Annual Report

(July 2016-June 2017)

HYDROLOGY AND WATER RESOURCES SERVICES DIVISION
NATIONAL CENTER FOR HYDROLOGY AND METEOROLOGY
ROYAL GOVERNMENT OF BHUTAN
THIMPHU: BHUTAN
JUNE 2017

This is an official publication of the Hydrology and Water Resources Services Division (HWRSD), National Center for Hydrology and Meteorology, Royal Government of Bhutan.
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His Majesty’s visit to GLOF EWS Station in Lunana in 2016

Foreword

First of all, I would like to congratulate the Hydrology and Water Resources Division (HWRSD), National Centre for Hydrology and Meteorology (NHCM) for publishing the Annual Report for the Fiscal Year 2016-17. This publication is very important since the Royal Civil Services Commission (RCSC) has introduced the Performance Management System (PMS) to monitor employee's effectiveness and to achieve the planned objectives & goals of the organization.

I would like to commend the Staff of the Hydrology and Water Resources Services Division for the outstanding performance in the fulfilment of their mandated tasks and planned activities for the FY 2016-17. The relentless effort invested by the division would go a long way to enhance their capacity in providing improved flood forecasting and early warning services and to remain focused towards becoming an outstanding hydro-met service provider in our country.

The year 2016-2017 is the watershed year for the NHCM, where it was delinked from the Ministry of Economic Affairs and created an autonomous central agency mandated to provide services on weather, climate and water resources. As such, the NHCM shall remain at the forefront in providing valuable weather, hydrological information and services to the nation. The timely dissemination of relevant information would enable our country to respond better to weather disturbances, thereby reducing the loss of lives and damages to the properties. Furthermore, the Hydro-met Services must work towards raising the public's level of awareness on the effects of climate change not only to mitigate and reduce disaster risks but also to improve the resiliency of our country, particularly with flood and GLOF.

I am confident that Hydro-met Services fortified with the common desire to better serve our country and people, will continue to move towards the realization of its vision.

Again, my heartfelt Trashi Delek to the HWRSD, NCHM in particular and all the staff of the centre in general.

(Karma Tsering)
Director

Acronyms

10 FYP	Tenth Five Year Plan
11 FYP	Eleventh Five Year Plan
ADC	Austrian Development Coordination
AWLS	Automatic Water Level Station
AWS	Automatic Weather Station
CNR	College of Natural Resources
CR	Control Room
CSD	Cryosphere Services Division
DCP	Data Collection Platform
DDM	Department of Disaster Management
DGM	Department of Geology and Mines
DGPC	Druk Green Power Corporation
DHMS	Department of Hydro-met Services
DIT	Department of Information Technology
DoLG	Department of Local Governance
EWS	Early Warning System
FMCR	Flood Management and Command Room
FWS	Flood Warning Section
GLOF	Glacier Lake Outburst Flood
GoI	Government of India
GWU	GLOF Warning Unit
HD	Hydrology Division
HOID	Hydromet Operations and Infrastructure Division
HQ	Head Quarter
HWRSD	Hydrology and Water Resources Service Division
ICT	Information Communication Technology
IFAS	Integrated Flood Analysis System
JICA	Japan International Cooperation Agency
LDCF	Least Developed Country Funding
MD	Meteorology Division
MHPA	Mangdechhu Hydropower Project Authority
MoHCA	Ministry of Home and Cultural Affairs
NCHM	National Centre for Hydrology and Meteorology
NEC	National Environment Commission
NWFWC	National Weather Flood and Warning Centre
PHPA-I	Punatsangchhu Hydropower Project Authority- I
PHPA-II	Punatsangchhu Hydropower Project Authority- II
R&D	Research and Development
RCSC	Royal Civil Service Commission
RGoB	Royal Government of Bhutan
RIMES	Regional Integrated Multi-Hazard Early Warning System
SOP	Standard Operating Procedure
UNDP	United Nation Development Programmed
WCSD	Weather and Climate Services Division
WMO	World Meteorological Organization

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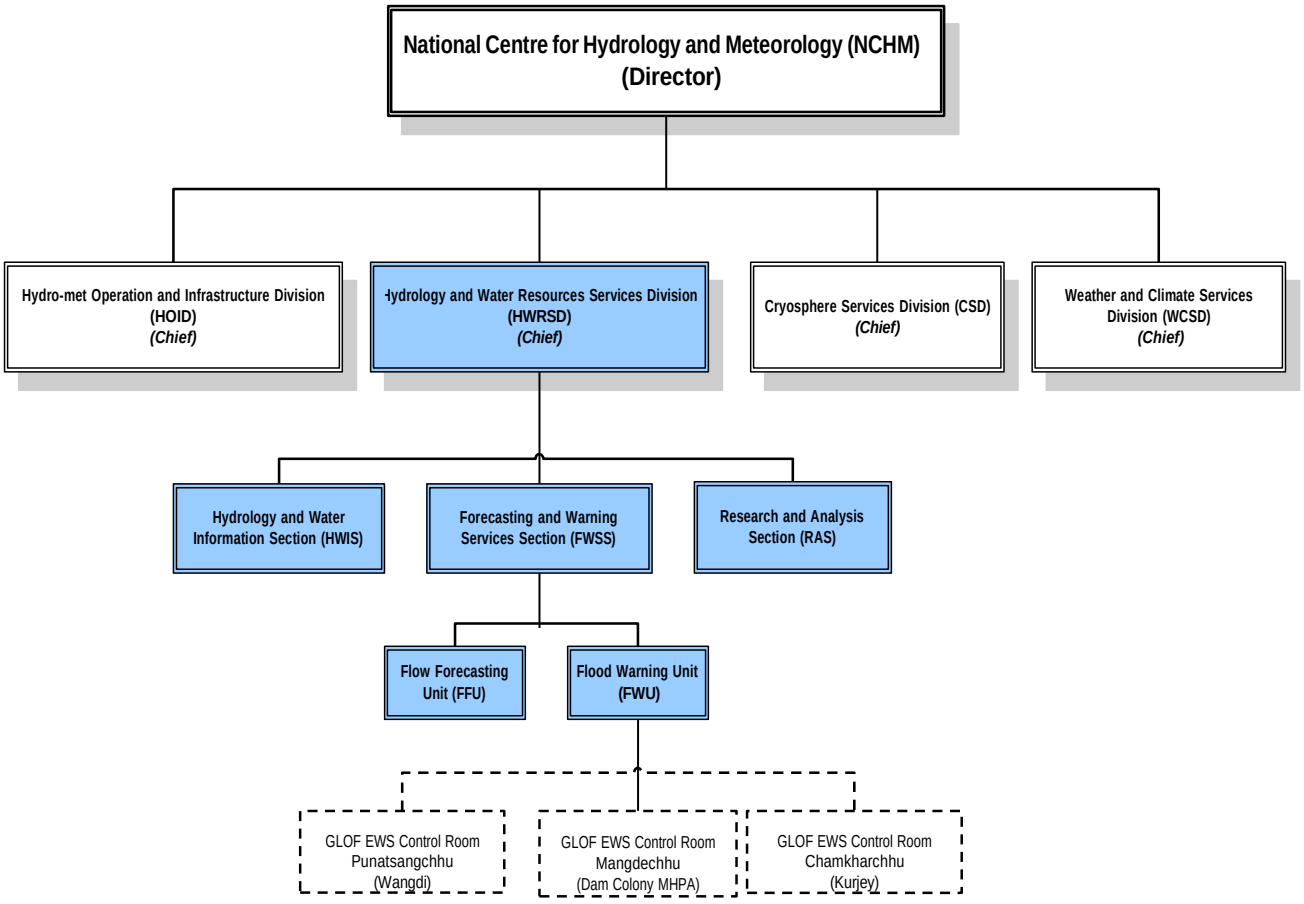
Hydrology and Water Resources Services Division, NHCM



Introduction

1 BACKGROUND

Bhutan is small mountainous country located between latitudes 26° 45' N to 28° 10' N and longitudes 88°45' E to 92°10' E, bordered by China to the north and India to the south.

The variation of climate and its extremes are dependent on the altitude. In case of Bhutan, the vast elevation differences for small stretch (approximately elevation of 200m in south to 7000m in North within a distance of less than 175km) with steep terrain expose the country to different hydro-meteorological hazards. In addition to the recurrent flash floods, landslides, wind storms and river erosions, Bhutan is considered highly vulnerable to the threats of glacial lake outburst floods (GLOFs) because, most of the important infrastructure, agricultural land and over 70% of human settlements are located along the main drainage basins.

1.1 Climatology and Hydrological Features

The Indian southwest monsoon, which sweeps in from the Bay of Bengal has strong influence on the climate of Bhutan with dry winter and wet summer monsoon, and the temporal variations or diversity in climate are correspondingly extreme. Thus, while southern Bhutan is generally hot and humid sub-tropical conditions, the high Himalayan Mountains in the northern borders of the country experience severe alpine climate, and are under perpetual ice & snow.

Bhutan's climate does vary considerably between the valleys and within the valleys, depending on altitude levels. These features also make the rainfall differ considerably within relatively short distances due to rain shadow effects. From past records, the mean annual rainfall varies approximately from 2,500 to 5,500 mm in the southern foothills, 1,000 to 2,500 mm in the inner valleys, and 500 to 1,000 mm in the northern part of the country**.**

1.2 River System of Bhutan

Bhutan is landlocked country with abundant water resources, which are mostly in the form of rivers. There are quite a number of lakes located in remote and high altitude alpine areas of this country. These lakes are formed due to increased melting of glaciers and sudden outburst of these lakes would result in flash floods/GLOF with severe damages to the life and property downstream.

The major rivers of the country flow north to south, with their sources in the alpine zone and flowing right down to the tropical zone on the border with India. The rivers of Bhutan generally have steep gradients and narrow steep-sided valleys, which occasionally open up to give small areas of flat land for cultivation. They carry large volumes of flow and sediment during the monsoon season and significant snowmelt at the end of the dry season. Short rain-fed tributaries descend even more steeply from east or west to join these major rivers. Due to the steep longitudinal gradients and the high annual runoff, these rivers provide significant potential for hydropower development, with an estimated theoretical potential of 30,000 MW (PSMP, 2004).

The existences of distinct rainy and dry seasons are the main reasons for large seasonal variations in river flows. The rivers in Bhutan carry large volumes of flow and, often, also high sediment during the monsoon season. However, the flow is relatively low during the dry season due to the limited rainfall and limited existence of major groundwater reservoirs. Snowmelt from the high altitude alpine areas in the north contributes to the flow at the end of the dry season. Apart from the major north-south flowing rivers, Bhutan has a dense network of small perennial and rain-fed tributaries that flow down the steep slopes and side valleys, often as waterfalls, to join the major rivers.

Bhutan is broadly divided into four major river basins (Figure 1) viz. Amochhu, Wangchhu, Puna-Tsangchhu, and Manas River Basins. They all originate from the high altitude alpine snow cladded area in the north, and flows into the Brahmaputra River to the south in Indian plains.

The Amochhu is trans-boundary river that origin in China and flows through the western districts of Ha and Samtse, before it finally drains into the plains of India via Phuntsholling. The Jaldhaka is small trans-boundary river that that originates from southeastern Sikkim in the eastern Himalayas. The river enters into Bhutan and is joined by Bindu Khola and other small tributaries under Sibsoo Dungkhag, Samtse.

The Wangchhu consists of three major tributaries from the three valleys of Thimphu, Paro and Ha. They originate within Bhutan from the glaciers and snow-capped mountains in the north. It flows south to the Indian plains through Chhukha district.

The Punatsangchhu (or Sankosh river) consists of two major tributaries, Phochhu and Mochhu, that originate from Gasa Dzongkhag. The two rivers join at Punakha Dzong to become Punatshangchu (Sankosh) that flows through Wangdue Phodrang, Tsirang and Sarpang dzongkhags, before flowing to the Indian Plains.

The Manas is the biggest river basin, which drains almost all the catchments of Central and Eastern Bhutan. It comprises of four major sub-basins, namely: Mangde Chhu and Chamkhar Chhu (which both originate close to Gangkhar Puensum), Kuri Chhu (which originates from China), and Dangmechhu (formed by joining two main tributaries-Kholongchhu that originates from the northern-eastern part of Trashi Yangtse and Gongri that originates from China and flows from Aurunacha Pradesh in India to Bhutan). Kurichhu and Gongri are transboundray Rivers that originates from Autonomous region of Tibet, China.

The three minor rivers that drains through the southeastern corner of the country are Nyera Ama Ri, Nonori Chhu, and Jomo Chhu (Dhansari).

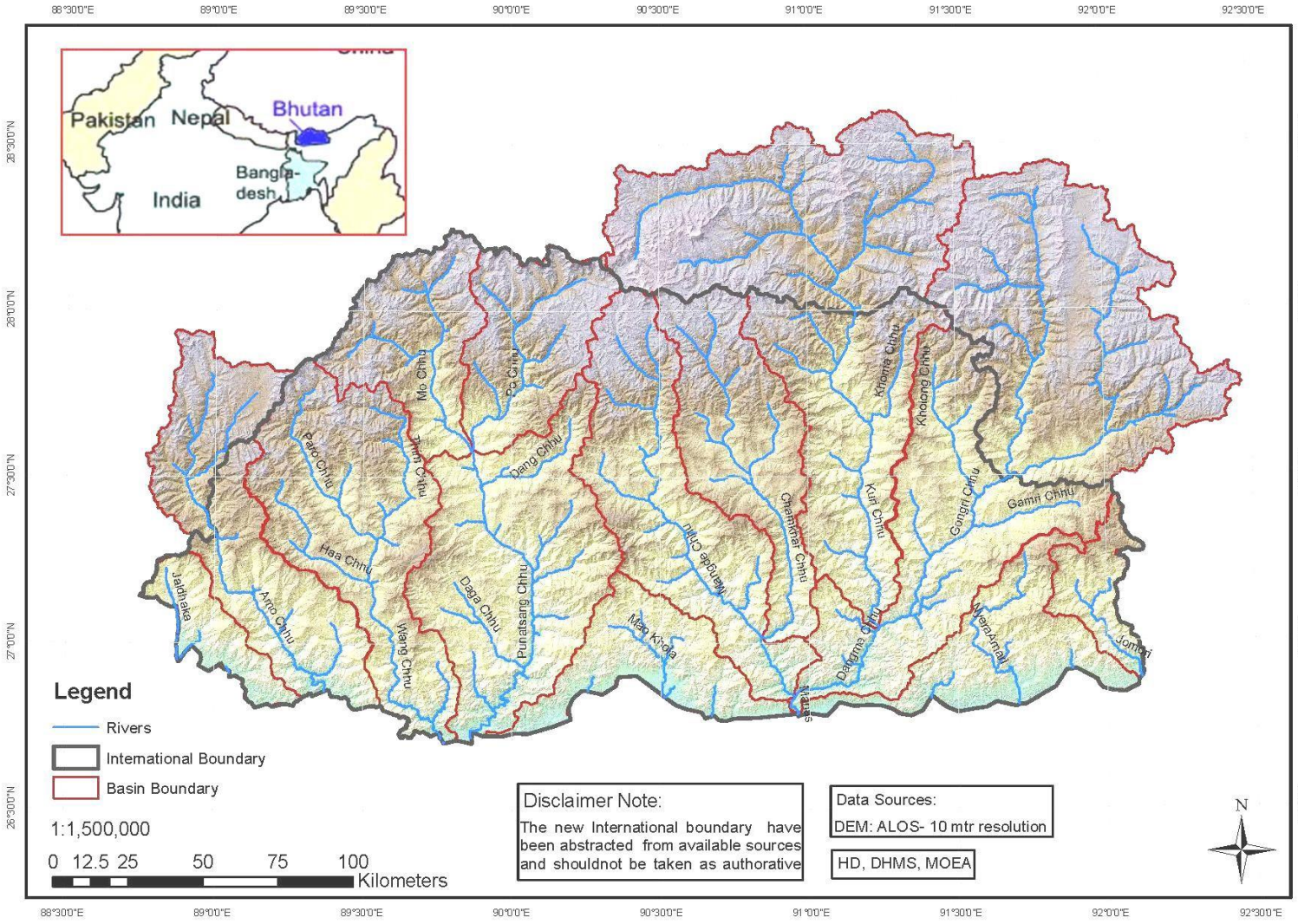


Figure 1: River System and Basins Map of Bhutan

NCHM Volunteers for MoEA Flower Plantation -2017

2 NATIONAL CENTER FOR HYDROLOGY AND METEOROLOGY (NCHM)

The National Centre for Hydrology and Meteorology is the nodal agency responsible for weather, climate and water resources in Bhutan established to fulfil the following vision and mission of the Royal Government of Bhutan. The NCHM is newly established center instituted as a result of the recommendations of Organizational Development exercise by Royal Civil Service Commission in 2016.

2.1 Vision, Mission and Goals of NCHM

Vision:

Make Bhutan hydro-met ready and resilient nation by taking on the challenges of working with complex physical processes utilizing advanced technologies, modern communication systems and highly skilled employees.

Mission:

Provide quality, accurate, reliable, usable, location-specific and timely services to reduce risks and to optimize benefit in the following areas:

- Create value and enhance societal benefits from hydro met resources for sustainable development;
- Protect life, livelihood and development infrastructure from hydro met hazards.
- Safeguard the environment
- Ensure continuity of hydro met monitoring and observations
- Promote endogenous capacity building
- Meet international commitments and contribute to international cooperation

2.2 Hydrology and Water Resources Services Division

The Hydrology and Water Resources Services Division (HWRSD) is one of the four technical divisions established under the National Center for Hydrology and Meteorology (NCHM). Based on the new organizational structure and mandates of NCHM, the following are the mandates and functions of the HWRSD:

2.2.1 Mandates and Functions

The HWRSD is mandated to monitor, assess, and conduct targeted science research on hydrology and water resources so that policy makers and the public have the understanding they need to enhance preparedness, response, and resilience.

The division is focal point for hydrology, water resources and flood/GLOF warning services of NCHM. Some of the specific functions are:

a. Formulate plans and programs related to hydrology, flood forecasting and warning services;
b. Management of national hydrological database system and dissemination

c. Monitoring and Provide Flood/GLOF Early warning services;
d. Provide flow forecasting services;
e. National focal point to operate hydrological flow forecasting & flood early warning systems and monitor extremes hydrological events 24x7, particularly the flood/GLOF events from the Flood Management Control Rooms (FMCR);
f. Coordinate and conduct research in the field of hydrology, water resources climate change impacts;
g. Assessment of Water Resources, Flood and GLOF Risks and hazard mapping.
h. Institutional cooperation and linkage related to Hydrology and Flood information exchange;
i. Education, advocacy and awareness about hydrology, flood/GLOF and early warning systems;
j. Publications of Hydrological Data Book and Research Papers.

2.3 Status of Hydrological and Flood Monitoring Network in Bhutan

Until June 2016, the National Hydrological network consists of sixteen (16) Principal Hydrological Station *(equipped with bank operated cable-way system with a current meter to measure the discharge on major rivers)* and nine (9) Secondary Hydrological Station *(where flow/discharge are measured using traditional float method).* The daily observations of the stations were done manually by regular staff posted in the stations.

As a part of modernization of hydrological network and enhance the density of station in Bhutan, new hydrological stations were installed and the existing manual hydrological stations were upgraded to Automatic real-time station (AWLS) under NAPA-II and other donor assisted projects implemented by NHCM. As of June 2017, there are nineteen (19) Principal hydrological Station and thirty-one (31) Secondary hydrological Stations installed along the different river basins and sub-basins in Bhutan (Details as in the Annexure).

The hydrological network also includes the fifteen (15) Sediment Sampling Stations and eight (8) Sediment Laboratories which are setup and operated in parallel with some of the river gauging stations.

Further, with the aim to protect and ensure preparedness from the threat of rainstorm flood and GLOF, Flood/GLOF Early Warning Systems were being installed and are operational in the following three (3) river basins as mentioned below:

a. GLOF Early Warning System (EWS) in the Punakha-Wangdi Valley (10 Real time Automatic ALWS/AWS Station, Basin Control Room (Wangdi) and 18 Warning Sirens);

b. Rainstorm and GLOF EWS in the Mangdechhu sub-basin (2 Real Time Automatic AWLS/AWS Station, Basin Control Room and 3 Warning Sirens);

c. Rainstorm and GLOF EWS in the Chamkarchhu sub-basin (4 Real Time Automatic AWLS/AWS Station, Basin Control Room and 6 Warning Sirens).

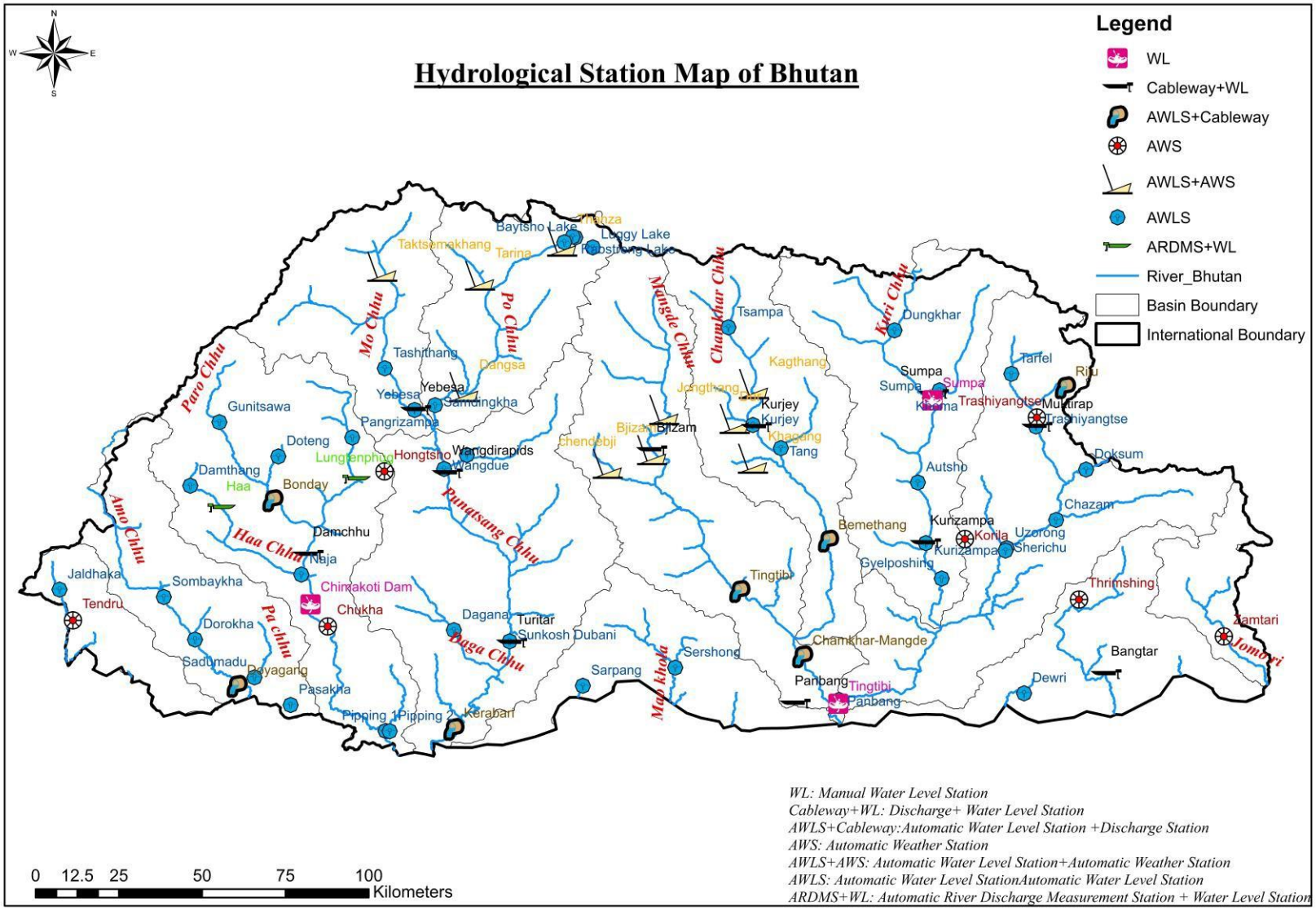


Figure 2: Hydrological Station Map

Table 1: Annual Performance Agreement (APA) Targets and Services Delivery of HWRSD for FY 2016-17.

Sl.No.	Objective	Action	Success Indicator	Unit	Planned (June 2016)	Achievement (July 2017)
1	To improve Flood/GLOF Early Warning Services to minimize loss of lives and properties.	Operation of GLOF Early Warning System for 24/7	Number of GLOF/Flood EWS issued during the severe weather	No.	100%	- GLOF/Flood on Punatsangchhu, Mangdechhu & Chamkharchhu monitored 24x7 and informed relevant authorities and hydropower plants on timely basis. - River level status of Punatsangchhu, Mangdechhu & Chamkharchhu disseminated to the relevant agencies on sub-daily basis including glacial lake level of Luggye, Thorthormi, Rapsthreng and Baytsho in Phochhu headwater.
			Numbers of Workshop/training for GLOF EWS Control Room and modelling	No.	4	- Conducted training/workshop on "Control Room Operation and Maintenance" for the Control Room staff of Kurji, Mangdechhu, Wangdi and FMCR, NWFWC. (4nos- 1 training in each control rooms), - Participated and deputed 3 resource persons for "Hydro-meteorological induction courses" for newly recruited hydromet technicians and Engineers at Punakha (1no.). - Participated and deputed 4 resource persons for "understanding hydromet data and services" for the stakeholders at Paro (1no.).

Sl.No.	Objective	Action	Success Indicator	Unit	Planned (June 2016)	Achievement (July 2017)
2	To deliver and enhance hydrological and related environmental information & services to the public, government and other users	Hydrological Modelling and Flood Forecasting Capacity built	Different Hydrological Model software selected and piloted in Bhutan rivers	No.	2	- Following hydrological models are currently being piloted: - MIKE 11 in Mochhu in collaboration with ICIMOD - HBV in Mangdechhu, Chamkharchhu and Wangchhu. - IFAS for Mangdechhu, Chamkharchhu and Wangchhu
			Selected Hydrological Model setup for different river basins and operational	No	2	- Following hydrological models are currently operational on pilot basis: - HBV in Mangdechhu, Chamkharchhu and Wangchhu (3nos.).
		Hydrological information/ documents published and related services delivered	Hydrological Year book published	No.	1	Hydrological Data Book for the Year 2016 published and disseminated.
			Flood advisories prepared and issued based on the modelling results		5	FMCR, NWFWC of HWRSD issued flood advisories and river level status on sub-daily basis to the relevant stakeholders during the monsoon (Min. 2 flood advisory bulletins are issued).
			Education materials/maps related to Flood and GLOF EWS published and disseminated	No.	2	- Annual Report for HD published and disseminated to relevant agencies. - Flood bulletins are published and disseminated. - Maps related to GLOF EWS, flood hazards etc… updated and disseminated.
			Hydrological and Sediment data provided to users based on request		100%	Hydrological and sediment data provided to all the users based on request.
			Review and publication of documents related to Hydrology, Water Resources, Flood/GLOF etc.		100%	- SOPs and O&M manuals for the GLOF and Rainstorm Flood EWS in Mangdechhu, Chamkharchhu and FMCR of NWFWC developed, published and disseminated.

Remote Automatic Water Level Station (AWLS) for
GLOF EWS at Rapstreng Tsho, Lunana

3 HYDROLOGICAL EXTREMES 2016

3.1 July Flood 2016- Southern Bhutan

Every year Bhutan is impacted South-West monsoon. However, heavy torrential monsoon rains in July/August 2016 led to flash floods and landslides impacting and cutting off many parts of the south Bhutan from the rest. Four districts of Samtse, Chhukha, Tsirang and Sarpang in the southern part of Bhutan are worst affected by floods. Other districts affected by flood are Phuentsholing, Lhamoiyzingkha and Gelephu. The continuous heavy rainfall triggering flash floods started from 22nd July 2016. Many landslides resulting in major roadblocks on the national highways, farm roads and damages to bridges. NCHM issued the weather warning and advisory of the events.

His Majesty the King accompanied by Prime Minister visited the all affected areas of southern Bhutan and personally overseen the search and rescue mission including rehabilitation.

HM at the flood affected area in southern Bhutan *(Source: Internet)*

Flood in Sarpang *(Source: Kuensel)*

Budhini Bridge damaged by flood in Samtse *(Source: Kuensel)*

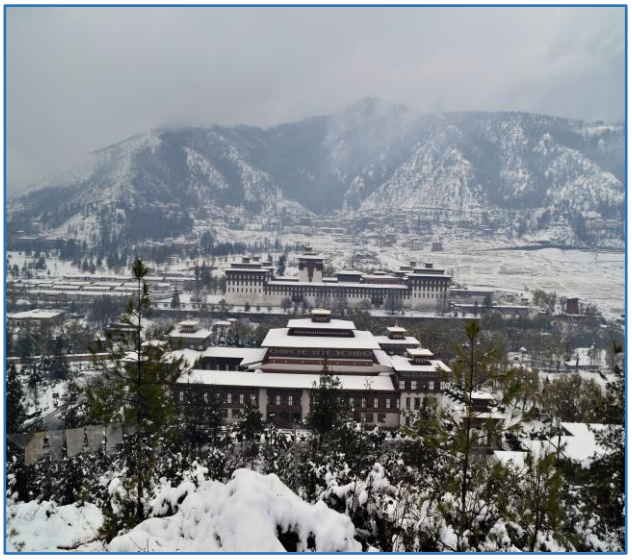
Highway damaged at Kamji on Thimphu-Pling National Highway *(Source: BBS)*

3.2 Heavy Snow Fall-2017

Bhutan received the heaviest snow fall in March 11, 2017 after several years. Thimphu recorded more than 7 inches of snowfall (NCHM, March 2017). It is also the country's heaviest snowfall in the recent memory. Snowfall in Bhutan is due to the western disturbance (WD) that is the westerly wind blowing towards the eastern Himalayan range bringing moisture from the Mediterranean region.

(Source: http://yellow.bt/bhutan-calendar-april-2017)

First snowfall of 2017, NWFWC, Thimphu



First snowfall of 2017 in Thimphu (*Source: Druk Trails*)

4 SUMMARY OF FINANCIAL STATEMENT

The summary of the financial statement for the FY 2016-2017

Items	Total budget allocated in millions (Nu.)	Expenditure in millions (Nu.)	Remarks
1. Project (PHPA)	1.954	1.954	
2. Project (MHPA)	8.866	8.866	
Total	**10.82**	**10.82**	

Table 2: Detail Budget Break down

Sl. No.	Activity	Approved budget in millions(Nu.)	Expenditure in millions (Nu.)
A	**PHPA Co-financing**		
1	Plants & Equipment - General Tools, Instrument	0.809	0.809
2	Computers & Peripherals	0.14	0.14
3	Professional Services	0.14	0.14
B	**MHPA Co-financing**		
1	Training - HRD	0.115	0.115
2	Professional Services	2.14	2.14
3	Plant & Equipment-General Tools, instruments	0.248	0.248
4	Exp.on Structure-others	1.322	1.322
5	Furniture	0.171	0.171
6	Office Equipment	0.1	0.1
9	Computers and Peripherals	1.684	1.684
	Total	**10.82**	**10.82**

Cableway Station at Kurjey, Bumthang

HIGHLIGHTS OF ACCOMPLISHMENTS FOR THE FY 2016-2017

AWLS at Tsampa on Chamkharchhu at 3700 m

5 HIGHLIGHTS OF ACCOMPLISHMENTS FOR THE FY 2016-17

5.1 GLOF Early Warning System (EWS)

5.1.1 His Majesty's Visit to Lunana

His Majesty the King visited Lunana in October 2016. During the visit, His Majesty also met with the staff of the NCHM and inspected GLOF EWS facilities installed in the Lunana area to provide GLOF early warning services to Punakha-Wangdi valley and other infrastructure downstream. Out of 10 (ten) real time remote monitoring hydrological and weather station and 18 warning sirens installed along the Punatsangchhu basin, five (5) remote automatic weather/flood/GLOF monitoring stations and three (3) sirens in Lunana area. GLOF EWS facilities are operated and managed by the NHCM.

Pic 1: His Majesty's visit to GLOF EWS Station, Lunana

Pic 2: His Majesty's visit to Flood Warning Site Office, Thanza, Lunana

Since two NCHM technicians are only government employee stationed at Lunana throughout the year, His Majesty granted greenhouse equipment and accessories to cultivate and grow vegetables for self-consumption, as well as to showcase to the people of Lunana. The construction of green house was completed by NCHM staff with funding from PHPA co-financing during the FY 2016-17. NCHM plans to work with Gasa Dzongkhag for the operation of green house.

5.1.2 Renovation of Flood Warning Site Office

NCHM deputed two regular staff at Thanza, Lunana for physical monitoring of lakes and weather in Lunana area. They serve as a backup to the automatic GLOF EWS installed by transmitting manual data from Lunana to GLOF EWS Control Room, Wangdi as per the daily data transmission schedule. They are also responsible for running and maintenance of GLOF EWS facilities installed in Lunana area.

To facilitate the staff working in the very high altitude, the Flood Warning Site Office at Thanza was constructed during the FY 2014-15 with the funding from PHPA. However, the office building was completely damaged by the windstorm in December 2016. Considering

the importance of the office, it was renovated during the FY 2016-17 through PHPA co-financing project implemented by HWRSD, NCHM. The HF radio and other communication facilities are operated from this site office.

Pic 3: Damaged Flood Warning office

Pic 4: Renovated Flood Warning Office

5.1.1 Maintenance of GLOF-EWS Facilities at Lunana

The GLOF-EWS facilities are required to be maintained from time to time to keep fully operational to provide GLOF EWS services downstream. Although day today routine maintenance works are being carried out two regular staff stationed at Lunana, every year, NCHM deputed technical maintenance team in the month of September-October to carryout major maintenance and replacement of damaged parts to keep the system fully operational.

Pic 5: Maintenance of Water level sensor at Lunana

Pic 6: Repairing of Solar Panel at Lunana

All the costs related to procurement of spares and maintenance of GLOF EWS facilities along the Punatsangchhu were covered from the PHPA co-financing project implemented by NCHM. With the completion of PHPA con-financing project, it will be a challenge for NCHM to maintain the system as there is limited recurrent budget from RGoB.

5.1.2 GLOF Control Room at Kurjey Regional Office

Initially, the GLOF EWS Control Room of Chamkharchhu was established inside the old Hydrology Site Office at Kurjey, Bumthang by JICA Contractor. Upon completion of the new NCHM Regional Office, Bumthang, the control room was shifted to the new building by HWRSD staff in January 2017. The control room is equipped with real time monitoring display and communication facilities with backup power generator to keep the system operational during the power failures.

Pic 7: Regional Office, Bumthang

Pic 8: Control Room

5.1.3 Realignment of DCP Antenna

The GLOF EWS was installed along Mangdechhu and Chamkharchhu sub basin through JICA-TCP supported project implemented from 2013-2016. The project was implemented by NCHM and the GLOF/Rainstorm warning systems were installed and operational in the basins from March 2016. HF communication is being used as the primary communication for the GLOF EWS for Mangdechhu and Chamkharchhu sub-basin with DCP (satellite communication) through GTS as a backup communication.

However, realignment of DCP antenna had to carried out due to migration of Meteosat-7 at 57 ° to Meteosat-8 at 41.5° with effect from March 2017 as per the communication received from JICA Experts/Consultants in January 2017. Considering the remote monitoring stations located in the deep valley, the satellite communications with Meteosat-8 could not be established. Later, JICA contractor confirmed that Meteosat-8 cannot be used for the project in Bhutan as the direction of antenna is blocked by mountain ridges and suggested for change to other satellites to use the DCP communication for the EWS.

Pic 9: Realignment of DCP for EUMETSAT from Meteosat-7 at 57 ° to Meteosat-8 at 41.5 °.

5.1.4 Installation of AWS in the Mangdechhu Sub-basin

Adequate numbers of climate station (AWS) with good quality time series data is essential to perform hydrological modelling. To enhance the coverage of network in Mangdechhu basin three additional AWS were installed along Mangdechhu sub-basin under MHPA Co-financing. Three AWS stations at Dorji Goenpa, Simphu and Dam Colony were installed during the FY 2016-17.

Dam Colony *Dorji Goenpa* *Simphu*

Pic 10: AWS installed in Mangdechhu sub-basin

Data from these three stations are transmitting on real time to National Weather and Flood Warning Center, NCHM in Thimphu. Data will be used for running hydrological modelling as well as to provide early warning services during the extreme weathers.

5.1.5 Training for Control Room Operators

There are three control rooms operational in Chamkharchhu, Mangdechhu and Punatsangchhu basin. Each control room is operated by regular staff recruited with effect from January 2017. Control rooms are operated 24x7 on a shift basis. HWRSD through the support of MHPA-financed project conducted hands on training on operation and maintenance of control room facilities and SOP. The training also included site visits and maintenance of field stations. Training were conducted by resource persons from HWRSD and FWS. Details of the training given below.

Control Room (CR)	Date	No. of Participants
a. Kurjey CR, Bumthang	5-7 June 2017	6
b. Mangdechhu CR, Trongsa	9-11 June 2017	4
c. Wangdue CR, Wangdue	15-19 June 2017	6
d. FMCR, NWFWC, Thimphu	20-22 June 2017	5

Pic 11: Hands on Training for GLOF-EWS control room operators

5.1.6 Construction of Generator Shed at NWFWC, Thimphu

National Weather and Flood Warning Center (NWFWC) is the national supervisory and command center for real time monitoring of hydromet hazards and issue advisory/warnings in Bhutan. NWFWC is operational 24x7 and continued power supply is essential to keep the systems and facilities running. A DG power backup was installed to supply power during power failures. A combined generator shed and kitchen was constructed to safe guard the DG set and to facilitate cooking for the 24x7 control room operators during emergencies and holidays.

Pic 12: Generator Shed Constructed at NWFWC, Thimphu

5.2 Capacity in Hydrological Modelling

Hydrology and Water Resources Services Division, NCHM has capacity in hydrological modeling built through NORAD Phase IV project and JICA TCP project. For the FY 2016-17 the following two hydrological models were installed and running in Bhutan as pilot project

a. HBV Modeling

HBV is a semi-distributed conceptual model used to calculate river discharge using rainfall, temperature, topography & land Use.

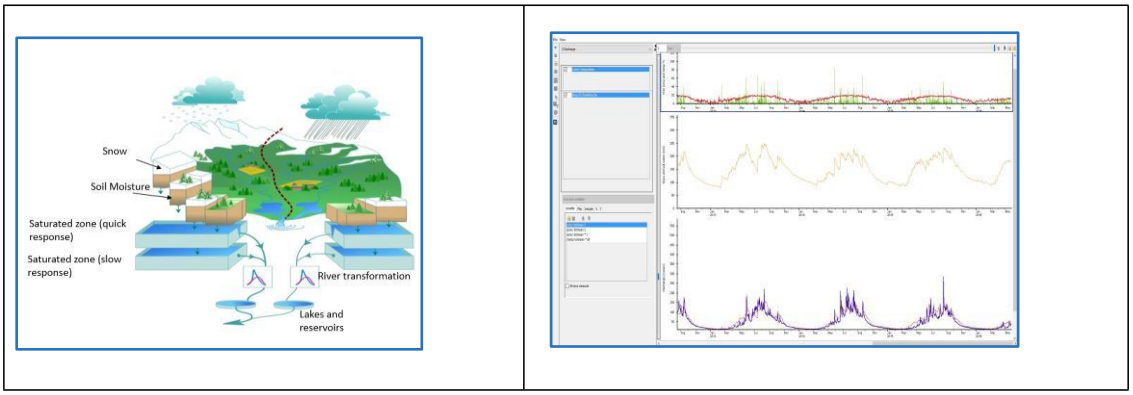


Figure 2: *Outputs of HBV Model for Chamkhar Chhu*

A HBV licensed hydrological model was procured from the Swedish Meteorological and Hydrological Institute (SMHI) through NORAD-IV supported project. With the technical back stopping from the Norwegian Water Resources (NVE), HBV model were set up on pilot river basin in Bhutan- Mochhu, Mangdechhu Wangchhu and Chamkarchhu basins in Bhutan. The outputs of the model will be used for inflow forecasting for hydropower plants and flood forecasting.

b. Integrated Flood Analysis System (IFAS) Modelling

An (IFAS) is a distributed hydrological model used to calculate river discharge using rainfall Topography & Land Use. A model is being tested in Wangchhu and Chamkarchhu basins in Bhutan IFAS model was used for calculating river flow for development of flood hazard maps in the Mangdechhu and Chamkarchhu basin.

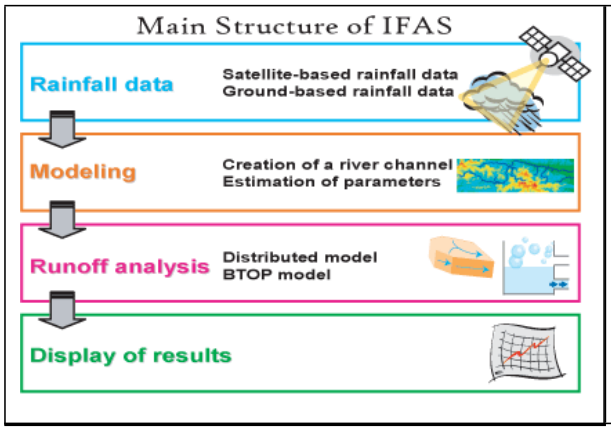


Figure 3: IFAS Model Structure

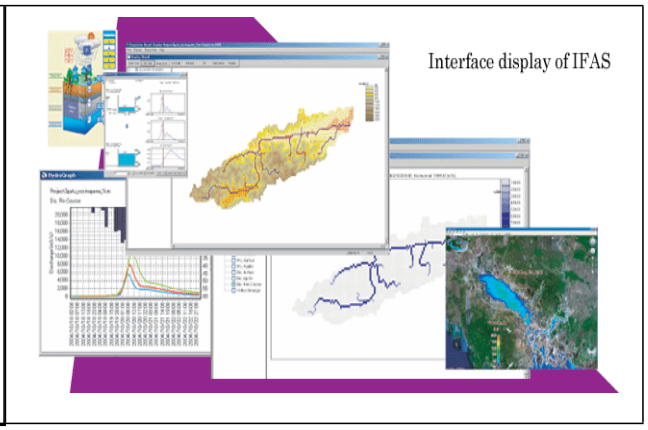


Figure 4: IFAS Model Interface Display
Sources: ICHARM/PWRI Web site

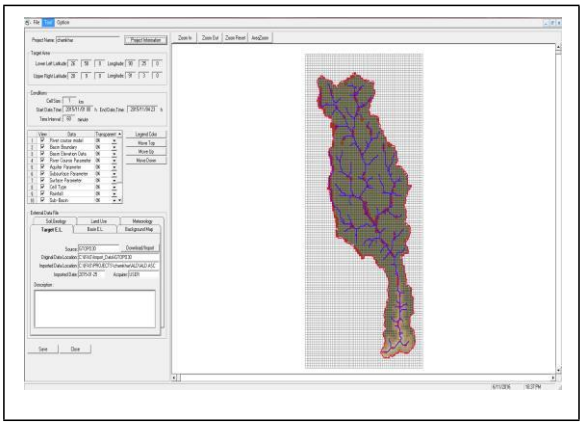


Figure 5: IFAS Model Setup of Chamakharchhu

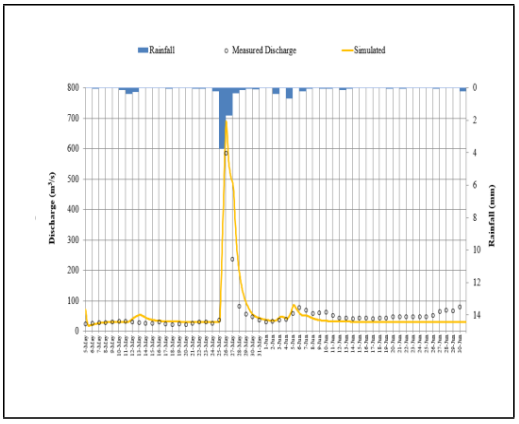


Figure 6: Outputs of IFAS Model for Chamkhar Chhu

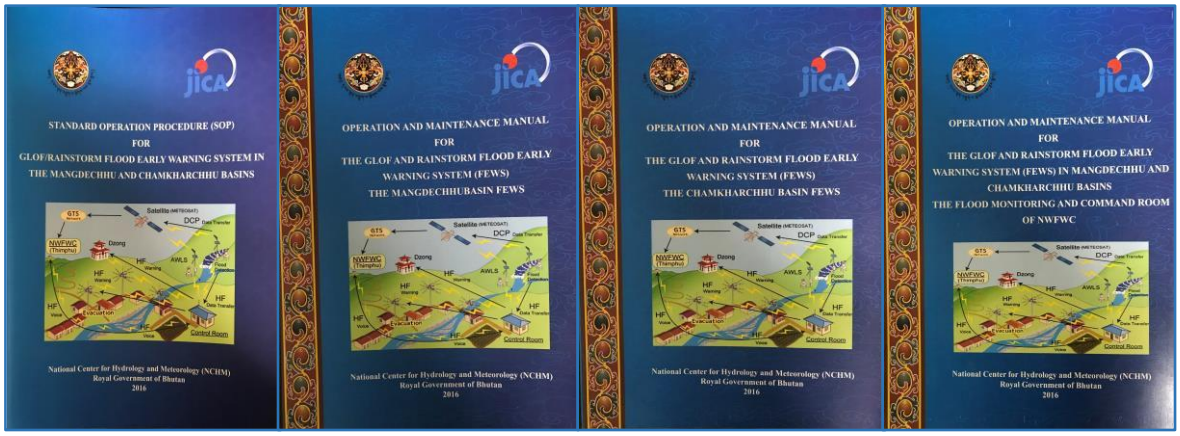
5.3 Publications

5.3.1 Publication of SOP and Operation Manuals for GLOF EWS

Standard Operating Procedure (SOP) and Operation Manuals for GLOF-EWS Mangdechhu and Chamkharchhu were developed jointly by HWRSD and JICA Experts in consultation with relevant stakeholders. Following manuals were published under MHPA Co-financing

and distributed to all the control rooms, Department of Disaster Management, Local Government of Trongsa and Bumthang, MHPA and relevant agencies.

a. Standard Operation Procedure (SOP) for GLOF/Rainstorm Flood Early Warning System in the Mangdechhu and Chamkarchhu Basins
b. Operation and Maintenance Manual for the GLOF and Rainstorm Flood Early Warning System in the Mangdechhu Basin;
c. Operation and Maintenance Manual for the GLOF and Rainstorm Flood Early Warning System for Chamkharchhu Basin;
d. Operation and Maintenance Manual for the GLOF and Rainstorm Flood Early Warning System in the Mangdechhu and Chamkarchhu Basins- The Flood Monitoring and Command Room (FMCR) of NWFWC, Thimphu.



Pic 13. SOP and O&M Manuals for GLOF-EWS Published

5.3.2 Hydrological Data Book

For dissemination as well as for archival of hydrological and sediment data in hardcopy, HWRSD published hydrological data book every year. Hydrological Data Book 2016 was published with financial support from MHPA Co-financing Project. This publication contains one year of hydrological time series data of the hydrological stations across the country.

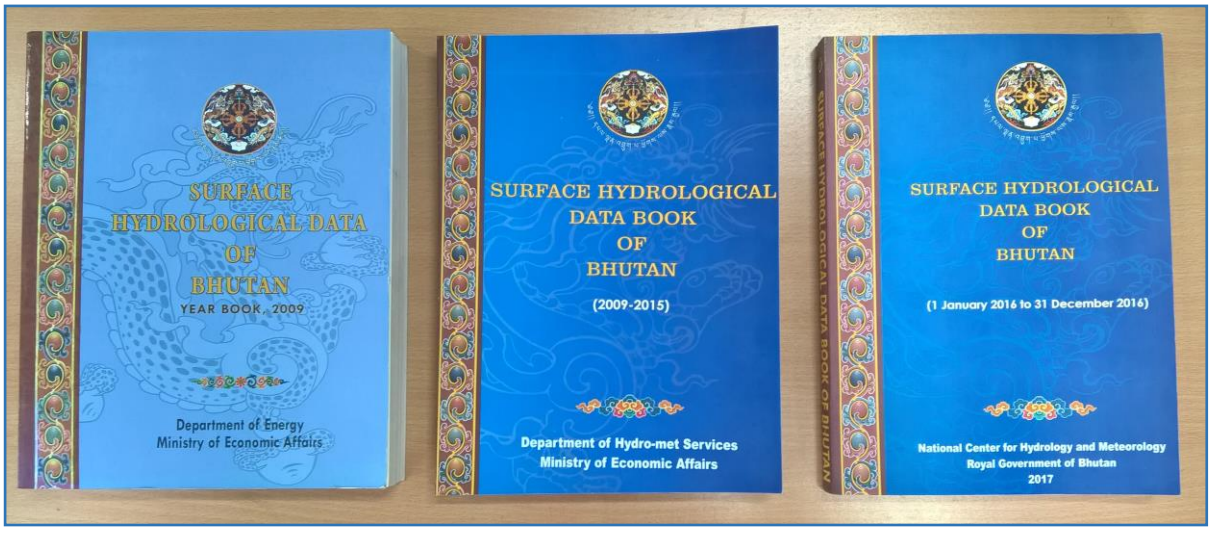
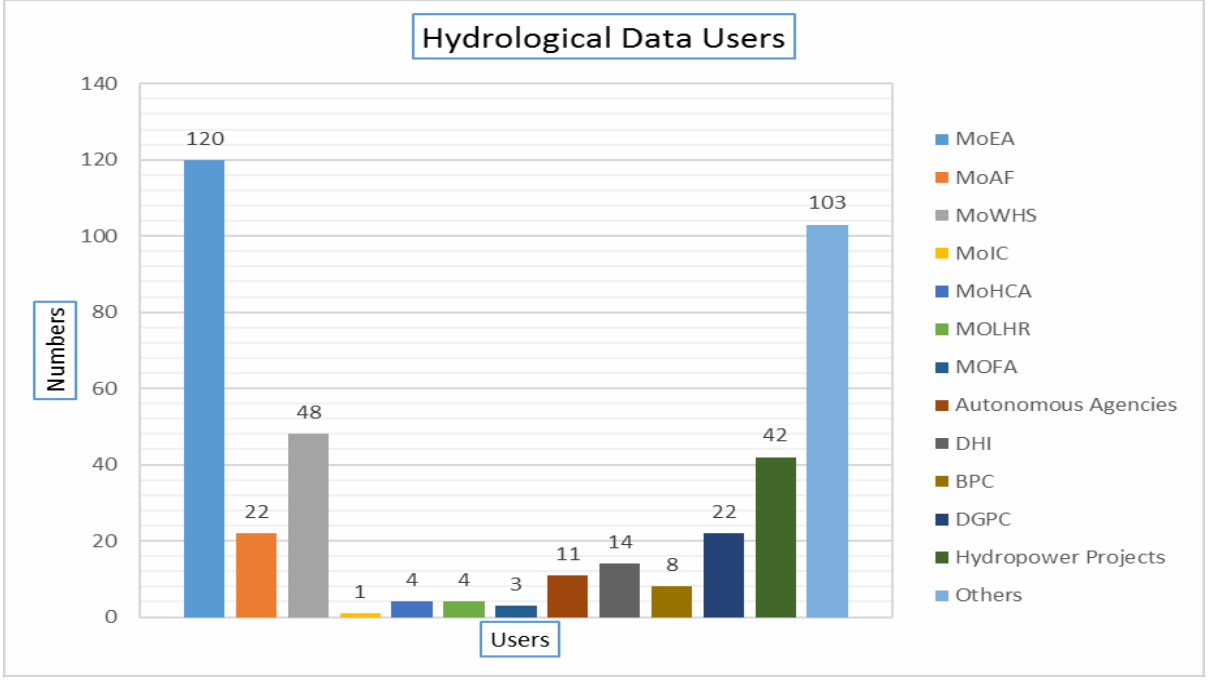


Figure 1: Three Surface Hydrological Data Book Publications including 2017

5.3.3 Dissemination of Hydrological and Sediment Data

Beside the flood and GLOF early warning products and services, the Hydrology and Water Resources Services Division (HWRSD) also provides raw and processed hydrological time series data to line agencies, private individuals, academic researchers and students based on the request. The main user of hydrological data in Bhutan is hydropower sector for planning and development of hydropower projects (Department of Hydropower and Power Systems and Druk Green Power Corporation (DGPC) and Hydropower Project Authorities.



5.4 Technical Backstopping Services

5.4.1 Gasa Dzongkhag

Based on the request of Dasho Dzongda, Gasa Dzongkhag Administration, the then Hydrology Division, DHMS deputed a technical team to installed Water Level Gauge on Mochhu at Gasa Tsachu and Baychu on Zamayzam from 4 August, 2016.

Hydrology Division, DHMS team with support from the Gasa Dzongkhag Administration has successfully installed the Manual Gauge at the above sites. River level observations will be done by Gasa Dzongkhag local staff and data will be shared with the relevant agencies during the dieters such as flood.

Dasho Dzongda, Gasa appreciated the Department of Hydro-met Services, MoEA for the delivery of prompt technical back stopping services for setting up of the water level gauges at the above sites.

Pic 15: Water Level Guage Installed for Gasa Dzongkhag.

5.4.2 E-Flow Studies

Minimum Environmental flow for hydropower project is being implemented by National Environment Commission under ADC funding. NHCM is one of collaboration partner for the implementation of the project. HWRSD officials provided technical backstopping field survey and flow modelling.

Pic 16: Data Collection for E-flow for Mochhu

5.4.3 Hydro-met Stakeholder Workshop

Through NAPA-II project, NHCM conducted workshop on understanding Hydro Met and Cryosphere Data and Services to the stakeholders at Paro in March/April 2017. HWRSD deputed technical staff as resource persons for the workshop to deliver lecture presentation on "Operational Hydrology, Hydrological modelling, flood forecasting and GLOF early warning services". More than 70 participants from relevant stakeholders attend the workshop including the UNPD officials.

Participants for 1st Workshop, Paro

Participants for 2nd Workshop, Paro

Pic 17: Workshop Understanding HydroMet and Cryosphere Data and Services

5.4.4 Hydrology and Meteorology Induction Course

A week long induction courses on "Hydrology and Meteorology" was conducted new officer and hydromet technicians were conducted from 18-27 May 2017 at Punakha under the NAPA-II project funding. The main objective of workshop to impart basic course on operational hydrology and meteorology to perform their duties in their respective station. The participants were also briefed on duties and overall mandates of NCHM. HWRSD deputed technical staff as resource persons for the induction course to deliver lecture on "Operational Hydrology, Hydrological modelling, flood forecasting and GLOF early warning services".

Participants visited NWFWC, Thimphu

Participants Performing Flow Measurement of River

Pic 18: Induction Course for new Recruits

CAPACITY BUILDING & HUMAN RESOURCE DEVELOPMENT

Hydrological Assessment after July 2016 Flood at Bumthang

6 CAPACITY BUILDING AND HUMAN RESOURCE DEVELOPMENT

Being a technical agency, National Center for Hydrology and Meteorology continues to develop its manpower resources to provide adequate pool of qualified and well trained professional, technical and administrative personal for effective and efficient delivery of services. With approved fund from RGoB and donors fund projects the Hydrology and Water Resources Services Division, NCHM for the FY 2016-17 implemented in country and number of ex-country trainings. Further, Hydrology and Water Resources Services Division personnel got opportunities to attended international meetings, workshop, seminar and conferences related to hydrology, flood, disasters, early warning and climate change impacts organized by regional and international organization. The workshop and seminar provide opportunities and international exposure related to their work.

6.1 In-country Training and Meetings

To keep up with the pace of modernization of Hydro-Meteorological equipment, the skills and knowledge of our field staffs who dealing with using the equipment in the field on a daily basis needs to be enhanced. Based on the availability of fund, the division always organized workshop and refreshers course of the field technicians and observers from time to time. The officials in the division also attended and organize workshops, seminars and trainings

Table 3 :Trainings/Workshop/Seminars/Symposium attended in FY 2016-17

Sl. No	Title	Participant Name	Date (Duration)	Venue/ Country	Funding
1	National Water Symposium	Mr. Karma Dupchu, Chief; Mr. Tshewang Rigzin, Dy. EE	10-12 May 2017	Ariya Hotel, Olakha, Thimphu	NEC
2	Workshop on E-flow and Hydrological Modelling	Bikash Pradhan, Engineer; Chimi Namgyel, Statistian	23-27 May 2017	Rochokpel hotel, Thimphu	NEC
3	Stakeholder Workshop on Hydrology and Meteorology	Mr. Jamyang Zangpo, Engineer; Mr. Chimi Namgyel, Statistian; Ms. Samjana Rai; Mr. Pema Dorji, Technician	27 March-7 April 2017	Paro, Bhutan	NAPA-II

Pic 19:Participants of National Water Symposium, Thimphu.(Facebook page of HE Prime Minister of Bhutan)

6.2 Ex-country Trainings and Meetings

Through international and bilateral funding program, HWRSD staff got opportunities to attend trainings, meetings and conferences outside in various countries for the FY 2016-17.

6.2.1 Training

The following officials attended the training and study tour for the FY 2016-17 under donor supported projects.

Table 4 :Training/Study Tour attended by HWRSD personnel for the FY 2016-17

Title	Participant Name	Date (Duration)	Venue/ Country	Funding
1. Training on Modelling for e-flow	a. Mr. Tandin Wangchuk, Engineer, HWRSD, NCHM b. Mr. Bikash Pradhan, Engineer, HWRSD,NCHM	July 18- Aug 4, 2016	Stuttgart/Germany	ADC Project through NEC
2. Flood Forecasting, Control Room operations and Hydrological Services delivery in South East Asia	a. Karma Dupchu, Chief HWRSD, NCHM b. Mr. Pema Wangdi, Assistant Engineer, HWRSD, NCHM c. Tshewang Rigzin, Engineer HWRSD, NCHM d. Ngawang Namgyal, Technician, HWRSD, NCHM	Oct 30 – Nov.11, 2016	Philippines/ Thailand	NORAD-IV/NAPA-II
3. Capacity Development for Flood Risk Management with Integrated Flood Analysis System (IFAS)	a. Mr. Sangay Tenzin, AE HWRSD, NCHM b. Mr. Tshewang Dorji, DDMO, Bumthang	July 3- 30 July 2016	Tsukuba/Japan	JICA
4. Training of Trainers	a. Sangay Tenzin, AE HWRSD, NCHM b. Tandin Wangchuk, E HWRSD, NCHM	March 6 – March 17 2017	IIRR/Philippines	NAPA-II
5. Regional Glacio-hydrological training on SPHY and VIC Model	Mr. Ngawang Namgyal, Technician, FMCR, NCHM	May 16 – 23 May 2017	ICIMOD/Nepal	ICIMOD

Pic 20: Training on E-Flow Modelling in Germany

Pic 21: Study Tour on Flood Forecasting, Control Room Operations in Philippines and Thailand.

Pic 22: Training on Flood Risk Management with Integrated Flood Analysis System (IFAS)

Pic 23: Training of Trainers (TOT) in Philippines

6.2.2 Meeting and Conference

As per the mandates of NCHM, the officials from the Hydrology and Water Resources Services Division during the FY 2016-17 attended bilateral, regional and international meetings and conferences related to weather, climates and water resources.

Table 5: Meeting/Conference /Workshop/Seminar attended in FY 2016-17

Title	Participant Name	Date (Duration)	Venue/ Country	Funding
Regional Conference on Risks and Solution: Adaptation Frameworks for Water Resources Planning, Development and Water Management in Southeast Asia	Mr. Karma Dupchu, Chief HWRSD, NCHM	July 12-13 July 2016	Colombo/Sri Lanka	World Bank/IWMI
Regional Learning Platform: Mainstreaming Disaster Risk Reduction and Resilience into Sustainable Development with Focus on Poverty Eradication	Mr. Karma Dupchu, Chief HWRSD, NCHM	March 29- 31 March 2017	UN-ESCAP/Thailand	UN-ESCAP
Remote Sensing Based Glacier Mapping and Monitoring	Mr. Tshewang Rigzin, Dy. EE, HWRSD, NCHM	March 20-24 March 2017	ICIMOD/ Nepal	CMP-B
Joint Group of Experts (JGE) meeting on Flood Management.	Mr. Karma Dupchu, Chief HWRSD, NCHM	19-20 April 2017	Thimphu, Bhutan	RGoB
Cross Border Workshop on Disaster Preparedness and Mitigation for Improved Water Governance of Brahmaputra River Basin	Mr. Karma Dupchu, Chief HWRSD, NCHM	April 26- April 29 2017	Dhaka/ Bangladesh	SachiWATER
Multi Hazard Early Warning System (MHEWS)	Mr. Sangay Tenzin, Engineer, HWRSD,NCHM	22 May-23 May 2017	Cancun/Mexico	WMO

Pic 24: Workshop: Mainstreaming Disaster Risk Reduction and Resilience into Sustainable Development

Pic 25: Workshop on Remote Sensing Based Glacier Mapping and Monitoring

7 INSTITUTIONAL VISITS TO CONTROL ROOMS

GLOF EWS Control Room in river basin and Flood Monitoring and Command Room (FMCR), NWFWC, Thimphu are operational for 24/7. These facilities and establishment made access to public and students to create awareness about flood and disaster as well to enhance the visibility of NHCM. Officials from international, regional, national organizations including the local government officials visited the Control Rooms. Detail as given below.

Sl.No.	Institute/Agency	Visited	Visit Date
1	World Bank Officials	NWFWC	August 3 , 2016
2	Dzongkhag Disaster Management Committee (DDMC) of Thimphu	Wangdue Control Room	January 7, 2017
3	JICA Expert Survey Team	NWFWC	January 24, 2017
4	Chief Representative of JICA Bhutan Office and JICA officials	Bumthang Control Room	January 24, 2017
5	National Staff of JICA Bhutan Office	Wangdue Control Room	February 12 , 2017
6	JICA Expertise Mr. Kazutoshi MASAUDA, GIS/RS Specialist of the Project for Formulation of Comprehensive Development Plan for Bhutan 2030 implemented by Department of Human Settlement (DHS), MoWHS	NWFWC	February 17, 2017
7	UNDP Assistant Secretary General, H.E Haoling Xu and UNDP officials	NWFWC	14 March 2014
8	JICA Consultants for Detailed Planning Survey on the Project for Power System Master Plan 2040 in Bhutan	NWFWC	April 13, 2017
9	GoI Delegation for Joint Group of Experts (JGE)	NWFWC	April 20, 2017
10	Students of College of Natural Resources, RUB	Wangdue Control Room	June 7, 2017
11	Students of College of Natural Resources, RUB	NWFWC	June 8, 2017
12	Finnish Ambassador to Bhutan	NWFWC	1 April 2017

Pic 26: UNDP Assistant Secretary General with Director and Officials of NCHM during his visit to NWFWC

Pic 27: Finnish Ambassador to Bhutan visit to NWFWC

Pic 28: Visitors to National Weather and Flood Warning Center (NWFWC)

ON GOING PROJECTS

Completion and Handing taking of JICA-TCP Project *(Source: HWRSD Facebook page)*

8 PROJECTS IMPLEMENTED BY HWRSD

The following projects were directly implemented by the Hydrology and Water Resources Services Division, NCHM.

8.1 JICA TCP Project

The three year JICA supported project "Capacity Development of GLOF and Rainstorm Flood Forecasting and Warning in the Kingdom of Bhutan (2013-2016)" was implemented by the Department of Hydro-met Services (now called National Centre for Hydrology and Meteorology), Ministry of Economic Affairs in collaboration with relevant agencies and local government of Trongsa and Bumthang.

The project started in 2013 and all the activities are completed by August 2016.

8.1.1 Handing Taking of JICA TCP Project

Upon successful implementation of all the activities and delivery of the all the expected outputs, JICA handed over all the equipment and facilities procured and established through the project to the National Centre for Hydrology and Meteorology, RGoB for operation. The Handing Taking Over of the Equipment and Facilities ceremony was held on August 26, 2016 in Energy Conference Hall, Thimphu. The Handing Taking Note was signed between Mr. Koji Yamada, Chief Representative, JICA, Bhutan Office and Mr. Karma Tsering, Director, National Centre for Hydrology and Meteorology on the behalf of RGoB. The handing taking over ceremony was attended by JICA Experts, Officials from JICA Bhutan Office and NCHM officials.

Pic 29: Handing Taking of the JICA TCP Project

8.1.2 Final Minutes of Meeting

The Final Minutes of Meeting of the project completion report was signed between Mr. Karma Tsering, Director, NCHM and Mr. Yasuhiko KATO, Chief Project Advisor, JICA on 29 August 2016.

As a courtesy, Director, NCHM has presented a souvenir to JICA Experts for their support and successful implementation of the project.

Pic 30: Signing of Final Minutes of Meeting

8.2 MHPA Supported Project

The project "Institutional Strengthen and Setting up of GLOF Early Warning and Rainstorm Flood Forecasting in Mangdechhu and Chamkarchhu Basins" is co-financed by the Mangdechhu Hydropower Project Authority (MHPA). The project started in 2014 and was completed in 2017. The project implemented by the Hydrology and Water Resources Services Division of NCHM in collaboration with Department of Disaster Management (DDM), Ministry of Home and Cultural Affairs. The following were the main activities implemented for the FY 2016-2017:

a. Construction AWS in Mangdechhu Basin
b. Construction of Generator shed, NWFWC, Thimphu
c. Procurement of furniture, ICT and office equipment,
d. In country training on Operational Hydrology and Control Room operation for Control Room Operators
e. In country workshops on Hydrological Modelling

The project was formal completed in June 2017. The Project completion report was submitted in July 2017 to GNHC.

Pic 31: MHPA Project Completion Report

8.3 PHPA Supported Project

Punatsangchhu Hydropower Project Authority (PHPA-I and II) Co-financed Project for the installation of GLOF Early Warning System in the Punakha-Wangdi Valley was implemented by the Hydrology and Water Resources Services Division of NHCM. The PHPA support project started in 2009 and was formally completed in July 2017. During the FY 2016-17 following are main activities implemented:

a. Running and Maintenance of GLOF EWS Stations and facilities
b. Renovation of Flood Warning Office at Thanza, Lunana
c. Construction of Green house at Lunana
d. Procurement of spare parts for GLOF EWS Stations

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Wangdi
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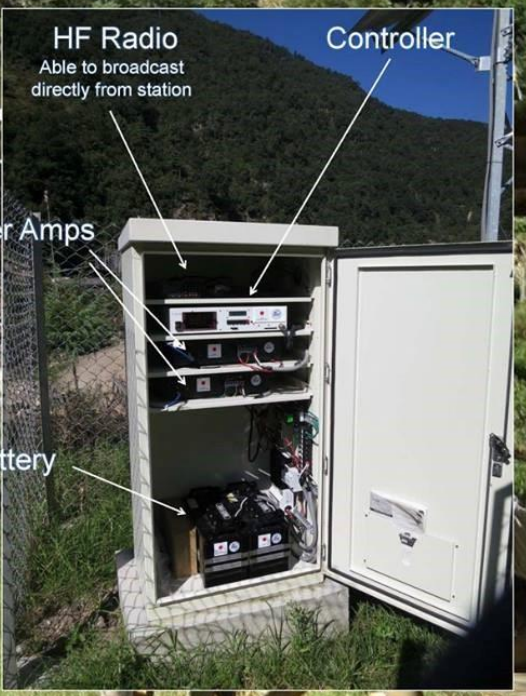
Flood Monitoring and Command Room

SIREN STATION, BJIZAM PRIMARY SCHOOL, TRONGSA

HF Communication
With MHPA Control Room



Annexures

9 ANNEXURES

9.1 Annexure-I: List of Hydrological and GLOF EWS Station

Table 6: List of Principal Hydrological Station with AWLS

Sl. No.	Station No:	Station Name	River Basin	Dzongkhag	Latitude	Longitude	Altitude	Catchment area
1	11210045	Doyagang on Ammochhu	Amochhu	Chhukha	26:53:12	89:20:60	354.6	3650.0
2	12800045	Lungtenphug on Wangchhu	Wangchhu	Thimphu	27:26:48	89:39:40	2260.0	663.0
3	12490045	Damchhu on Wangchhu	Wangchhu	Chhukha	27:14:26	89:31:38	1990.0	2520.0
4	13700045	Yebesa on Mochhu + AWLS	Punatsangchhu	Punakha	27:37:59	89:49:03	1230.0	2320.0
5	13490045	Wangdirapids on Phochhu + Mochhu	Punatsangchhu	Wangdi	27:27:45	89:54:11	1190.0	6271.0
6	13320045	Turitar on Sankosh	Punatsangchhu	Tsirang	27:00:21	90:04:36	320.0	8593.0
7	13140045	Kerabari on Sankosh	Punatsangchhu	Dagana	26:46:06	89:55:41	150.0	10355.0
8	14580045	Bjizam on Mangdichhu +AWLS	Manas	Trongsa	27:31:28	90:27:17	1848.0	1390.0
9	14180045	Tingtibi on Mangdiechhu (Downstream)	Manas	Zhemgang	27:08:50	90:41:59	530.0	3320.0
10	15490045	Kurjey on Chamkharchhu +AWLS	Manas	Bumthang	27:35:13	90:44:13	2600.0	1350.0
11	16520045	Sumpa on Kurichhu +AWLS	Manas	Lhuntse	27:39:50	91:12:54	1170.0	
12	15600045	Bemethang on Chamkharchhu	Manas	Zhemgang	27:16:50	90:56:15	1300.0	
13	16200045	Kurizampa on Kurichhu	Manas	Mongar	27:16:26	91:11:37	519.0	8600.0
14	17670045	Muktirap on Kholong Chhu + AWLS	Manas	Trashi Yangtse	27:35:16	91:29:40	1640.0	905.0
15	17400045	Uzorong on Gongri	Manas	Tashigang	27:15:38	91:24:30	554.0	8560.0
16	17120045	Pangbang on Dangme chhu + AWLS	Manas	Zhemgang	26:50:30	90:50:30	136.0	20935.0

Table 7: List of Secondary Gauging Stations

Sl.No.	Station No:	Station Name	Basin	Dzongkhag	Latitude	Longitude	Altitude	Catchment area
1	12460045	Hachhu	Wang Chhu	Haa	27:22:16	89:17:08	2700.0	320.0
2	12550045	Parochhu (Bondey)	Wang Chhu	Paro	27:23:12	89:26:03	2220.0	1101.0
3	13810045	Samdingkha on Phochhu	Punatasangchhu	Punakha	27:38:28	89:51:50	1220.0	1284.0
4	14240045	Tingtibi on Dakpichhu	Manas	Zhemgang	26:50:30	90:57:30	580.0	122.0
5	16130045	Lingmethang on Maurichhu	Manas	Monger	27:15:42	91:11:20	565.0	284.0
6	16500045	Sumpa on Khomachhu	Manas	Lhuntse	22:39:34	91:12:46	1145.0	611.0
7	16350045	Autsho on Kurichhu	Manas	Lhuntse	27:25:59	91:10:38	814.0	8453.0
8	17410045	Sherichhu on Sherichhu	Manas	Mongar	27:15:15	91:24:36	542.0	437.0
9	12350073	Chimakoti Dam on Wangchhu	Wangchhu	Chhukha	27:06:34	89:32:02	1820.0	3550.0

Table 8: Automatic Water Level Station (AWLS) and Automatic Weather Station (AWS) for Flood/GLOF Early Warning and Siren

Sl. No.	Station No.	Station Name	Basin	Dzongkhag	Latitude	Longitude	Altitude
A		**Flood Warning for Lingkhana Palace**					
1		Begena on Thimchhu (Wangchu)	Wangchhu	Thimphu			
B		**GLOF EWS for Punatsangchhu basin**					
2	13950150	Luggy Tsho Automatic Water Level Station (AWLS)	Punatasangchhu	Gasa	28.07133	90.29600	4485
3	13930150	Thorthormi Automatic Water Level Station (AWLS)	Punatasangchhu	Gasa	28.09795	0.24867	4364
4	13900510	Automatic Water Level Station (AWLS)	Punatasangchhu	Gasa	28.10040	90.24152	4354
5	13870150	Bay Tsho Automatic Water Level Station (AWLS)	Punatasangchhu	Gasa	28.08537	90.21915	4339
6	13850150	Thanza, Lunana on Pochhu (AWLS +AWS)	Punatasangchhu	Gasa	28.08668	90.21322	4120
7	13840150	Tarina-Wachey on Phochhu AWLS+AWS	Punatasangchhu	Gasa	27.99514	89.99145	3570
8	13600150	Dangsa on Pochhu (AWLS + AWS)	Punatasangchhu	Punakha	27.69472	89.94881	1600
9	13790150	Taktsemakhang on Mochhu (AWLS +AWS)	Punatsangchhu	Gasa	28.01884	89.72760	3289
10	13750150	Tashithang on Mochhu (AWLS + Rainfall)	Punatasangchhu	Punakha	27.74564	89.73443	1584
11	13700150	Yebesa on Mochhu (AWLS+ Rainfall)	Punatasangchhu	Punakha	27.63338	89.81485	1240
12		18 Warning Sirens (3 in Lunana, 15 along the Punakha-Wangdi Valley)	Punatasangchhu	Punakha			
C		**Rainstrom and GLOF EWS on Mangdechhu basin**					
12	14700150	Jongthang on Mangdechhu (AWLS + AWS)	Manas	Trongsa	27.63300	90.48900	2136
13	14580150	Bjizam on Mangdechhu (AWLS+AWS)	Manas	Trongsa	27.52500	90.45600	1866
14		Three Warning Sirens (Bjizam, MHPA Dam and MHPA Power house)	Manas	Trongsa			
D		**Rainstrom and GLOF EWS on Chamkharchhu basin**					
15	15600150	Tsampa on Chamkharchhu (AWLS)	Manas	Bumthang	27.85600	90.66200	3674
16	15610150	Tsampa on Chamkharchhu (AWS)	Manas	Bumthang	27.86000	90.65900	3708
17	15550150	Kagthang on Chamkharchhu (AWLS+ AWS)	Manas	Bumthang	27.70300	90.73100	2895
18	15480150	Kurjey on Chamkharchhu (AWLS+AWS)	Manas	Bumthang	27.59300	90.72800	2619

Table 9: List of New Hydrological Station under NAPA-II Project

Sl.No	Station ID	Station Name	Basin Name	Dzongkhag	Latitude	Longitude	Elevation
1	12900145	Dodena on Wangchhu	Wangchhu	Thimphu	27.57927	89.63488	2540
2	12850145	Pangrizampa on Wangchhu	Wangchhu	Thimphu	27.55910	89.64658	2445
3	12200145	Pipping on Wangchhu	Wangchhu	Chhukha	26.76850	89.73630	172
4	12480145	Damthang on Haachhu	Wangchhu	Haa	27.42930	89.20937	2970
5	12400145	Naja on Haachhu	Wangchhu	Haa	27.18983	89.50895	1960
6	12600145	Doteng on Paachhu	Wangchhu	Paro	27.50822	89.44692	2440
7	12150145	Pipping on Pippingchhu	Wangchhu	Chhukha	26.76758	89.74742	171
8	13400145	Chuzomsa on Dangchhu	Punatsangchhu	Wangdiphodrang	27.51210	89.95575	1325
9	13200145	Dagana on Dagachhu	Punatsangchhu	Dagana	27.04012	89.92070	868
10	13140145	Kerabari on Sunkosh	Punatsangchhu	Dagana	26.77257	89.92113	140
11	15300145	Tang on Tangchhu	Manas	Bumthang	27.53070	90.80348	2580
12	16100145	Gyelposhing on Kurichhu	Manas	Mongar	27.17905	91.23767	482
13	16600145	Dungkhar on Dungkharchhu	Manas	Lhuntse	27.84800	91.11017	1595
14	17000145	Tarfel on Kholongchhu	Manas	TrashiYangtse	27.73082	91.42558	2040
15	17500145	Riju on Gamrichhu	Manas	Trashigang	27.69320	91.57178	754
16	14100145	Chamkhar-Mangde on Mangdechhu	Manas	Zhemgang	26.96827	90.86245	220
17	11300145	Sombaykha on Amochhu	Manas	Haa	27.12950	89.13790	830
18	11220145	Pasakha on Singyehhu	Manas	Chhukha	26.83827	89.48013	391
19	11250145	Sadumadu on Pachhu	Manas	Chhukha	26.91283	89.38267	366
20	22500145	Jaldhaka on Jaldhaka	Jaldhakachhu	Samtse	27.14944	88.85627	831
21	23100145	Sarpang on Sarpangchhu	Maokhola	Sarpang	26.89020	90.26908	337
22	24100145	Bangtar on NyerAmochhu	NyerAmochhu	Samdrupjongkhar	26.92128	91.68112	310
23	24200145	Dewri on Dewri	NyerAmochhu	Samdrupjongkhar	26.86977	91.45993	430

Table 10: Flood Warning Stations Operated by Flood Warning Section (GoI)

Sl. No.	Station No.	Station Name	River Basin	Dzongkhag	Latitude	Longitude	Altitude
A		**Water Level Flood Warning Station**					
2	11100149	Dorokha on Ammochu (AWLS + Met)	Ammochu	Thimphu	27.01472	89.22208	479.0
3	12350149	Chhukha on Wangchhu (AWLS+ Met)	Wangchhu	Chhukha	27.04989	89.58039	1374.0
4	13300149	Wangdi on Punatsangchhu (AWLS+ Met)	Punatsangchhu	Wangdi	27.47453	89.89447	1211.0
5	13210149	Dubani on Sankosh (AWLS+Met)	Punatsangchhu	Tsirang	27.00992	90.07139	324.0
6	23400149	Sershong on Aiechhu (AWLS+Met)	Punatsangchhu	Sarpang	26.93906	90.51836	301.0
7	14150149	Tingtibi on Mangdechhu (AWLS+Met)	Manas	Zhemgang	27.02714	90.78381	
8	16200149	Kurizampa on Kurichhu (AWLS+Met)	Manas	Mongar	27.27458	91.19486	500.0
9	16510045	Sumpa on Kurichhu (WL)	Manas	Lhuntse	27.66614	91.20594	1170.0
10	17400149	Chazam on Gongri (AWLS+Met)	Manas	Trashigang	27.33694	91.54633	685.0
11	24150149	Pangzam on Neyra Ama Ri (AWLS+AWS at Thrimshing)	Manas	Trashigang	27.10539	91.58903	1136.0
12	25200149	Zamtari on Jomori (AWLS +AWS)	Jomori	S/Jongkhar	27.02283	91.99917	665.0

Sl. No.	Station Name	River Basin	Dzongkhag	Latitude	Longitude	Altitude
B	**Met Station**					
13	Tendru Met Station (AWS)	Jaldakha	Samtse	27.06616	88.89277	959.0
14	Pungtha	Ammochu	Samtse	27.08326	89.269902	1222.0
15	Gomtu, Pagli, Samtse		Samtse	26.620505	89.18613	275.0
16	Sombekha	Amochhu	Haa	27.166388	89.104166	1841.0
17	Dungna	Ammochu	Chukha	27.034130	89.395436	1493.0
18	Thimphu-Jungzhina at Indian Embassy	Wangchu	Thimphu	27.501944	89.637777	2291.0
19	Dagapela	Punatsangchhu	Dagana	26.934166	89.949722	1277.0
20	Tsirang	Punatsangchhu	Tsirang	27.001944	90.124444	1599.0
21	Kamechhu	Punatsangchhu	Wangdue	27.27250	90.031666	662.0
22	Samdrup Jongkhar	Dungsamri sub-basin	S/Jongkhar	26.798502	91.504338	170.0
23	Deothang	Dungsam-ri Sub-basin	S/Jongkhar	26.8600	91.46333	861.0
24	Tokarong (Narphung)	Dungsam-ri	S/Jongkhar	26.9725	91.533055	1663.0