transport civil work materials and equipment to Lunana by the early May 2011. However, due to prolong winter season and heavy snow fall on the high altitude passes materials could not be transported on time to Lunana. Bad weather conditions in the month of May and June 2012 also hampered the Lowering of Throthormi lake component of the project implemented by DGM as well.

Based on the request of the Contractor an additional time extension of 40 days was provided to the Contractor (intended date of completion 27 September 2011) compensating the duration of transportation of materials and equipment that was affected by bad weather conditions.

DoE supervision team along with some workers arrived at Lunana on 25 June 2011. Civil works were carried out simultaneously along with the installation of equipment in Lunana.

Based on lessons learnt through hands on training imparted during the installation of equipment in the lower region of Punakha-Wangdue valley, installation of all the water level/weather station and sirens stations in the Lunana region were done independently by DHMS staff and local Contractor staff. The installation work was directly supervised by the by Project Engineer, DHMS with backstopping services by Sutron experts via phone and e-mails from USA.

Installation, testing of stations in Lunana region were done in the first and second week of August 2011. Installation team returned back from Lunana to Thimphu in second week of August 2013. As required SAT Form for each site was duly signed upon successful completion of testing detail as given below.

Sl. No.	Name of Station	Date of SAT Form signed	Remarks
1	Rapstreng Tsho AWLS	10 August 2011	
2	Bay Tsho AWLS	10 August 2011	
3	Thorthormi AWLS	10 August 2011	
4	Lugye Tsho AWLS	13 August 2011	
5	Thanza AWLS/AWS	12 August 2011	
6	Tenchey-Thanza Siren	11 August 2011	
7	Tshojo Siren	12 August 2011	
8	Ledhi Siren	14 August 2011	

Photo 20: Progress of civil works in Lunana (August 2011)

Photo 21: Installation of AWS, AWLS and Sirens in Lunana (August 2011)

5.3 Integration of System and Trainings

Upon completion of installation in both the regions, the final integration of GLOF EWS system were conducted by following two experts from M/s Sutron Corporation USA.

a. Mr. Daren Tagg, Water Resources Engineer
b. Mr. Shweta Garg, Software Engineer

DHMS installation team returned back from Lunana to Thimphu in the last week of August 2011. The GLOF EWS system training was organized from 29 August 2011- 9 September 2011 at Wangdue. The integration training workshop was attended by participants from Hydro-met Services and local contractor staff. Prior to training sessions, M/s Sutron distributed various manuals developed for the operation of GLOF EWS installed to all the participants. The manuals include the following:

a. Bhutan GLOF Early Warning System Manual- Real time data---everywhere any time, Sutron Corporation, USA
b. Bhutan GLOF Early Warning System Control Centre Software, Version 1.00, Operator's Manual , Document Revision 1.0 September, 2011, Sutron Corporation
c. Tempest™ Hydro-Met Analysis System Version 4.9 User's Guide Document Revision 1.0 August 2010,Copyright 2010 Sutron Corporation
d. Tempest(tm) Data Acquisition Server Extensions for DCP Sessions *Addendum to Tempest(tm) DAS (LRGS) Users Guide,* Tempest DAS, Version 8, Document Revision 1.0 March 1, 2010, Sutron Corporation Sterling, VA
e. Tempest™ DCS Toolkit, Version 4.9, DECODES (Device Conversion and Delivery System) Reference Manual Document Revision 1.0 January, 2011 ,Sutron Corporation
f. Tempest™ DCS Toolkit, Version 4.9, User's Guide, Document Revision 1.0, August, 2009
g. Tempest™ LRGS, Local Readout Ground Station Satellite Receiver, Version 7.2, User's and Administrator's Guide Document Revision 2.0 September, 2009, Sutron Corporation

The GLOF EWS operation training was conducted into two parts:

a. Training on Operation of Control Room of GLOF EWS at Wangdue for DHMS staff by M/s Sutron experts from 29 August -3 September 2011.

b. Training on Remote Stations Maintenance of the GLOF EWS System was organised in Thimphu as well as in the field by M/s Sutron experts (5-9 September 2011)

The training included both presentations as well as hands on trainings at the sites and control centre. During the training of operation of Control Room, GLOF system was tested by activating the all the 17 sirens simulating different flood levels of remote monitoring stations. The trainings were attended by both the staff from the Employer as well as from local Contractor staff. After the training all the participants were awarded certificates by the M/s Sutron Corporation.

Photo 22: Training Session at Wangdue (August 2011)

5.4 Final Acceptance Testing and Handing Taking of GLOF EWS

The Final Acceptance Testing was conducted along with the training from 29 August, 2011 to September 9, 2011 for operation of whole system as per the requirement of Bidding Document.

The Final System Acceptance and Completion Certificate were signed between the Project Management, DHMS, MoEA and the Contractor (M/s USD Enterprise JV with M/s Sutron Corporation representatives) on 9th September 2011. The GLOF EWS installed in the Punakha-Wangdue Valley was formally taken over by the Department from 9th September 2011 and system was operational thereafter.

5.5 Challenges and Lessons Learnt

5.5.1 Easy Installation

All the equipment supplied for the project were designed and manufactured in such a way that it could easily detached and assembled easily during the transportation and installation. For example installation of equipment took hardly more than 4 to 5 hours at each site. However, for some siren station installation took more time as some of items such as siren poles that were procured locally were not fitting properly with sirens.

5.5.2 Hands on Training during the Installation

Installations of equipment in the field were carried out as hands on training for the staff of DHMS as well as for local Contractor staff to build the local capacity under Sutron expert's supervision with prior workshop on different components and function of equipment. This mode of installation helped and built the DHMS capacity in installation as well as operation of equipment and system. Installations of all the stations in Lunana region were independent carried out by DHMS and local contractor staff.

5.5.3 Testing and Commission of System

As per the Sutron Company quality assurance requirement following tests were performed for each remote sites during installation and a whole system before being taken over by the Employer/Purchaser after the Factory Acceptance Testing (FAT).

a. Site Acceptance Testing (SAT)
b. Final Acceptance Testing

The project management found these tests were very important. These three tests must be included as the mandatory requirements of the bidding document for the future projects.

Chapter 6
Operation of GLOF EWS

6.1 Operation of GLOF EWS

The GLOF EWS installed in the Punakha-Wangdue was integrated as a part of national flood warning network operated by DHMS. The GLOF Warning Unit (GWU) under the Flood Warning Section (FWS) of the Hydrology Division (HD), DHMS, MoEA is directly responsible to look after operation and maintenance of the GLOF Early Warning System installed with dedicated personnel at the Control Room. All the remote stations in Lunana region are being looked after by the regular staff posted at Thanza, Lunana. The GLOF Monitoring and Oversight Group (GMOG) was established within the DHMS entrusted to provide overall guidance for the overall operation of the system installed and up-gradation. The GMOG is chaired by Director, DHMS with its members from all the divisions under the department.

The main Control Room for GLOF EWS located at the Wangdue, Flood Warning Office is manned by duty personnel of FWS for 24/7.

6.2 Standard Operating Procedure (SOP)

Total fund allocated for the project component was limited and the Standard Operating Procedures (SOP) for the GLOF Early Warning System was formulated internally by the Department of Hydro-met Services (DHMS). The manual outlined the basic principles and concept of the GLOF EWS warning procedures, which are to be observed and referred by all the flood monitoring and warning staff and other stakeholders.

The SOP Manual was formally launched during the opening session of the "International Conference on Glacier Lake Outburst Flood (GLOF) - Reducing Risks and Ensuring Preparedness" held at Paro, Bhutan from 5^{th}-7^{th} December 2012.

6.3 Education and Awareness on GLOF EWS

Education and awareness of GLOF EWS was part of the Department of Disaster Management (DDM) component. DDM organized number of education and awareness program for vulnerable communities and institutions related to GLOF EWS along the Punatsangchhu Valley. DHMS project management always took part in public education and awareness activities organized by DDM related to flood and GLOF.

6.3.1 Awareness in Punakha-Wangdue

DDM organized number of education and awareness program along the Punakha-Wangdue valley during the project period covering the whole basin till Lhamozingkha Dungkhag (Kalikhola). The project management officials from DHMS and DGM were always engaged along with DDM during such activities.

6.3.2 Awareness in Lunana

To hold meetings with village communities in Lhedi, Tshojo and Tenchey/Thanza to impart education and awareness on the GLOF risk reduction and community-based disaster management best practices and strategies, a team from DDM and DHMS visited Lunana from 22 July – 13 August 2012. The team was led by the Director, DHMS, detailed as given below.

Name	Designation	Agency
Karma Tsering	Director	DHMS-MOEA
Pema Wangyel	Chief	DDM-MOHCA
Sangay Tenzin	Executive Engineer	DHMS-MOEA
Chencho Tshering	Program Officer	DDM-MOHCA
Japchoo	Assist. Program Officer	DDM-MOHCA

Beside education and awareness activities, DHMS team also inspected the physical and functional conditions of the component of GLOF-EWS and carried out some maintenance and identification of sites for expanding the functionalities of the data collection platform (DCP) by integrating more sensors and augmenting communication capability for those watersheds not covered by the present system.

Photo 23: Community meeting at the Lhedi Primary School (30 July 2012)

6.3.3 Mock Drill

The mock drill of the Automatic GLOF EWS installed in the Punakha-Wagdue Valley was conducted from 24-31 October 2012 by DHMS in collaboration with DDM, MoHCA, local government and officials from UNDP. Mock drill was conducted for each siren station explaining vulnerable communities and institutes about the operation of GLOF EWS by DHMS and natural disaster risk reduction and prevention by DDM. Meeting also explained the importance of the GLOF EWS project to communities. Communities were asked to take ownership and take responsibility to look after the infrastructures that are built in their community. At the end of community meeting a mock drill was conducted by activating siren where community participants were asked to move to the safe area identified by DDM in consultation to community in their locality.

Photo 24: Mock Drill briefing to community at Khawajar and Wolathang, Punakha (October 2012)

Photo 25: Mock drill at Khuruthang, Punanaka (October 2012)

6.4 Problems of GLOF EWS

Upon taking over of the system in September 2011, the GLOF EWS was operational transmitting data to the control room. However, the following problems were occurred due to instrumentation and harsh weather at remote monitoring sites in Lunana.

a. Thorthormi AWLS

Due to false water level rise at Thorthormi Automatic Water Station, Lunana, all the three sirens in Lunana got activated on 27 December 2011 between 4:19 to 4:20 AM. The matter was reported to the Contractor. Upon reviewing the log files of station, M/s Sutron reported it was due to icing that blocked the dual orifice terminal that was submerged under the water. To overcome problem, DHMS will relocate the station to main Thorthromi lake as these station is located on outlet of the lake where the water level reduce during the winter months.

b. Total Precipitation Gauge (TPG), Thanza

The Total Precipitation Gauge (TGP) installed at Thanza was not recording the correct precipitation data due to high evaporation as they have not put the right anti-evaporator oil to prevent evaporation. The matter was discussed with supplier. M/s Sutron through local contractor supplied new TPG as replacement to re-install at Thanza, Lunana. The DHMS Engineer also identified the right anti-evaporator. Re-installation TPG at Thanza will be carried out by DHMS and the Contractor in the summer 2013 (June-September 2013).

c. Thanza AWLS

At 7:15 AM on 22nd January 2013, all the 14 sirens along the Punakha-Wangdue Valley got automatically activated due false rise in water level at Thanza, Automatic Water Level Monitoring (AWLS) creating false alarms in the valley. Like the earlier occasion this was also caused by the icing that blocked the dual orifice terminal submerged under the water when the water level decreases during the winter. Activation of Sirens in the lower region could have prevented from the Control Room as the system is designed in such a way that it will wait 30 minutes before automatically activation of sirens by the system. Thus, the false alarm occurred due to lapses from the Control Room, Wangdue. DHMS will rectify station equipment problem in the coming summer 2013. The false alarm in the Punakha-Wangdeu valley was covered by media. An article that came out in Kuensel dated 23 January 2013 is given Figure 2.

6.5 Training of DHMS Staff

Besides hands on trainings organized and provided during the installation to build further capacity within the department for sustainable operation of the system installed, through the PHPA- Project Co-financing support, DHMS sent three officials to attend a tailored made training course on “Hardware and Software Training of Bhutan GLOF Early Warning System” organized by at M/S Sutron Corporation, Virginia, USA from 21st January 2013-4th February 2013. Nomination of participants were done in such a way that civil engineer, electrical engineer and ITC background staff attended the training based on requirement of multi-disciplinary team

to operate and maintain the system. Currently these three engineers are working as 'Trainer of Trainee (ToT)' for the operation and maintenance of the system installed.

Flood Early Warning Siren

False alarm fails to alarm

Ice caused a rise in water level, which activated a sensor and caused the alert to go off

TENZIN NAMGYEL, WANGDUE

At 7:15 yesterday morning, when a strange alarm rang across Punakha and Wangdue valley, Dechen, who stays close to the Punatsangchu riverbank, called her friend in Bajo town to find out if there had been fire.

GLOF

"I thought the sound was from police fire brigades," Dechen said. "I couldn't figure it out until one of my neighbours told me that the sound was from flood early warning siren."

Except for a few, many people like Dechen in the two dzongkhags could not identify the sound, while those, who knew, deliberately didn't bother to respond, convinced that the alarm had no message of danger. "I knew there won't be flood in winter, so I didn't run out of my house," a Punatsangchu employee, Tenzin, said.

The sound, which indicated flood from Phochu in Lunana was put off within 15 minutes, after hydro-met officials at Glacial Lake Outburst Floods (GLOF) early warning control centre at the old Bajo town realised that it was a false alarm.

Chief hydrology officer Karma Drupchu, with the Department of Hydro-met Services, said because of ice there was a rise in water level, which crossed the alert and alarm set for early warning system at Thangza stream, the main confluence of potentially dangerous lakes - Lugi tsho, Thorthormi, Rapstreng and Baytsho.

He said a sensor, which is placed in the river to indicate flood was exposed, creating a false alarm.

The early warning device at Thangza stream would send signals to the centre, if the water level at the source reaches 8.7m. Experts would then study the data and re-confirm before informing people at the risk zones.

Part of the blame went to people at the centre, whose responsibility it was to analyse data sent by the sensor at the source. "The alarm should have rung, if there was really a flood," Karma Drupchu said.

The team would do a study to find out what went wrong in the system.

In case a GLOF occurs in upstream Phochu, three sirens in Lunana would send signal to 14 sirens installed along the Punatsangchu, which would then ring for an hour every three minutes. "Within this period, people in danger zones should evacuate," Karma Drupchu said.

On the tone, he said, it would be better if there could be a unique tone for early warning system. "Common tones may confuse people," he said.

Many said the tone for ambulance, fire brigades and flood early warning system are similar. The early warning system was set up in 2011 to avoid risks from floods and GLOF.

The early warning flood siren at Kamichhu, Wangdue

I knew there won't be flood in winter, so I didn't run out of my house"

Tenzin
A Punatsangchu employee

Figure 3 Article in Kuensel dated 23 January 2013 (Source: Kuensel Corporation)

6.6 Challenges and Lessons Learnt

6.6.1 In-house Development of SOP

The Standard Operating Procedure (SOP) for GLOF Early Warning System was developed in-house by DHMS rather than by Consultants. UNDP appreciated the initiative and quality of the SOP developed.

6.6.2 Integration of GLOF EWS for Hydro-met Data Collection

For the sustainable operation and maintenance of GLOF EWS system installed, the system is already integrated as a part of national hydro-meteorological network for hydro-meteorological data collection using the same communication. Additional hydro-meteorological stations were incorporated in the design of the system to collect hydro-meteorological data using the same communication of the GLOF EWS.

6.6.3 Problems as Lesson Learnt

The GLOF EWS installed was operational transmitting data from remote stations as per the design. However, there were incidences of few problems such as false alarms created due to instrument failure. For the Department these problems were always good lessons learnt for the operation of system, based on which DHMS incorporated necessary correction to system equipment as well as procedures.

Chapter 7
Sharing and Dissemination

7.1 Visits to GLOF EWS Sites

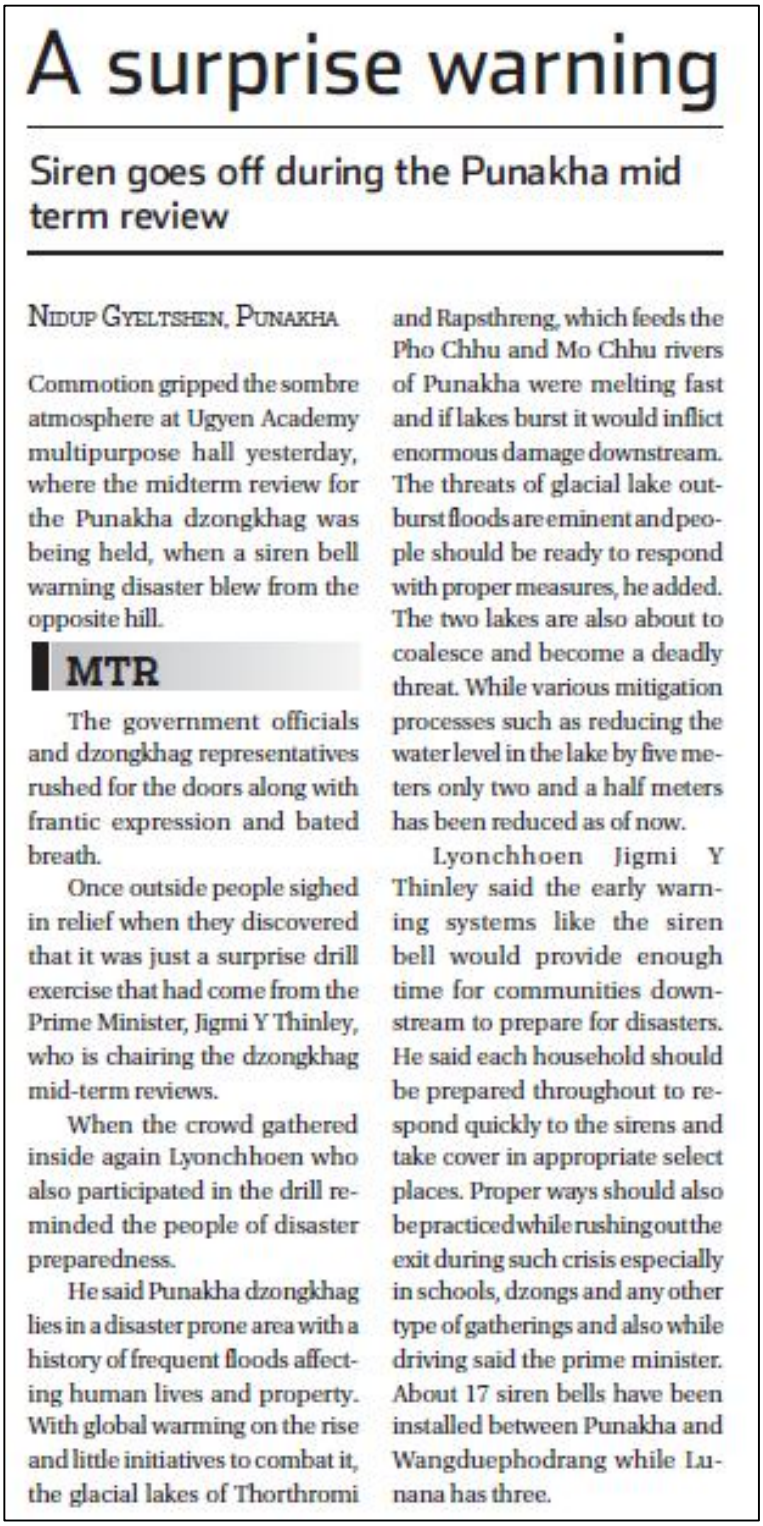
7.1.1 Surprised Activation of Siren

As per the special instruction of the Honorable Prime Minister of Bhutan Lyonchen Jigme Y Thinley, Siren at Khuruthang Town was activated during the Mid-term review of 10th FYP of Punakha Dzongkhag held at Kuruthang on 31 January 2011. In fact, the project management of DHMS was instructed by the Lyonchen to activate Siren secretly during the course of the meeting to see the public reactions and to create awareness on the GLOF EWS system installed. The reaction of public was published in Kuensel dated February 1, 2011 (Figure 3).

7.1.2 Visit to GLOF EWS by Project Board Members

The members of the Project Board (PB) of the GLOF project visited the GLOF EWS sites and Control Room on 9th February 2012. During which the project management got opportunities to explain about the system components and aspects of the remote stations as well as the operation of GLOF EWS control room to the members.

The members of PB includes the Secretary/Chairman, Ministry of Economic Affairs, DG/Directors of DGM, DDM, DHMS, Department of Public Health Services, Department of Roads, Dasho Dzongda from Punakha, Gasa and Wangdue Dzongkhag Administration and representative from GNHC and NEC. Other members are from UNDP, ACO, WWF and the respective project managers.



A surprise warning

Siren goes off during the Punakha mid term review

NIDUP GYELTSHEN, PUNAKHA

Commotion gripped the sombre atmosphere at Ugyen Academy multipurpose hall yesterday, where the midterm review for the Punakha dzongkhag was being held, when a siren bell warning disaster blew from the opposite hill.

MTR

The government officials and dzongkhag representatives rushed for the doors along with frantic expression and bated breath.

Once outside people sighed in relief when they discovered that it was just a surprise drill exercise that had come from the Prime Minister, Jigmi Y Thinley, who is chairing the dzongkhag mid-term reviews.

When the crowd gathered inside again Lyonchhoen who also participated in the drill reminded the people of disaster preparedness.

He said Punakha dzongkhag lies in a disaster prone area with a history of frequent floods affecting human lives and property. With global warming on the rise and little initiatives to combat it, the glacial lakes of Thorthromi and Rapsthreng, which feeds the Pho Chhu and Mo Chhu rivers of Punakha were melting fast and if lakes burst it would inflict enormous damage downstream. The threats of glacial lake outburst floods are eminent and people should be ready to respond with proper measures, he added. The two lakes are also about to coalesce and become a deadly threat. While various mitigation processes such as reducing the water level in the lake by five meters only two and a half meters has been reduced as of now.

Lyonchhoen Jigmi Y Thinley said the early warning systems like the siren bell would provide enough time for communities downstream to prepare for disasters. He said each household should be prepared throughout to respond quickly to the sirens and take cover in appropriate select places. Proper ways should also be practiced while rushing out the exit during such crisis especially in schools, dzongs and any other type of gatherings and also while driving said the prime minister. About 17 siren bells have been installed between Punakha and Wangduephodrang while Lunana has three.

Figure 4: Article from Kuensel, 1 February, 2011 (Source: Kuensel)

Photo 26: PB members visited GLOF EWS Control Room, Wangdue (February 10, 2012)


Photo 27: PB visited one of the Siren site in Punakha-Wangdue Valley (February 10, 2012)

7.1.3 Visit to GLOF EWS by LEG

The Least Developed Countries Experts Group Meeting (LEG) was held in Thimphu, Bhutan from 9-13 March 2012. The LEG members visited the GLOF EWS sites and Control Room on March 11, 2012 to learn more about the GLOF project implemented in Bhutan. LEG was established with the objective of supporting the preparation and implementation strategy of national adaptation programme (NAP).

Since the GLOF project was one of the first NAPA project funded through LDCF, Project Management got an opportunity to showcase the project to LEG members as well as other officials from UNFCCC or other donors. Officials from UNFCCC appreciated the system installed and assured allocation of more fund for the second NAPA project for the hydro-met component. Because their visit component 3: Enhanced national capacity for managing climate risks under the project "Addressing the risk of climate-induced disasters through enhanced national and local capacity for effective actions" of the Bhutan Second NAPA Project got fund allocation for about USD 4.410 million. The project will be implemented by DHMS in the 11th FYP.

Photo 28: LEG members visited GLOF EWS control Room, Wangdue (March 11, 2012)

7.1.4 Visit to GLOF EWS by Austrian Delegation

A delegation led by H.E Mr. Fritz Neugebauer, Second President of the Austrian National Council accompanied by Mrs. Katharina Stourzh, Chief of Cabinet, Mr. Raimund Magis, Deputy Head of Mission, Austrian Embassy, New Delhi, India and Mrs. Christine A. Jantscher, Resident Coordinator, ACO, Thimphu, Bhutan visited the GLOF EWS Control Room on 2 May 2012. The project management presented and briefed the delegations about the GLOF EWS network stations and its operation procedures.

Photo 29: Austrian delegation visited the GLOF EWS Control Room (May 2012)

7.2 International GLOF Conference

The "International Conference on GLOF Risks Reduction" was organized by the Ministry of Economic Affairs in collaboration with UNDP, Bhutan Office from 5-7 December 2012 to facilitate sharing of project lessons learnt and application of project experience in future interventions in Bhutan and other GLOF prone countries. More than 60 participants attended the conference including the participants from international organizations such as World Bank Global Fund for Disaster Risk Reduction (WB/GFDRR), International Centre for Integrated Mountain Development (ICIMOD), Japan International Cooperation Agency, Norwegian Water

Resources & Energy Directorate, University of Vienna and the Mountain Institute along with institutions and experts/ practitioners on GLOF from around the world.

Figure 5: International GLOF Conference, Olathang Hotel, Paro (5 December 2012)

7.2.1 Visit to GLOF EWS Site

On 7th December 2012, the conference organizer organized field trip to GLOF EWS sites and Control Room in Punakha-Wangdue Valley for both national and international conference participants. Participants visited the GLOF EWS Control Room, the project management got opportunity to showcase and explained about the GLOF EWS installed in Bhutan. Most of the participants appreciated the robust EWS integrated with hydro-meteorological data collection system.

Chapter 8
Follow up Actions and Conclusions

8.1 Follow up Actions

From the experience, knowledge and skills gained from the implementation of the project, DHMS is planning and will be carrying out the following activities as follow up of the current GLOF EWS project implemented in Bhutan.

a. Expansion of GLOF EWS on Mochhu Sub-basin

The project balance fund amounting to USD 210,700.00 was allocated to GLOF EWS component implemented by DHMS. DHMS will use the above fund to expand the GLOF EWS on Mochhu-sub-basin to set up a comprehensive GLOF EWS covering whole Punatsangchhu river basin. Only supply of goods and related services (equipment and software upgrade/modification) will be performed by M/ Sutron Corporation, USA. Civil work, installation of remote stations will be carried out by the DHMS staff to cut down the cost based on the knowledge and skills gained by staff through implementation of the current GLOF EWS project.

b. GLOF EWS on Mangdechhu and Chamkarchhu Basins

One of main objective and outputs of the project component was to document, share technical knowledge and lessons learnt from the current GLOF early warning system for the future. The project documents also specified that there should be a replication plan developed for early warning system in the Chamkhar Valley.

As follow of this project, DHMS initiated and submitted project proposal to establish GLOF EWS on Mangdechhu and Chamkarchhu Valley to JICA. The project "***Capacity Development of GLOF and Rainstorm Flood Forecasting and Warning in the Kingdom of Bhutan***" under the JICA Technical Assistance will be implemented in the 11th FYP. The field survey of the project by a team of JICA experts was completed in March 2013. The project implementation may start in the first year of 11th FYP. The main purpose of the project is to enhance capacity of the Department of Hydro-met Services and relevant line agencies on emergency response against GLOF/rainstorm flood to develop disaster resilient society against natural disasters such as GLOF and rainstorm flood for Climate Change Adaptation in Bhutan.

8.2 Conclusion

GLOF EWS installed in the Punakha-Wangdue valley was the first GLOF EWS project implemented by the Department of Hydro-met Services, Ministry of Economic Affairs with limited knowledge and experiences. This was because there was no good operation GLOF EWS in the region as well as in other parts of the world. Therefore, the project provided good opportunity for the project management in particular and department to study, review and learnt about tendering process, types and selection of hydro-met equipment, communication, warning equipment as well as other ICT equipment.

The fund allocated from the GEF/UNDP to the project component was just sufficient for the procurement of equipment and installation of system and limited fund for capacity building of DHMS for operation and maintenance of system. However, with co-finance received from the Phuntsangchhu Hydropower Authority (PHPA-I and PHPA-II), DHMS could set up a comprehensive GLOF EWS on Phochhu basin integrated with hydro-meteorological data collection system.

The three the components of GLOF project were implemented by the three departments (Department of Geology and Mines (DGM), Department of Hydro-met Services (DHMS) and Department of Disaster Management (DDM). This mode of project implementation enhanced institutional cooperation and linkage between the agencies to further collaborate and carry out the work related to disaster risk management in Bhutan especially related to GLOF and other hydro-meteorological hazard.

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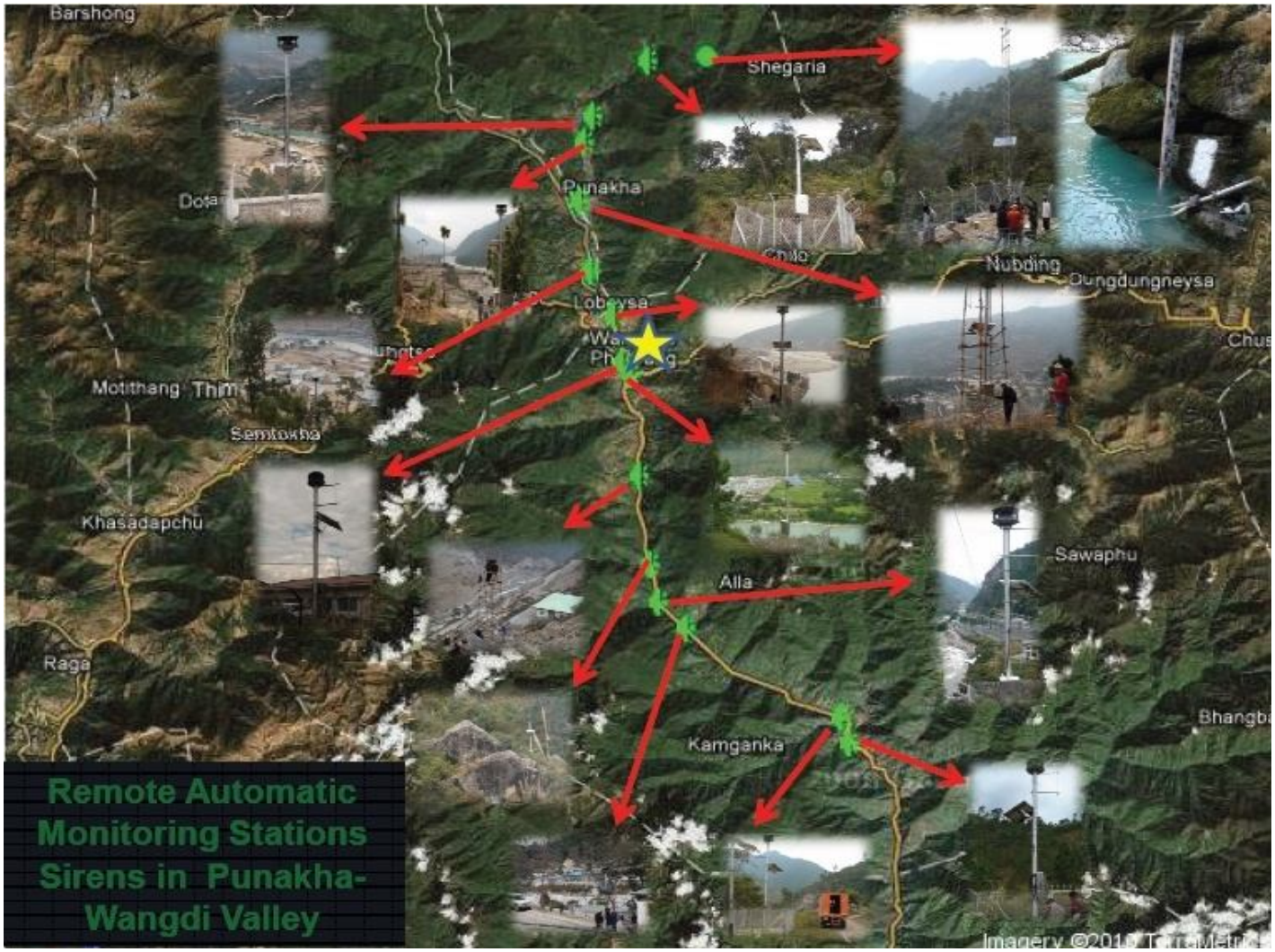
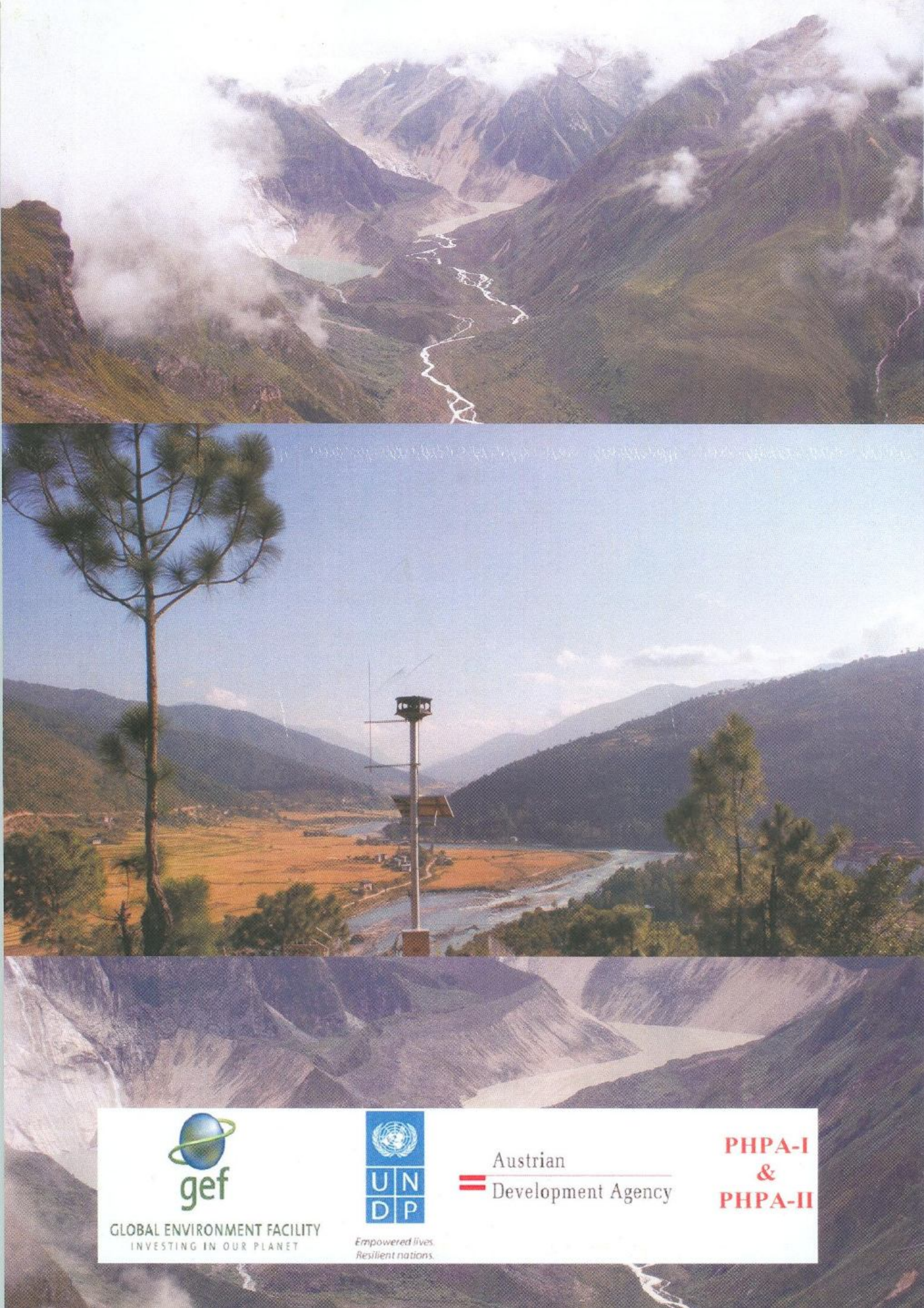
Remote Monitoring Stations and Sirens in Lunana Area

Remote Monitoring Stations and Sirens in Punakha-Wangdue valley





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