

Annual Report (July 2018 to June 2019)

NATIONAL CENTER FOR HYDROLOGY AND METEOROLOGY ROYAL GOVERNMENT OF BHUTAN 2019



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Acronyms:

11 FYP	Eleventh Five Year Plan
12 FYP	Twelfth Five Year Plan
AWLS	Automatic Water Level Station
AWS	Automatic Weather Station
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
FWS	Flood Warning Section
GEF	Global Environment Facility
GLOF	Glacier Lake Outburst Flood
GoI	Government of India
HQ	Head Quarter
ICT	Information Communication Technology
JICA	Japan International Cooperation Agency
IFAS	Integrated Flood Analysis System
LDCF	Least Developed Country Funding
MD	Meteorology Division
MHPA	Mangdechhu Hydropower Project Authority
MoHCA	Ministry of Home and Cultural Affairs
NEC	National Environment Commission
NWFWC	National Weather Flood and Warning Centre
OEM	Original Equipment Manufacturer
PCRD	Planning, Coordination and Research Division
PHPA-I	Punatsangchhu Hydropower Project Authority- I
PHPA-II	Punatsangchhu Hydropower Project Authority- II
RIMES	Regional Integrated Multi-Hazard Early Warning System
R&D	Research and Development
RCSC	Royal Civil Service Commission
RGoB	Royal Government of Bhutan
SOP	Standard Operating Procedure
UNDP	United Nation Development Programmed
WMO	World Meteorological Organization
NCHM	National Center for Hydrology and Meteorology
HSDRRP	Hydro met Services and Disaster Resilience Regional Project
WB	World Bank
WRF	Weather Research and Forecast.

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1. Organization

The National Center for Hydrology and Meteorology (NCHM) is a scientific and technical autonomous agency of the Royal Government created in 2016, in line with the Organizational Development Exercise (ODE) carried out by the RCSC. Accordingly, during 92nd Lhvengye Zhungtsog meeting held on 11 December 2015 accorded the formation of Centre after reorganizing the Department of Hydro-met Services (DHMS) under Ministry of Economic Affairs (MoEA). The main reasons for the reorganization was to streamline the agency's mandates and functions to avoid duplication amongst various other agencies. The mandates and staff of Glaciology Division from the Department of Geology and Mines (DGM), MoEA were transferred to the Center and the division was renamed as the Cryosphere Services Division (CSD). Similarly, the mandate and staff of the Aviation Meteorological Section from the Department of Air Transport (DoAT), Ministry of Information and Communication (MoIC) were transferred to the Center. Bhutan Civil Aviation Authority (BCAA) designated NCHM as the Aeronautical Meteorological Service Provider (AMSP) within Bhutan. The Center was created to improve the efficiency and effectiveness in providing information and services of hydrology, meteorology, cryosphere and climate science that is required by various sectors and the public.

Chronology of Institutional Development of Hydro-Met Services in Bhutan



Figure 1: Institutional Development of Hydro-met Services in Bhutan



Figure 2: Restructuring of Department of Hydro-met Services (DHMS),MOEA to National Centre for Hydrology and Meteorology (NCHM)

2. Governing Board

A Governing Board (GB) governs the Center with its members nominated from relevant sectors approved by the Cabinet.



- 1. Secretary, National Environment Commission Secretariat (NEC)- Chairman
- 2. Director General, Department of Disaster Management (DDM), Ministry of Home and Cultural Affairs (MoHCA)- Member
- 3. Director, Department of Agriculture, Ministry of Agriculture and Forestry (MoAF)- Member
- 4. Director, Department of Public Health (DoPH), Ministry of Health (MoH)- Member
- 5. Director, Department of Huma Settlement (DHS), Ministry of Works and Human Settlement (MoWHS)- Member
- Director, Department of Hydropower and Power Systems (DHPS), Ministry of Economic Affairs (MoEA)- Member
- 7. Director, National Center for Hydrology and Meteorology (NCHM) - Member Secretary

3. Vision, Mission and Core Values

3.1 Vision, Mission and Mandates

Vision

Center of Excellence in Hydrology, Meteorology and Cryosphere Science and Services

Mission

Monitoring and understanding of hydrology, weather, climate and cryosphere, for timely provision of information and services to protect lives and property and support national needs for ecologically balanced sustainable development.

3.2 Core Values



3.3 Goals

NCHM goals are to:

- a) Improve result-based decision support service for weather incidents and events that threaten lives and livelihoods;
- b) Enhance climate services to understand and adapt to climate-related risks;
- c) Develop capacity to provide integrated and coupled monitoring, detection and forecast services to support assessment and management of water resources and hydro-meteorological hazards;
- d) Build competence to provide sector-relevant information for socio-economic development, and support the development of integrated environmental services to foster healthy communities and ecosystems;
- e) Sustain highly skilled professional workforce equipped with training, tools and infrastructure to fulfil the mission.

4. Mandates

MANDATES

Provide scientific and technological services in hydrology, water resources, meteorology, climatology, and cryosphere to ensure the safety and socio-economic well-being of society and to support national and international needs.

The detail mandates are as listed below:

- a. Planning and operation of national hydrological (surface and subsurface) and meteorological (surface and upper air) observation network and its communications systems required for monitoring and data collection;
- b. Study and monitor cryosphere (snow, glaciers, glacier lakes, permafrost) and its associated risks to implement appropriate mitigation and adaptation measures;
- c. Study and provide public weather services, severe weather warnings, meteorological data management, aviation meteorological services, agrometeorology and climate change information and services;
- d. Study and carryout water resources assessment, hydrological forecasting, hydrological data management, dissemination of hydrological data and information and provide early warning services related to flood and GLOF;
- e. Assessment and mapping of hydro-meteorological and GLOF hazards at the subbasin and basin level;
- f. Capacity and human resources development through training and education;
- g. Application of science and technology in operational meteorology, hydrology and cryosphere for development of services and products;
- h. Promote collaboration and institutional linkages with national, regional and international organizations related to weather, climate, hydrology, cryosphere, and water resources for exchange of data, research and technology transfer.



Figure 3: Approved Organization Structure of NCHM

5.2 Staffing

The center has an existing staff of 178 out of the total 214 approved staff strength by the RCSC (June 2018). Currently 5 staffs are on EOL.

Division/Secretariat	Approved by RCSC	Existing	Gap
1. Secretariat	11	9	2
2. Cryosphere Services Division (CSD)	8	8	0
3. Weather and Climate Services Division (WCSD)	32	31	1
4. Hydrology and Water Resources Services Division (HWRSD)	16	15	1
5. Hydro-met Operation and Infrastructure Division (HOID)	139	116	23
Total	206	179	27

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In terms of position category, the Center has 2 officials under the Executive and Specialist, 38 under P level, 138 under SS and S level, 16 under O level and 17 under in other category. Since the Center maintains more than 250 national hydro-meteorological station networks covering the whole of Bhutan, the maximum staff (more than 65%) are under the Support and Supervisory category followed by Professional and Management level (18%).



Figure 4; Distribution of Staff by Position Category

Table 2: Staff distribution by Position category

Position Category	No. of Staff	Remarks
1. Executive and Specialist	2	Director (EX) and Specialist (ES)
2. Professional and Management	38	P level
3. Support and Supervisory	139	SS and S level
4. Operational	10	O level (Drivers)
5. ESP/GSP/Contract	17	
Total	206	

5.2.1 Staff Superannuated

After serving more than 30 years, the following staffs were superannuated during the FY 2018-2019.

Sl. No	Name	Designation/Division	Appointment Date	Superannuated date
1	Mr. L. B Pantha	Hydro-met Technician - III, HOID	12/2/1982	10/07/2018
2	Mr. Dhendpu Tshering	Principal Engineer, HOID	29/1/1986	01/09/2018
3	Mr. Tenzin Dorji	Hydro-met Technician- I, HOID	01/12/1980	1/03/2019
4	Mr. Dhanapati Dhungyel	GSP, HOID	01/01/1989	01/01/2019
5	Mr. UB Chettri	GSP, HOID	12/05/1986	1/03/2019

After serving the nation for nearly four decades (39 years), Mr. Tenzin Wangdi, Sr. Hydro-met technician superannuated on 25th March 2019. He served in various capacities in the field of hydrological data collection, sediment data analysis and mini-micro hydel feasibility studies. He joined the service on 1st December, 1980.

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Figure 5: Mr. Tenzin receiving Lifetime Service Award from Director, NCHM



5.2.2 New Staff Joined

After the successful selection thorough the RCSC in 2018, the RCSC deputed three new civil engineers (Ms. Yeshi Choki, Ms. Sonam Choki and Mr. Thinley Wangchuk) based on the vacancy of the Center. Ugyen, Dy. Engineer was redeployed by RCSC to the Center from the Ministry of Home and Cultural Affairs from 20 January 2019.

Director, NCHM and Division Chiefs formally welcomed four engineers and briefed about the NCHM and roles for civil servant on 22 January 2019 afternoon. NCHM will organize induction course for the new engineers before starting their works with respective divisions. Also, 13 redeployed technicians from Ministry of Education joined NCHM.



Figure 6 : Four new Engineers joined the Center from January 2019

6. Center's 12 FYP (2018-2023)

The Center's 12th Five Year Plan (2018-2023) has two programs that are directly linked to NRKA 6 and NKRA 8 indirectly to all the NKRAs and SDG as weather and climate and water resources contributes or impacts all the Sectors.



Figure SEQ Figure * ARABIC 7: NCHM 12 FYP SKRAS linkage with NARKS and other global goals

7. Annual Performance Target (APT) for 2018-2019 FY

The Annual Performance Target (APT) for NCHM is approved and signed during the last Governing Board (GB) meeting. The planned activities under the APT for 2018-2019 for NCHM are tabled below with achievements. The Center had four Objectives, seven Actions and twelve Success Indicator.

- a. Hydro-meteorological and cryosphere disasters assessed & reduced,
- b. Access to hydro logical information and understanding of national water availability improved,
- c. End-to-end operational National Framework for Climate Services (NFCS) and
- d. Provide effective and efficient admin, direction and related common support services.

7.1 APT Score of the center for last three years

SI No.	Financial Year	APT Score
1	2016-2017	97.8%
2	2017-2018	99.45%
3	2018-2019	100%





Figure 8: Signing of NCHM APT with Chairman of GB during the 3rd Governing Board Meeting

Y 2018-2019 with achievements as of June 2019	d Achievements (June 2019)	 Construction of toilet, kitchen, damaged boundary, retention wall and fencing at Wang du Control Room completed Maintenance of 56AWS, 16 Class A, 30 AWLS, 25 Manual Hydro, 37 GLOF EWS+Siret completed. Procurement of spare parts for GLOF station, AWS, AWLS, Manual Stations completed Wind profiler at Paro International Airport installed and operation. AWOS upgraded and operational Integrated ceilometer and visibility sensors installed and operational to existing AWOS of the airports Annual maintenance of snow monitoring stations completed. 	 Daily weather forecast prepared and disseminated (365 days) Weather reports prepared, issued and shared with relevant agencies, Dasho Dzongda and DDMO of 20 Dzongkhags Weather Forecasting Room of the National Weather and Flood Warning Cemter (NWFWC Operational for 24/7 on shift, GTS, Himawasricast and WRF system maintained and operated 24/7) Extreme weather advisories prepared and issued using the Common Operating Platform (SMARTMET)
HM for F	Plannec (June 2018)	7	و
T of NCE	Unit	Number	Number
Table 3: AP	Success Indicator	Hydro met and Flood/GLOF warming network enhanced.	Weather forecast and advisories on extreme weather events issued
	Action	Critical Hydro-met infrastructures & Network enhanced	Reliable and timely issuance of severe weather forecasts, warnings,
	Objective	1. Hydro- meteorological and cryosphere disasters assessed & reduced	

Assessment and monitoring of cryosphere and associated hazards conducted.	Assessment and monitoring of cryosphere and associated hazards conducted.	Number	4	 Time Series Monitoring of Glacial lakes in Pa Chhu sub basin carried out and completed and report submitted. Annual monitoring of Benchmark glaciers (Thana) completed and report submitted. Annual monitoring of Benchmark glaciers (Gangju La) completed and report submitted. Annual monitoring of Benchmark glaciers (Gangju La) completed and report submitted. Annual monitoring of Benchmark glaciers (Gangju La) completed and report submitted.
	A ssessment of	Number		1. Pre-feasibility studies for installation of GLOF/Flood EWS carried out and completed for the Thimchu Sub-Basin and Haachhu Sub-Basin and report prepare.
	hydrological hazard conducted.)	2. Flood Hazard Assessment of the Amochhu Basin (Toorsa Area) completed with following outputs:
				a. Hydrological field survey of the area
				b. Hydro-dynamic modelling of the study area
				c. Flood Hazard mapping of the area
		Status	Flood	Flood Forecasting Model set up, calibrated and operational for following basins:
Assessment	Flood forecast,	of Work	forecasting model	1. Wangchu Basin
and monitoring of	GLOF/Flood warning/advisories		Operational	2. Amochhu Basin
cryosphere	services issued.			3. Dagachhu Sub-basin.
hazards conducted.				Flood Advisories and Outlook issued during severe events apart from water level status shared to relevant stakeholders
		Percent	100	Effective common services provided to technical divisions in terms of networking, website update, and ICT related support. Administered the budget related work for NWFWC for effective

					delivery of scientific services and products.
		Effective ICT and related support services provided to deliver hydro- met services and products			All systems maintain and kept operation (GTS, Himawari Satellite System, WRF, SMART-Met and Data Acquisition Server) for timely delivery of services.
2. Access to hydro logical information and understanding of national water availability improved	Mean annual filow of main river basins generated	Mean annual flow of main river basins generated	Status of Work	Publication of annual Data book & Flow status	 Annual Surface Hydrological data Book published for 2019 River Flow Status 2019 published
	Enhance the dissemination of reliable hydro-met information services	Monitoring and Transmission of hydro met data to HQ	Days	within 40 days	Data observation, collection, monitoring stations, Data transmission to HQ within 40 days continued.

 Operation and maintenance of aviation met equipment at all airports completed Daily Aviation Meteorological observations, services and products (METAR/SPECI) provided Upgradation of meteorological observation stations at airports completed 	 National Climate Outlook Forum (NCOF) organised successfully Seasonal prediction (summer outlook 2019) issued and disseminated 	 Seasonal prediction (winter outlook 2018) issued and disseminated Climate monitoring (annual) Historical climate information and data provided to users Weather and climate information updated on the NCHM website Climate projection for Bhutan prepared and issued Climate monitoring (Monthly) issued. 	Common administration, finance and ICT services efficiently delivered to enhance end to end operation of national framework for climate services
m	8		100
Number	Number		Percent
Aviation met services provided	Climate services issued		Effective ICT and related support services provided to deliver hydro- met services and products
Enhance and dissemination of reliable weather & climate information services			
3. End-to-end operational National Framework for Climate Services (NFCS)			

8. Summary of Financial Statement

8.1 Budget Appropriation Past 5 years

The following table shows the total budget allocation (RGoB + Donors) of the erstwhile DHMS, MoEA for the FY 2013-2014, 2014-2015, 2015-2016 and then to the Center from 2016-2017, 20-17-2018. The Center was formally delinked from the MoEA from February, 2017.

Sl. No			DHMS (MoE	A)	NC	HM
	Funding	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018
1	RGoB	43.0	56.56	54.53	55.0	76.87
2	Donors (GOI, World Bank, ICIMOD, PHPA, MHPA etc.	47.3	68.01	183.82	250.6	117.93
	Total	90.3	124.57	238.34	305.6	194.80

Table 4: NCHM Financial Summary (Nu. in million)

Source: NCHM Finance/Accounts

8.2 Financial Summary for the FY 2018-2019

The financial summary for the FY 2018-2019 (Nu. in million)

Sl. No	Funding	2018-2019	Remarks
	- unung	2010 2013	
1	RGoB	89.726	
2	Donors (GOI, World Bank and others)	80.785	
	Total	170.511	

Source 2: NCHM Finance/Accounts

9. Highlights of Climate Status in Bhutan for the year 2018

Annual Rainfall

The annual average rainfall (area average) was 1649.9 mm in 2018. The country as a whole received near-normal rainfall with most of the regions receiving rainfall slightly below the average. The highest 24-hour rainfall was recorded at Phuentsholing with 270 mm. Gasa experienced the highest number of rainy days with 209 days (with rainfall greater than or equal to 1mm). However, the highest annual rainfall was recorded at Phuentsholing followed by Sipsoo, Bhur and Deothang.

Maximum and Minimum Temperature

The annual average maximum temperature was 22.8 °C and the annual average minimum temperature was 11.5 °C. The highest temperature was recorded at Tangmachu with 40 °C and the lowest was recorded at Haa with -12.5 °C. Haa experienced a greater number of days with the minimum temperature below zero compared to other regions with 107 days.

Monsoon 2018

Bhutan experiences monsoon from June to September. It is one of the predominant seasons of the year that influences much of the climate in Bhutan. In 2018, the country as a whole received near-normal rainfall, however, during months of July and August, most of the stations received slightly below-normal rainfall.



Figure SEQ Figure * ARABIC 9: Comparison of monsoon (JJAS) observed rainfall of 2018 with long term average (1996-2017)

Snow fall 2018

Bhutan received several snowfalls which was a light snow/rain over the country. Most of this weather events occurred in the higher altitude regions of the country. First snowfall of 2018 winter was on 18 December, 2018. The snowfall occurred due to the peripheral effect from the cyclonic storm named "PHETHAI" developed over the Bay of Bengal. Following this event, western, central and northern parts of the country received light

snowfall in the first two months of the year, 2019. This event occurred due to western disturbances.

Date	Location	Quantity	
	Thimphu	2.00 cm (Depth)	
	Paro	1.27cm (Depth)	
18 Dec, 2018	Наа	12.00 cm (Depth)	
	Gasa	12.90 cm (Depth)	
	Bumthang	6.80 cm (Depth)	
	Наа	0.20 mm (SWE Rainfall)	
9 Jan. 2019	Gasa	4.00 cm (Depth)	
, , , , , , , , , , , , , , , , , , ,	Bumthang	0.20 mm (Depth)	
8 Feb, 2019	Наа	3.70 cm (Depth)	
9 Feb, 2019	Наа	2.80 cm (Depth)	
25 Feb, 2019	Gasa	11.20 mm (SWE Rainfall)	
26 Feb, 2019	Gasa	10.00 mm (SWE Rainfall)	
27 Feb, 2019	Gasa	10.40 mm (SWE Rainfall)	
28 Feb, 2019	Gasa	1.50 mm (SWE Rainfall)	

The following table shows records of snowfall in the country.

Table 5: Snowfall Record during 2018-2019 FY



Figure SEQ Figure * ARABIC 10: News Coverage of first Snowfall 2018

10. Highlights of Hydrology and River flow in Bhutan for the Year 2018

10.1 River Flow Status of Bhutan

The annual average flow of 25 years (1992 to 2017) is compared to the average flow of 2018 for the five hydrological stations of different river basins. Each station is located in different basins but does not serves as the representative flow of the whole basin.

SI. No	Station Name	Basin/Sub Basin	Average Flow (till 2017) m ³ /s	Average Flow 2018 in m ³ /s
1	Lungtenphu on Wangchhu	Wangchhu	22.26	16.62
2	WangdueRapid on Punatsangchhu	Punatsangchhu	292.62	304.90
4	Kurjey on Chamkharchhu	Manas	52.75	50.89
5	Muktirap on Kholongchhu	Manas	63.92	62.18





The annual average flow of Punatsangchhu for the year 2018 shows slightly above the mean annual average of 25 years (1992-2017), while in general Wangchhu and Manas basin annual flow found to be below the mean annual average for the same period.

Figure 11: Monthly Flow Comparison of Kurjey Station

10.2 GLOF from Thorthomri Lake on 20 June 2019

On the 20th June 2019, there was a sudden unusual rise of water level followed by a sharp drop in the water level at Subsidiary lake II of Thorthormi glacial lake in Lunana. The rise in water level was detected by the remote water level sensors installed at subsidiary lake II of Thorthormi lake at 6.55 PM on 20th June 2019. The excessive melting of glaciers due to increased temperature was one of causal factors for breaching of the subsidiary lake II and drained out water causing the flood. Based on the emergency meeting at DDM on the evening of 21st June 2019 chaired by the Cabinet Secretary and attended by the Secretary of the Ministry of Home and Cultural Affairs and Dasho Zimpon, His Majesty's Secretariat, NCHM deputed assessment team to lunana from 23rd to 27th June 2019. A rapid Assessment Report of Throthomi lake was submitted the Government July 2019.

Highlights of FY 2018-2019 Accomplishments

11. End-to-end Operational National Framework for Climate Services (NFCS)

Weather and Climate Services Division of the Center is responsible to study and provide public weather services, severe weather warnings, meteorological data management, aviation meteorology, agro-meteorology and climate change information and services.

11.1 Weather Forecast Updates

The Weather Forecasting Room (WFC) under the National Weather and Flood Warning Center (NWFWC). Thimphu operates 24/7 and monitor weather conditions. WFC of WCSD of the Center issue daily weather forecast that are shared through Bhutan Broadcasting Service (BBS), Radio and other print media. Based on the severity of weather the Center also issues weather advisories and weather updates from time to time. The 72 hour forecast for the 20 Dzongkhag includes precipitation outlook with maximum minimum temperature. Media Facebook and Social such as (https://www.facebook.com/NationalCenterforHydrologyandMeteorology/) is extensively used by the Center for timely dissemination of information and weather advisories. The Center also provide special weather forecasts based on the user needs and requirements.



Figure 12: Map showing Forecast for all Dzongkhags

11.2 Climate Data and Information Services

The Center maintains the national climate database management system and provide climate data and related information and services. Center carries out climate data processing, quality control, analysis and archival. During the FY 2018-2019, Center completed the quality control of temperature and rainfall data for all Class A meteorological stations and data are provided to users, sectors and individuals on request.

The Center produces monthly and annual climate monitoring report, and seasonal forecasts.

a) National Climate Outlook Forum (NCOF-5)

The Fifth National Climate Outlook Forum (NCOF-5) was held on 28th May, 2019 at Paro, Bhutan. This forum was established in 2015 as part of the World Meteorological Organization's (WMO) Global Framework for Climate Services (GFCS) for guiding the development and application of climate information in decision-making in climate-sensitive sectors. NCOF is one of the main annual program of Center, where seasonal outlook for monsoon are issued to key stakeholders. In order to harmonise scientific seasonal prediction with traditional/indigenous knowledge, the Center also collaborates and work with the Pangri Zampa College of Astrology, *Zhung Dratshang* (Central Monastic Body), Thimphu



Figure 13: Director, NCHM and Director, DoA (MoAF) with Participants of NCOF-5, Paro

b) Monsoon Outlook 2019

Center released the outlook for 2018 Winter Monsoon (December, January, February) and 2019 Summer Monsoon (June, July, August and September 2019). The outlook were prepared using a statistical model (Climate Predictability Tool) with inputs such as the Global Sea Surface Temperature and Observed Data (Rainfall) of Bhutan. In addition, the outputs from the 14th South Asian Seasonal Climate Outlook Forum (SASCOF-14) for monsoon season 2019 and the seasonal probabilistic multi-model ensemble of WMO Lead Centre for Long Range Forecast were used. The Center predicted that winter rainfall for Bhutan during 2018 would be below normal and the rainfall for Bhutan during 2019 summer monsoon season is likely to be near-normal to slightly above normal.



Figure 14: Outlook released for Winter Monsoon 2018 and Summer Monsoon 2019

a) Dissemination of Meteorological Data

The Center also provides meteorological data to Government agencies, the private sector, academic researchers and students, corporate sector, foreign institute and others as per the request.



11.3 Aviation Meteorological Services

11.3.1 National Aeronautical Meteorological Service Provider

As per the provision of the Civil Aviation Act Bhutan, 2016, the Bhutan Civil Aviation Authority (BCAA) designated NCHM as the National Aeronautical Meteorological Service Provider (AMSP) within Bhutan in August 29, 2017. The Center monitors all the aviation observations stations in Paro International Airport and other three domestic airports. The Center has dedicated staff in all airport for monitoring of aerodrome weather conditions and reporting to ATC for updating the pilots for landing and take-off.



11.3.2 Setting up of Manual Met Observatory in all Airports

During the FY 2018-2019, the Center installed the manual aviation met observatory to enhance the weather observations to provide reliable weather forecast as a backup to the automatic weather observing station (AWOS). This manual station measures maximum and minimum air temperature, relative humidity, wind speed and direction and rainfall.



Figure 16:Manual Met Observatory at Gelephu (i), Yonphula (ii), Bumthang (iii) and Paro (iv) Airports

11.3.3 Maintenance of AWOS in all Airports

The Center maintain and operate airport weather stations at all aerodromes of the country, Paro International Airport and three domestic airports, to provide the operational meteorological information for safe, regular and efficient air navigation as well as meteorological support to the near-real-time activities of the aviation industry. Annual maintenance of AWOS in all airport was completed including the AWOS damaged by elephants inside the Gelephug Domestic airport, as detailed below:

Date	Airport Name	Details of maintenance work carried out
8 th –10 th November, 2018	Gelephu domestic airport	Rectification of mast damaged by elephant.
29 th – 31 st December 2018	Bumthang Domestic airport	The power fluctuation of the system was resolved by providing the power the backup.
2 nd – 4 th January 2019	Gelephu domestic airport	The server was down, new server was set up in new computer.
23 rd May 2019	Gelephu domestic airport	All the computer was done, new server was again set up.

Table 7:List of Maintenance carried out





Figure 17:Distorted AWOS at runway 29 of Gelephu (left), AWOS Mast rectified (right)

11.4 Agro-meteorological Services

Under the World Bank supported project Hydromet Services and Disaster Resilience Regional project the Center closely worked with the Departmental Agriculture (DoA), Ministry of Agriculture and Forests in developing the Decision Support System (DSS) to improve Agrometeorological Services in Bhutan. A web based online (http://sesame-bt.rimes.int/login/login_form) platform called SESAME (Specialized Expert System for Agro Meteorological Early Warning) was developed by the RIMES¹ to generate and disseminate agro-met bulletins based on short and medium range weather and climatic parameters were piloted in Bhutan (Paro and Sarpang Dzongkhag). The DSS is expected to be operation in the current FY 2019-2020. The role of NCHM is to input forecast data into SESAME.



Figure 18: Participants during SESAME Workshop held at Paro

11.5 Historical Climate Analysis and Climate Projection of Bhutan

NCHM implemented Pillar 1: Enhancing Information Base for Hydro met Services and Climate Resilience under the Project "Strategic Program for Climate Resilience (SPCR)" supported by World Bank and implemented by GNHC. One of the important studies delivered under the project is "*Analysis of Historical climate and Climate Projection for Bhutan*" that was official released coinciding with World Meteorological Day on 23 March 2019, by HE *Sonam Lyonpo*.

¹ The Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) is an international and intergovernmental institution, owned and managed by its Member States, for the generation and application of early warning information. It was established on 30 April 2009, and was registered with the United Nations on 1 July 2009. RIMES is based in Bangkok located at the campus of the Asian Institute of Technology in Pathumthani, Thailand.

12. Hydrology and Water Resources Services

12.1 Hydrological Modelling, Mapping and Flood Forecasting Services

12.1.1 Operation of Hydrological/Flood Forecasting using model in pilot river basins

a) Recalibration of HBV Model for Flow Forecasting Model

HBV is a semi-distributed conceptual model used to calculate river discharge using rainfall, temperature, topography & land Use. A licensed HBV model was developed by Swedish Meteorological and Hydrological Institute (SMHI) widely used in the Scandinavian countries for flood forecasting.



Figure 19:HBV Model Schematic (L) and Model Output (R)

The same model was used piloted in Bhutan in the Mochhu and Mangdechhu sub-basin during the FY 2016-2017. For the FY 2018-2019, HBV model was recalibrated on the Mochhu, Mangdechhu and Chamkharchhu, Sub-basin using more ground stations installed and weight distribution of each meteorological station was calculated to provide more re-presentative rainfall throughout the catchment.

b) HBV Model for Flow Forecasting for Dangchhu Hydropower Plant

Based on the request of Druk Green Power Corporation (DGPC), the Center provided technical backstopping services for setting up flow forecasting model for Dagachhu power plant. HBV Model is operation for Dangachhu. The Center provide daily flow forecast outputs of dam with Dagachhu Power Plant from the NWFWC that is required for the operation and transmission of power to India.

c) HEC-HMS Flow Forecasting Model

NCHM in collaboration with RIMES² set up hydrological model for river flow forecasting using the HEC-HMS model for Wangchu Basin. The model is operational with weather forecast input from regional WRF and Local WRF Results. The forecasting model is operational and would be useful for inflow forecasting for hydropower plants and flood forecasting. Based on the lesson learnt and enhanced capacity of Centre, the HWRSD is replicating this model (HEC-HMS) for Amochhu basin to be used for flow and flood forecasting and warning. The system is expected to be fully operational by middle of the 12 FYP.

² The Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) is an international and intergovernmental institution, based in Bangkok located at the campus of the Asian Institute of Technology in Pathumthani, Thailand.



Figure 20: Dashboard for Flow Forecasting System in Wangchhu and Amochhu Basin

12.2 Flood Hazard Mapping

The flood frequency analysis integrating with 1D Hydraulic model (HECRAS) and Geographic Information System (GIS) was used to prepare flood hazard maps of different return periods for Phuentsholing town plan area in the Ammochu. Gumbel Max distribution was used to calculate the flood peak of different return periods of 2 years, 5 years, 10 years, 20 years and 50 years. The flood peak from frequency analysis were input into HEC-RAS model to find the corresponding flood level and extents in the study area. The model results were used in integration with ArcGIS to generate flood plain maps. Flood depths and extents have been identified through flood plain maps.



Figure 21: HEC-RAS Model Outputs (top) and Flood Hazard Map of Toorsa (below)





12.3 Hydro met and Flood/GLOF warning network enhanced

a) Pre-feasibility Study on Installation of GLOF/Flood Early Warning Systems in Wangchu Basin

The Center has planned to install flood EWS on Wangchu and Ammochhu during the 12 FYP. The Hydrology and Water Resources Services Division (HWRSD) carried out the pre-feasibility study for the installation of GLOF EWS and flood hazard mapping for the Wangchu basin. The EWS on Wangchhu basin is expected to be supported by JICA through a new TCP project. The Wangchu has main sub-basins of Thimchu, Pachu and Haachhu which covers an area of 1193, 1281 and 782 sq.km respectively. The Wangchhu basin was selected since the capital city of Thimphu and Paro, international airport and hydropower plants and a large population of Bhutan are settled in this river basin.



Figure 22: Map of Wangchuu Basin with three (1) and Location of Pre-sites



Figure 23:Discharge Measurement at Thimchu Headwaters (L) Relation between Catchment area and % Flow (R)

12.4 Dissemination of Hydrological Data

The Center also provides hydrological data to Government agencies, the private sector, academic researchers and students, corporate sector, foreign institute and others as per the request. The following chart shows the percentage of data services catered to various entities.



Figure 24: Shows center providing data to different organization
13. National Hydro-met Observation Network

13.1 Annual Maintenance of Hydro-Met Observation Network

The Center maintains national hydro-met observational network that consists of more than 250 stations covering Bhutan the whole of the country.

Table 8: List of Hydro-Met Observational Network

Type of Monitoring Station	Number
1. Meteorology/Climate Station	155
2. Cryosphere (Snow and Glaciers) monitoring Stations	20
3. Hydrological/Flood Observation Station	59
4. Sediment Sampling Stations	16
Total	250

The annual maintenance of the stations is carried every year before the monsoon to rectify any issues in data transmission, replacement of damaged parts details are given below.

Table 9: List of Stations under taken annual maintenance

Sl. No	Station Category	Station Type	Total Maintenance in 2017-2018 FY	Total Maintenance in 2018-2019FY
1	GLOF -EWS	Automatic	0	37
2	Hydrological Stations	Manual	24	19
3	Hydrological Stations	Automatic	45	30
4	Meteorological Stations	Manual	20	20

The maintenance team also carries out discharge measurement and comparison between Float Method and ADCP, comparison between Float Method and Pygmy Current Meter measurement.



Figure 24: Cross section profiling using ADCP



Figure 25: Cross section profiling using Cableway

13.2 Lean flow measurement

The Center also carry out annual lean flow measurement of streams that are not covered by the national network to study the firm flow and its changes change. The lean flow was started in 2000 to understand the flow variability of the streams that are not gauged. There are more than 72 numbers of streams and rivers included for lean flow measurements as on 2018.

The spot lean flow measurement is annual events that are carried out by HOID in the month of March, when the flow of the rivers/stream are at the lowest by wading method.



Figure 26: Annul Maintenance of Hydro-Met Stations in Picture

13.3 Inauguration of Zamtari Flood Warning Station on Jomori

Flood Warning Station on Jormri (Dhansari) at Zamtari under Jomotshangkha Dungkhag, Sandrup Jongkhar under GOI program of the Center during the FY 2017-2018. The site office was inaugurated on 6th December 2018 by Director and Dasho Dungpa of Jomotshangkha, and was attended by local government official and communities of Serthi & Langchenphu Gewogs. The station would not only facilitate sharing flood warning information to India and downstream was also in hydro-met data collection of Jomri.



Figure 27: Inauguration of Site Office (L), NCHM Management with Site Staff (R)

13.4 Construction of Sediment Laboratory

Site office with Sediment lab was constructed at Jampani under Jomotsangkha Dungkhag during the FY 2018-2019 under Flood Warning GOI Program. The new site was established as per the recommendation of the Joint Group of Experts (JGE) on Flood Management between India and Bhutan to study the sediment load of the Jomori/Dhansari river.



Figure 28: Sediment Lab at Jampani during construction (L) and after completion (R)

13.5 Installation/Upgradation of Hydro-Met Stations

Class A Weather Statiion from the Punakha Dzong was shifted to a new location at Lekithang based on the request from the Dzongkhag Administration. Automatic Weather Station (AWS) was installed at Lekithang on 17 March 2019. Similarly, Automatic Water Level Station (AWLS) was installed on Dangchhu at Chuzomsa, Wangdue Phodrang on 25 June 2019. Data from these stations are transmitted in real time to Thimphu.

During the FY 2018-2 019, HOID also upgraded 5 Old AWSs supplied by RT Company, Nepal with MICRO-step system for those stations located at Babesa, Paro DSC, Zhemgang, Kanglung and Mongar to harmonise the system and data transmission.



Figure 29:New Automatic Weather Station at Punakha (L) and Upgraded AWS at Paro (R)

14. Cryosphere Monitoring and Services

14.1 Annual Monitoring of Benchmark Glaciers

Glaciers are the best natural indicators of climate change (WGMS, 2016) and it is therefore critical to monitor glacier and glacier mass change to understand long-term behaviour and its impact on water resources. Since there is not much information on glacier mass balance of Bhutan and the Himalayan region in general, the Center has established two long term Benchmark monitoring glacier station in Bhutan viz. Gangju La Glacier in the head water of Phochhu sub-basin and Thana in the head water of Chamkhar chhu sub-basin.

The Cryosphere Services Division (CSD) is responsible to carryout annual glacier mass balance of glaciers across the country. In continuation to the past fiscal year, the CSD successfully completed field work for the FY 2018-19 including data collection and reporting. The detail of bench glaciers changes is as below:

14.1.1 Gangju La glacier in Pho chhu Headwater

Gangju La Glacier is located in the Northern frontier of Bhutan at 27.94°N, 89.95°E with an approximate area of 0.215km². This clean ice glacier extends from elevation of 4900 to 5200 m.a.s.l. In glacio-hydrological year: 2017-18 (Autumn Net Balance), Gangju La Glacier revealed the glacier mass loss of -2390+202 mm w.e.a-1 with a terminus retreat of 15.07m. As mentioned by Tshering and Fujita (2016) and CSD, NCHM (2017), the glacier exhibited similar trends of maximum surface lowering at lower altitude and lesser at the higher altitude areas in 2018 as well. The detailed methodologies, data processing, results and recommendations are compiled in the "Scientific Report on Gangju La Glacier September 2018".



Figure 30: Geodetic Survey at Gangju La Glacier

14.1.2 Thana Glacier in Chamkhar chhu headwaters

Thana Glacier is located in the north-central part of the Bhutan Himalayas, oriented Southeast in the head water of Chamkhar Chhu, at 28.021°N and 90.607°E (Fig. 3) with a surface area of approximately 3.77 km2. This clean ice glacier extends from elevation of 5100 to 5700 m.a.s.l. This year (2018) Thana glacier exhibited net negative mass balance

of - 1565.571-mm w.e.a-1 through direct method and -1869.7 mm w.e.a-1 through geodetic method. Team also successfully tested the newly procured Ice Penetrating Radar (IPR) on Thana glacier and found the highest depth (maximum glacier thickness) of 175.74 m in the ablation zone.



Figure 31: Thana Glacier Field Survey Team 2019



Figure 32: Ice Penetrating Radar Survey on Thana Glacier (top left), Discharge Measurement (top right), Time Series Terminus Map of Thana Glacier from 1980-2018 (bottom left) and Time Series Changes of Chubda Lake (bottom right)

14.2 Time Series Monitoring of Glacial Lakes in the Head water of Paa Chhu.

A joint field expedition to study the glaciers and glacier lakes in the headwaters of Pa Chhu was conducted in May 2019. A joint team comprising of five officials from Cryosphere Services Division (CSD) and two officials from Sherabtse College travelled to the base of Mt. Jomolhari and Mt. Jichu Drake and conducted the following field works:

- a. Collected lake data,
- b. Collected water samples for isotopic analysis and other information which will contribute in assessing the potential threat of the lake to downstream;
- c. Bathymetry survey on Jichu Drakey lake and Jomolhari lake for lake bottom topography and water depth.
- d. Conducted In-situ data of shoreline mapping of the lake was done for future reference.
- e. Collected soil samples of the moraine dam for obtaining geo-technical parameters which will be used for running BREACH model for glacial lake hazard analysis.
- f. Aerial Photography survey using the Unmanned Aerial System (UAS) to generate high resolution DEM of the glacier.
- g. Outflow discharge measurement using Salt Tracer equipment to understand total surface runoff from lakes.



Figure33:Paachhu Field Survey Assessment Team The water samples for isotope analysis were collected for the whole stretch of Paa chhu from Jichu Darkey lake till Chunzom at Paro to assess the river flow contribution of glacier melt, ground water, precipitation (rain) and snow melt to the surface runoff of Pa Chhu. River flow contribution studies is being done by the Center in collaboration with Sherubtse College.



Figure 34: Glacier Ice Sampling for Isotope Analysis (L) and Bathymetry Survey on Karma Lake near Jichu Darkey Glacier (R)



Figure 35: UAS for Aerial Photography Survey at Karma Lake site (L) and Dilution Method (salt trace TQ-Commander Software) on the Jomolhari steam near Jangothang Base (R)

15. Publications and Reports

NCHM as a scientific and technical agency mandated to provide scientific and technical services in hydrology, water resources, meteorology, climatology, and cryosphere, the Centre published several technical reports during 2018-2019. Theses technical reports and other publication are made available in the website: www.nchm.gov.bt. The main technical publications were launched coinciding with the World Meteorological Day celebration on 23 March 2019.

The following reports were published and launched during 2018-2019 FY

- a) Analysis of historical climate and climate change projection for Bhutan.
- b) Re-assessment of potentially dangerous lakes of Bhutan
- c) Bhutan glacier inventory 2018
- d) Compendium of Climate and Hydrological Extremes in Bhutan since 1968 from Kuensel.

16. Extreme events Warning and Advisories

Bhutan observed a number of extreme events during the FY 2018-2019, accordingly the Center monitored and issued weather and flood advisories to the general public through the national TV and other social Media.

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Figure 36: Advisory sample

17. Ongoing Projects

17.1 Strategic Planning for Climate Resilience (SPCR)

The SPCR Strategic Planning for Climate Resilience (SPCR) project is supported by the World Bank with the goal to provide a strategy for climate-resilience, outlining the country's adaptation and development priorities, and an investment program to achieve its goals. The project has four pillars;

- a. Enhancing information base for hydro-met services and climate resilience
- b. Preparedness, food and water security
- c. Sustainable growth and resilient infrastructure
- d. Strengthening governance, institutional coordination and human resource capacity

NCHM is one of the four technical agencies under the SPCR and it is responsible for undertaking a technical study under the *Pillar I- Enhancing Information Base Hydro-met Services and Climate Resilience*. The fundamental objective of the study is to improve hydro-met base information and identify future investment plans. The list of studies carried out under the Pillar I of SPCR are as follows:

- a. Analysis of historical climate and climate change projection for Bhutan.
- b. Re-assessment of potentially dangerous lakes of Bhutan
- c. Bhutan glacier inventory 2018

Most of the allocated fund were used for the capacity building of the centre employees to carry out these studies.

17.2 The Hydro-met Services and Disaster Resilience Regional Project (HSDRRP)

USD 3.8 million World Bank supported the Hydromet Services and Disaster Resilience Regional Project (HSDRRP) coordinated by the Department of Disaster Management (DDM), Ministy of Home and Cultural Affairs. The project seeks to strengthen the Royal Government of Bhutan's (RGOB) capacity to improve national and district level capacity for disaster preparedness and response and provide weather and hydrological forecasting services including delivery in priority sectors and disaster related early warning systems. The project has three components (A, B and C)

- **a. Component A**: Hydromet Services Development (US\$ 1.60 million). The main objective of this component is to strengthen the capacity to improve hydromet monitoring, forecasting and service delivery to priority sectors;
- **b.** Component **B**: Disaster Preparedness and Response Capacity Improvement (US\$ 2.00 million) and
- c. Component C: Design of an agro met decision support system (US\$ 0.2 million)

Component A: Hydro-met Services Development is implemented by the NCHM with Sub-Component A1: Strengthening forecasting and services (US\$ 0.89 million) and Sub-Component A2: Institutional Capacity Strengthening, Project Management, Regional Collaboration and Monitoring and Evaluation (US\$ 0.21 million). The project strengthened and enhanced the centre capacity in the following areas:

- a. Aviation meteorological Observation systems with installation of aviation automatic weather observation system (AWOS) ceilometer & wind profiler at Paro International Airport.
- b. One ceilometer at Bumthang Domestic airport is completed in November 2018 and operational.
- c. Developed a Common Operating Platform for automated hydro-met services delivery (Set up SMART-Met System)



Figure 37:AWOS and Ceilometer installed at Paro International Airport through HSDRRP



Figure 38:SMART-MET for Weather Forecast and Service

18. Technical Backstopping Services to Line Agencies

18.1 Flow Forecasting System for Dagachhu Hydropower Project

Based on the request of Dangachhu Power Plant through the Druk Green Power Corporation (DGPC), NCHM provided technical backstopping services and developed flow forecasting system for Dagachhu Power Plant. NCHM team assessed the catchment and existing flow forecasting system used by DGPC and developed the rating equation.

The flow forecasting system was developed using the HBV model using climate data from Gaselo, Chapcha, Chukha and Dagana station and validated using the discharge data from Dagachhu station. The model was calibrated with data from 2015 January till 2018 December. The model was calibrated with $R^2 = 0.78$.



Figure 17. HBV Model Set up of Dagachhu

Based on the requirement of the Dangachhu Power Plant to transmit daily flow forecast to India in relation to power export requirement, the Center share daily flow forecast with Dagachhu Power Plant on daily basis.

18.2 Agrometeorological Services

As a part of the implementation of Component C: Design of an agro met decision support system of the World Bank supported the Hydro-met Services and Disaster Resilience Regional Project (HSDRRP) by the Department of Agriculture, MoA, the Center worked closely with DoA and consultant of agrometeorological decision support system called SEMAME in Bhutan. SESAME stands for Specialised Expert System for Agrometeorological Early Warning (SESAME)- it's a web-based decision support system developed for generating and utilizing relevant agrometeorological information for early warning of risks for natural hazards and guiding resource manseng plans and decisions. NCHM will be responsible to input weather and seasonal forecast data and information to the web-based SESAME system.

18.3 Internship for College Students

Four final year students undertaking BSc. Environment and Climate Studies from the College of Natural Resources interned with the Center for 2 months from 11 December 2018 to 11 February 2019. Their research was focused on weather and climate and the hydrology and water resources.

On 11 February with the completion of the internship successfully, the students presented their work to the Center. The students were presented with Certificates of Completion of their internship.



Figure 39: CNR Students presentation their work experience with NCHM Management after the internship.

19. Institutional Linkages and Collaboration

19.1 Interactive Session with Line agencies

The NCHM was identified as the nodal agency responsible for generation of information and delivery of products and services on weather, climate, cryosphere and water resources in Bhutan. Since weather, climate, hydrology, cryosphere data, information, and services are required by many agencies, to understand the needs of line agencies and to develop a long term strategic plan of the Centre for the 12 FYP and beyond, the Centre started interactive sessions with the Head of relevant agencies in Thimphu from May 2018- to July 2018 as listed.



Figure 40: NCHM Management with various Institutions

- a. Director and Sr. Officials of the Department of Air Transport Services (DoAT) Paro International Airport, Paro;
- b. Air Navigation Section of Bhutan Civil Aviation Authority (BCAA), Paro
- c. CEO, Thimphu IT Paro and Manager Data Center,
- d. Director and Chiefs, Department of Public Health, Ministry of Health,

- e. Managing Director and Sr. Officials of Druk Green Power Corporation Limited (DGPC), DHI
- f. Director and Chiefs, Department of Agriculture (DoA), Ministry of Agriculture and Forest (MoAF)
- g. Director and Chiefs, Department of Engineering Services (DoES), MoWHS
- h. Director General and Chief Engineers, Department of Roads, MoWHS,
- i. Director General, Department of Disaster Management, Ministry of Home and Cultural Affairs
- j. Offtg, Director and Chiefs, Tourism Council of Bhutan (TCB)
- k. Director General, Department of Research and External Relations, Riya University of Bhutan and representatives of Colleges under RuB and
- 1. Offtg. Chief and Sr. Officials, National Conservation Division (NCD), Department of Forests and Park Services, MoA.

Accordingly, NCHM conducted sectoral consultation to identify areas of collaboration and services required to develop a strategic collaboration plan and other related issues.

19.2 Letter of Agreement

The Center was designated as the National Aeronautical Meteorological Service Provider (AMSP) within Bhutan in August 29, 2017 by Bhutan Civil Aviation Authority (BCAA) as per the provisions of the Civil Aviation Act Bhutan, 2016.



Figure 41: Letter of Agreement (LoA) between the Director, Department of Air Transport (DoAT) and NCHM for coordination between Air Traffic Services (ATS) and Meteorological office for the provision of meteorological service for international and national air navigation (July 9, 2018), Thimphu

The Center attended the Civil Aviation Stakeholder-Coordination Meeting on July 9, 2018, Thimphu. On the side line a Letter of Agreement (LoA) between the Department of Air Transport (DoAT) & NCHM was signed to facilitate coordination between Air Traffic Services (ATS) and Meteorological office for the provision of meteorological service for air navigation. Aviation Meteorological Section of WCSD personnel of the

Center are provided office space and access to all the facilities of the Airports in Bhutan which are operated and maintained by the DoAT, MoIC.

19.3 Memorandum of Understanding (MOU) between Sherubtse College and NCHM

Research is one of the main mandates of the Center. A Memorandum of Understanding between the Center and Sherubtse College, Royal University of Bhutan, Kanglung, Trashigang was signed on April 15, 2019 at Kanglung to start a Joint Collaboration Research in the areas of weather, climate, cryosphere, Hydrology and water resources including the exchange of experts. The MoU is expected to facilitate use and provide access in sharing of scientific facilities, instruments and data including experts by the Parties for long term research in Bhutan.

The Center in collaboration with the College also organised a half day science workshop for the college faculty and students on 15 April, 2019. The Center's technical team presented the analysis of historical climate data and climate projection for Bhutan, updated Potentially Dangerous lakes report 2018 and Bhutan Glacier Inventory 2018 followed by discussion session. More than 200 students and faculty attended the seminar.

During their stay in Sherubtse, the team also visited Isotopic and bio-chemistry laboratory and other facilities that could be used for joint research activities. The Center informed the college that a funding has been secured from the World Bank to start the first joint collaboration research to study contribution from glacier melt and other associated sources contributing to the Parochhu on pilot.



Figure 42: MoU signing between Sherubtse College and NCHM. April 15th 2019 (L) and Isotopic and Biochemistry Laboratory at Sherubtse College (R).

20. Governing Board Meeting

20.1 3rd Governing Board Meeting

The 3rd Governing Board (GB) Meeting of the National Center for Hydrology and Meteorology (NCHM) was held today (10 April, 2019) at NORKHIL Boutique Hotel & SPA, Thimphu, Bhutan.

The meeting was chaired by Dasho Sonam P Wangdi, Chairman of GB/Secretary, National Environment Commission (NEC) and was attended all the GB members from the line agencies. The governing board members are:

- a. Director General, Department of Disaster Management, MoHCA ;
- b. Director, Department of Public Health, MoH;
- c. Director, Department of Human Settlement, MoWHS;
- d. Director/Department of Agriculture, MoAF;
- e. Director, Department of Hydro power and Power Systems (DHPS), MoEA and
- f. Director, NCHM.

The Annual Performance Target (APT) for the Fiscal Year 2018-2019 between Chairman and Director, NCHM was signed during the meeting. The GB also endorsed the APT of the Center for the FY 2019-2020.



Figure 43: Board members with the Chair, Dasho Sonam P Wangdi

21. Bilateral Meeting

21.1 Joint Group of Experts (JGE) on Flood Management between Bhutan and India

The Joint Group of Experts (JGE) on Flood Management between Royal Government of Bhutan (RGoB) and Government of India (GoI), was established in 2004 with constituted with following Terms of Reference (TOR):

"To discuss and assess the probable cause and effects of the recurring floods and erosion in the southern foothills of Bhutan and adjoining plains in India and recommend to both Government, appropriate and mutually acceptable remedial measures".

The NCHM led and coordinate the JGE mechanisms between RGoB and GoI. The 8th Meeting of the Joint Group of Experts (JGE) on Flood Management between Bhutan and India 1-3 November, 2018, Guwahati, Assam, India. The GoI delegation was led by Shri T.S Mehra, Commissioner (B&B Basins), Ministry of Water Resources, River Development & Ganga Rejuvenation (MoWR,RD &GR), Government of India (Go) and the RGoB delegation was led by Director, National Center for Hydrology and Meteorology (NCHM), RGoB.

The meeting discussed and reviewed follow-up action taken in the 7th JGE meeting held in 19-20 April, 2017 in Thimphu, Bhutan, report of 5th Joint Technical Team (JTT) meeting held on 26-27 April, 2018, Phuentsholling, Bhutan and recommendations made therein and other issues mutually agreed between the two sides during the meeting. The next JGE meeting will be held in Bhutan.



Figure 44: 8th Meeting of the Joint Group of Experts (JGE) on Flood Management between Bhutan and India 1-3 November, 2018, Guwahati, Assam, India

21.2 Meeting of the Joint Expert Team (JET) between India and Bhutan

Bhutan being the upper riparian share flood information with the Indian States of Assam and West Bengal for flood forecasting and warning through an established mechanism called the Joint Expert Team (JET) between Bhutan and India. JET is responsible to oversee and review the comprehensive scheme for establishment of Hydrometeorological and Flood Forecasting Network on Rivers Common to India and Bhutan. NCHM led and coordinate the Joint Expert Team (JET) Meeting between Bhutan and India. The JET meeting is held alternatively between Bhutan and India after 6 months. The 35th Meeting of the Joint Expert Team (JET) India and Bhutan was held at Paro, Bhutan during 6 -7 March, 2019.

RGoB delegation was led by Mr. Karma Dupchu, Director, NCHM and GoI delegation was led Mr. P.M Scoot, Chief Engineer (Brahmaputra and Barak Basin Organization-B&BBO, Central Water Commission (CWC), Ministry of Water Resources (MoWR), River Development (RD) & Ganga Rejuvenation (GR), GoI.

JET reviewed the progress of the Flood Warning Program of GoI implemented by NCHM for the FY 2017-2018/2018-2019 and approved the new activities for the FY 2018-2019.



Figure 45: Joint Expert Team with the Team Leaders

21.2.1 Technical Maintenance Officer (TMO) deputation from GoI

A Technical Maintenance Officer (TMO) is deputed to Bhutan on two years terms to oversee the Flood Warning Program of the Government of India (GoI). Flood Warning Program Office functions within the Hydro-met Operations and Infrastructure Division (HOID) of the Center.

NCHM hosted a joint Welcome and Farewell Dinner for Technical Maintenance Officer (TMO) on 22 April, 2019 to bid farewell to Shri Shravan Kumar Dwivedi, Outgoing Technical Maintenance Officer (TMO) who was with the Center since 2016 and to welcome Shri Raghavan Sundararajan, Incoming Technical Maintenance Officer (TMO).

The Flood Warning Program of GoI started in 1955 to share flood information of the rivers common to India and Bhutan.



Figure 46: Incoming TMO Shri Raghavan Sundarajan (L), Outgoing TMO Shri Kumar Dwivedi (R)

22. Regional and International meeting

22.1 5th Session of the World Meteorological Organization (WMO) Regional Association II (Asia - RA II) Working Group on Hydrological Services (WGHS), Thimphu, Bhutan, 26-28, November, 2018

Bhutan hosted the 5th Session of WMO Regional Association (RA –II) Working Group on Hydrological Services (WGHS)" at Thimphu on 26-27, November 2018. The session was followed by the "First Global Workshop on the Dynamic Water Assessment Tool (DWAT)" from 28-30 November, 2018.

The meeting was jointly organized by NCHM and WMO, with financial and technical support from WMO, Ministry of Environment (ME) and Korea Institute of Civil Engineering and Building Technology (KICT), Republic of Korea.

More than 12 international experts and participants from WMO Member States from the National Meteorological and Hydrological Services (NMHS) of RA-II region attended the meeting. The Participants also visited the National Weather and Flood Warning Center (NWFWC) of NCHM.

The 4th Session of WGHS, WMO RA II, was organized by WMO, Korea Ministry of Environment (ME) and Korea Institute of Civil Engineering and Building Technology (KICT) in Seoul, Republic of Korea from 17 to 19 October 2017.



Figure 47: International experts and participants from WMO Member States from the National Meteorological and Hydrological Services (NMHS) of RA-II region attending the WGHS, Thimphu

22.2 World Meteorological Congress (WMO)

WMO is a specialized agency of the United Nations (UN) with 193 Member States and Territories. It is the UN system's authoritative voice on the state and behaviour of the Earth's atmosphere, its interaction with the land and oceans, the weather and climate it produces and the resulting distribution of water resources.

Bhutan became a member of WMO in 11 February 2003. The NCHM is the national designated focal of WMO where the Head of the Center is the Permanent Representative (PR) of Bhutan with WMO. WMO Congress is held every four years and the Eighteen World Meteorological Congress (Cg-18) was held from 3- 14 June 2019 at the International Conference Center of Geneva (CICG). As per the Article 7(b) of the Convention of WMO, the Director as the PR of Bhutan with WMO attended the Cg18 along with other delegations from the Ministry of Foreign Affairs with funding from World Bank.

WMO Congress is supreme body that meets once every four years to determine the policy, governance and strategic plans of the organization. The Secretariat is headed by Secretary General.



Figure 48: Eighteen World Meteorological Congress (Cg-18), 3- 14 June 2019 at the International Conference Center of Geneva (CICG).

On the sideline of WMO Congress at Geneva, Director, NCHM made a courtesy call to Secretary General, WMO. Professor Petteri Taalas, SG, WMO was instrumental in initiating "Strengthening Hydro-meteorological Services for Bhutan (SHSD) implemented by erstwhile Department of Hydro-met Services (DHMS), MoEA from 2013 to 2016 in collaboration with the Finnish Meteorological Institute (FMI). Professor Taalas was the Director General of FMI before he was appointed as the Secretary General of WMO.



Figure 49: Director NCHM with Secretary General, WMO at WMO Secretariat, Geneva

22.3 Intergovernmental Panel for Climate Change (IPCC)

The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. The IPCC provides regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. IPCC was created by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). The IPCC is an organization of government that are members of the United Nations or WMO. Each IPCC member government has a National Focal Point identified by the relevant authorities of the Country. IPCC National Focal Points prepare and update the list of national experts to help implement the IPCC work program.

The National Center for Hydrology and Meteorology (NCHM) is designated National Focal point by the Ministry of Foreign Affairs vide letter no. MFA/MD/ 45/817/118 dated September 18, 2015 to "Prepare and update the list of national experts as required to help implement the IPCC work programme, and to arrange the provision of integrated comments on the accuracy and completeness of the scientific and/or technical content and the overall scientific and/or technical balance of the drafts".

During the FY 2018-2019, officials from the center attended the following IPCC Meeting with funding from the IPCC Trust.

Sl. No	IPCC Meeting	Date	Venue
1	Mr. Karma Dupchu, Director attended the Forty-Eight Session of the IPCC (IPCC-48) for consider the Special Report Global Warming of 1.5 ⁰ C	1-5 October, 2018	Incheon, Republic of Korea,
2	Dr. Singay Dorji, Chief, Weather and Climate Service (WCSD, NCHM attended the Forty-ninth Session of the IPCC (IPCC-49) for the adoption and acceptance of the Methodology Report titled "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories" (2019 Refinement).	8-12 May, 2019	Kyoto, Japan



Figure 50: During IPCC Meeting in Korea (above) and Japan (below)

22.4 RIMES 10th Annual Program Meeting, Bangkok, Thailand from 12-14 November, 2018

Regional Integrated Multi-Hazard Early Warning System (RIMES) for Indian Ocean is an inter-governmental, non-profit organization registered with the United Nations, under Article 102 of the United Nations Charter mandated to provide regional early warning services within the framework of IOC/UNESCO and WMO to build capacity of its members' countries in the early warning of tsunami and other hydro-meteorological

hazards and risks. Currently there are 22 member and 19 collaborating countries working with RIMES.

Based on the invitation letter of RIMES, Director and Mr. Sangay Tenzin, Offtg. Chief, Hydrology and Water Resources Services Division (HWRSD) of NCHM attended the RIMES 10th Annual Program Meeting held in Bangkok, Thailand from 12-14 November, 2018.

Officials from Bangladesh, Bhutan, Cambodia, Comoros, Djibouti, India, Lao PDR, Maldives, Mongolia, Mozambique, Myanmar, Nepal, Papua New Guinea, Philippines, Seychelles, Sri Lanka, Sudan, Tonga, Thailand, Timor-Leste, and Vietnam and the representative from WMO, UNESCAP, FAO, WFP, World Bank, Asian Development Bank, UK Met Office, and European Center for Medium-Range Weather Forecasts (ECMWF) attended the meeting.



Figure 51: RIMES 10th Annual Program Meeting, Bangkok, Thailand 12-14 November, 2018

23. Important Events

23.1 UNDP Administrator Visited NWFWC

His Excellency Mr. Achim Steiner, UNDP Administrator and UN Under-Secretary General visited Bhutan in march 2019 to Co-Chair for the 14th Round Table Meeting for Enhancing Happiness and Sustainable Development through Partnerships organised by UNDP and held from 12-14 March 2019, Thimphu. During his stay in Thimphu His Excellency visited the National Weather and Flood Warning Center (NWFWC) of the Center that is operational 24/7 on 12 March 2019. He was accompanied by Ms. Azusa Kubota, UNDP Resident Representative, Mr. Jürgen Nagler, UNDP Deputy Resident Representative and other officials from UNDP.



Figure 52: UNDP Administrator with Director, NCHM



Figure 53: Administrators visit to NWFWC

	United Nations Development Programme
	The Administrator
	19 March 2019 Engovernet lives Resident nations
1000	Dear Karma, It was a pleasure to meet with you and your team at the National Center for Hydrology and Meteorology during my recent visit to Bhutan for the 14th Kound Table Meeting. It was very insightful to learn about your centre's efforts towards strengthening climate duta for distabler risk reduction.
	We appreciate the important work that the Center is doing towards disaster preparedness and thank you for partnering with UNDP for the successful implementation of NAPA I and II Projects.
	partnership. Yours sincerely,
	Almi Flerins
	Mr. Karma Dopchie Director National Centre for Hydrology and Meteorology Thimphie
	Do Branchard Control for Population A Ministeriology Do Branchard Date: 2.4.10.3.12.019 Rig Nor 10020
	One Lessed Nations Pars, Mes York, NY 10117 Tel: (212) 906 5791 Tex. (202) 905 5778 www.undp.org

Figure 54: Appreciation Letter from the UNDP Administrator

NCHM was honoured to receive appreciation from the UNDP Administrator for the important work that our Centre has been doing towards disaster preparedness and partnering with UNDP for successful implementation of NAPA-I and II Projects in Bhutan.

23.2 Green Climate Fund (GCF) delegation visited GLOF EWS Control Room, Wangdue.

GCF delegations from GCF, HQ, South Korea visited GLOF EWS Control Room today. The delegation was accompanied by Dasho Dzongda, Dzongkhag officials of Wangdi and by officials from UNDP, GNHC and NEC.

Director and Chief, HOID of NCHM and control room staff of Wangdi received the delegations and made presentation of NCHM mandates and functions, EWS. And discussed about future projects to be submitted to GCF.



Figure 55: Green Climate Fund (GCF) delegation visited GLOF EWS

23.3 Australia Awards Regional Alumni participants' visited National Center for Hydrology and Meteorology, November 27, 2018.

Australia Awards Regional Alumni as the Champions for the Environmental Protection and Climate Action Workshop was held in Thimphu, Bhutan from 25-28 November, 2018. The field trip to NCHM was organized by the Australia Awards Bhutan office as a part of the Regional Australia Awards Alumni workshop on 27 November, 2018. Besides visiting the National Weather and Flood Warning Center (NWFWC) and participants has interaction session with the NCHM Management. The particiants were led by Mr. Rod Sollesta, Deputy Team Leader, Australia Awards South and West Asia, Colombo, Sri Lanka. One of the employees (Mr. Ugyen Chhophel, Statistician) of the Center also received the Australian Award in the in 2018 to pursue Master Course in Australia.

Figure 56: Australia Awards Regional Alumni participants' visited NCHM, 28 November, 2018



23.4 Launching of Scientific Reports and Website

Coinciding with World Water Day, 22 March, 2019 and to commemorate the World Meteorological Day, 23 March, 2019 on the theme " *the Sun, the Earth and the Weather*", Honourable Lyonpo Yeshey Penjore, Minister of Agriculture and Forests (MoAF) formally launched Center's website: <u>www.nchm.gov.bt</u> at Hotel Le Meridian.

Honorable Sonam Lyonpo together with Chief Representative of World Bank, Resident Representative of UNDP launched three scientific reports publication under the Strategic Program on Climate Resilience (SPCR) project fund by World Bank, Thimphu.

- a. Analysis of Historical Climate and Climate Projection for Bhutan
- b. Reassessment of Potentially Dangerous Glacier Lakes in Bhutan
- c. Bhutan Glaciers Inventory, 2018; and
- d. Compendium of Climate and Hydrological Extremes in Bhutan since 1968 from Kuensel.

These reports are made accessible to public and can be downloaded from the Center's website http://www.nchm.gov.bt/home/pageMenu/32.

The launching ceremony was also attended by representatives from United Nations office, UNDP, World Bank, JICA, WWF, other partners and bilateral organizations, member of parliament, senior's government officials from line agencies.



Figure 57: Chief Guest with Representatives from, International and line agencies



Figure 58: Reports Launched during the Event

23.5 Deputation of staff on Special duty Lunana

The Center is responsible for operation of Flood Warning Office established at Thanza, Lunana, Gasa after the 1994 GLOF. The Site Office is equipped with HF Wireless and mobile communication. Flood Warning Office at Thanza, under Gasa Dzongkhag communicates directly with GLOF EWS Control Room, Wangdi that is operational 24/7. Due to remoteness and difficult area, the Center deputes a team of two staff on special duty to Lunana for a period of one year. Team has to undergo medical check-up before they are deputed.

Mr. Tshering Wangchuk and Mr. Sonam Dorji, Hydro-met Technician, volunteered for this for the FY 2018-19 and left to Lunana via Gasa on 27 July 2018. Team was provided hands on training in HQ, Thimphu and field at Wangdi GLOF EWS Control Room for more than a week in operation of GLOF EWS, maintenance of equipment and use of communication system. They are responsible for physical monitoring of glacier lakes in Lunana as a backup to Automatic GLOF EWS installed along the Punakha-Wangdi Valley and transmit data to Wangdi Control room on sub-daily basis as per the schedule.







Figure 60: NCHM Luanna New Team (2018-2019)

At the same time NCHM Team - Mr. Tshering Dorji and Mr. Shyamnath deputed on the Special Duty for the (2017-2018) returned from Lunana after handing over the sites to the new team. The team joined back to office on 24 August 2018.

23.6 Asian Development Bank (ADB) Mission

NCHM management met with ADB mission team and Construction Development Corporation Limited (CDCL) of Bhutan on 6 May, 2019. The meeting discussed about NCHM support and partnership for the installation of Flood EWS and flood forecasting modelling for Ammochu under the Amochhu Land Development and Township Project (ALDTP) being implemented by CDCL under ADB support.

Since the installation of flood EWS is a planned activity for the Center in the 12 FYP, the meeting agreed to collaborate after finalizing the modalities between NCHM and project for the implementation of the flood forecasting and EWS to provide early warning services to the project during the construction and operational phase.



Figure 61: ADB Mission with NCHM Management(L) and mission visiting NWFWC (R)

23.7 JICA Team for Technical Cooperation Project

As a follow up to JICA TCP "Project for Enhancement of National Disaster Management Capacity in the Kingdom of Bhutan" implemented in the Mangdechhu and Chamkharchhu river basin, a second phase project proposal was submitted to JICA in 2015 to set up flood EWS in the Wangchhu basin.

Accordingly, JICA deputed six member detailed Planning Survey Team of the Technical Cooperation Project concerning "Project for Enhancement of National Disaster Management Capacity in the Kingdom of Bhutan" from 24 February to 16 March 2019. Team was led by Ms. Miko INAOKA, Sr. Deputy Director, Disaster Risk Reduction Group, Global Environment Department, JICA, HQ, Japan.

During their stay in Bhutan, JICA Survey team met with officials of the Department of Disaster Management (DDM), MoHCA, other relevant central and local government including international organizations in Bhutan. Team also visited the project target sites for the feasibility installation of flood EWS along the Thimphu and Parochhu. Flood EWS on Wangchhu will be establish in 12 FYP.



Figure 62: JICA Team with NCHM Management

23.8 Royal Civil Service Award Ceremony 2018, 13 December, 2018

Civil Service Award of the NCHM was held on December 13, 2018 in the Conference Hall of Energy Building of MoEA.

The Director, NCHM presented the Royal Civil Service Award medals to the officials of the NCHM in a simple ceremony. The recipients included nine Lifetime service awardees, six Gold, one Silver and two Bronze medallists from the Head Quarter, and site offices/stations located all over the country. The Dedicated Service Awards recognizes the completion of 10, 20 and 30 years in the service of the Tsa-Wa-Sum.

Coinciding with Civil Service Award, the NCHM also awarded Certificates of Appreciation to the four Outstanding Employees of the year 2016-2017 and five Outstanding Employees of 2017-2018. Finally, Trashi Khadar with office orders were issued to 11 employees to those employees who were due for promotion from January 2019 during the ceremony.



Figure 63: Civil Service Award of the Center, December 13, 2018

24. Human Resources Development

24.1 Capacity Building and Human Resources Development (HRD)

Being a technical agency, NCHM continues to develop its human 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 donor funded projects, NCHM for the FY 2018-2019 implemented a number of in country and ex-country trainings.

24.2 Long Term Study

Currently, following two officials are pursuing long-term studies in Australia.

Sl.No.	Name/Designation	Course	Institute/Country	Funding
1	Mr. Tshewang Rigzin, Engineer	Masters in Water Resources Management		World Bank
2	Mr. Ugyen Chhophel, Statistician	Master of Statistics/Master of Climate Change	Australian National University	Australia Awards Scholarship

24.3 Ex-Country Training

Through the support of international, bilateral and projects funding program, NCHM employee attended various trainings outside in various countries for the FY 2018-2019.

Table 10: Summary of Ex-Country Training

Sl. No.	Number of Training	Number of Officials attended
1.	20	55



Figure 64:A collage of ex-country training availed during 2018-2019 FY

24.4 Ex-Country Meetings/Workshops/Conference

As per the mandates of NCHM, during the FY 2018-2019 officials attended numbers of bilateral, regional and international meetings conferences and symposiums related to weather, climates, cryosphere and water resources.

Table 11.	: Summary	' oj	^t Ex-Country	Meetings	Workshop	os/Coi	nference	
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Sl. No	Number of Meeting/Workshop	Number of Officials who attended
1.	44	48



Figure 65: A Collage of Ex-country Meetings/workshops/seminars attended by NCHM Officials

24.5 In-Country Trainings/Workshops/Seminars

To enhance skills and knowledge of employees working with equipment's the Center organized workshop and refreshers course of the field technicians and observers from time to time to stay abreast with the pace of modernization of Hydro-Meteorological equipment. The officials also attend workshops, seminars and trainings organized by other line agencies.

24.5.1 Training_on_installations._onerations_of_the_Aviation_Met_Station_in_the_ Airport

Automatic Weather Observing System (AWOS) and Ceilometers were installed in the Paro International Airport and Bumthang domestic airport through the World Bank Supported Project "Hydro-met Services & Disaster Resilience Regional Project (HSDRRP). The Center in collaboration the Equipment Supplier conducted on-site training on installation, operation and maintenance of the AWOS and Ceilometer at Paro international Airport from 26th to 28th October 2018. Hands on training was attended by technical staff from HQ and operational staffs working at the airports.



Figure 66: During the installation operation demonstration of AWOS

24.5.2 Wet Humidity Calibration Equipment Training

The supplier M/s Michell Instruments, UK, conducted one day hands on training workshop on demonstration of "Wet humidity Calibration Equipment" in Thimphu. The equipment was procured through NAPA-II project funded by LCDF-GEF through UNDP-Bhutan. Timely calibration of equipment is very important to ensure quality control of data as the Center operates more than 150 Automatic Weather and Water Level stations across Bhutan.

Figure 67: Demonstration and hands-on training for calibration of Humidity sensors.



24.5.3 Google Earth Engine (GEE) Training

Google Earth Engine" (GEE) is a new emerging technology that provides easy, webbased access to an extensive catalogue of satellite imagery, other geo-spatial data, global water and climate data, etc. These data sets are stored in Google Cloud storage as a part of the Google Cloud public data program. Realizing the importance and benefit of such resources for the Center, the National Center for Hydrology and Meteorology conducted 5 days training on analysis using GEE from 10 - 14 June 2019 at DGM conference hall, Thimphu with expert from ICIMOD. The World Bank Project funded the training.



Figure 68: GEE Training Participants with the Trainer

24.5.4 Dissemination Workshop of SPCR Project

To disseminate the findings of the studies, provide awareness on hydro-meteorology, climate change and to discuss possible applications of the results of the SPCR technical studies, one-day workshop was organized by the Center at Paro on 28th May 2019. More than 50 participants across 40 different sectors including research and education institutes attended the workshop.



Figure 69: Participants during the Workshop
24.5.5 The Induction and Basic Operational Hydro-Met Course

During the FY 2018-2019, RCSC has redeployed more than 12 technicians to Center who were working with the Education sector. Since these technicians came from a different field, the Center conducted induction cum "Basic Hydro-met Operation" training in Thimphu before deputing to the sites. Training included hydro-meteorology principles and practical hands-on sessions.

The Certificates were awarded to all the participants after successfully completing of 6 days training by the Director on 28th December 2018.



Figure 70: Redeployed Technicians during Induction Course

24.5.6 Training on Installation and Operation of Meteorological Station

Based on the request by the Royal Bhutan Army (RBA), the Center conducted 5 days training on "Installation and Operation of Meteorological Station" for 9 RBA officials from 20-24 August, 2018.

Dasho Chewang Rinzin, Dy. Chamberlain to the His Majesty the King/Director, Royal Institute for Governance and Strategic Studies (RIGSS), Phuentsholing, awarded Certificate to participants on 24 August 2018.



Figure 71: Participants with Dasho Chewang Rinzin and NCHM Management

24.5.7 Annual Refresher Course on Operational Hydrology and Meteorology

More than 65% of the Center employees are technicians, who observe and look after the hydro-met network stations located across the country. Since primary data collection are being done by them, to enhance their skills and knowledge with changing technology, the Centre conducted "Annual Refresher Course on Operational Hydrology & Meteorology" from 3rd to 12th April, 2019 (10 days) at the Center's Regional Office, Kurjey, Bumthang. 26 hydro-met technicians from the site stations including 4 new engineers from head office attended the course. The course includes the sessions on basic hydro-met estations, operations, monitoring & maintenance of the hydro met stations, data collection processes and practical sessions at field.

Dasho Dzongda, Bumthang Dzongkhag Administration awarded certificate to partications during the closing session held on 12 April, 2019.



Figure 72: Site Technicians with the Trainers during the Refresher Course

24.5.8 Smart-Met Training

SmartMET is the visualizing and editing software of the Finnish Meteorological Institute (FMI) that can be used by forecasters to prepare weather forecasts.

SmartMET was procured by the Center through the support of NAPA-II and World Bank project in 2018. Procurement of Hardware & software of SMARTMET system was supported (Euro. 150,000/) under the NAPA-II project of LDCF through UNDP-GEF and capacity development training = Euro 60,000/ was supported through the HSDRRP Project of World Bank implemented by NCHM. Installation of the software and hands on training were conducted by FMI Experts in Bhutan in two phases.

The second training was conducted from $8^{th} - 12^{th}$ October 2018 and was attended by all the Weather forecasters and other staffs from the Weather and Climate services Division (WCSD). SmartMet is operational and is being used as the main tool for providing weather forecast.



Figure 73: NCHM Forecaster during Smart-Met Training

24.5.9 Linux and Grads Training

Based on the requirement for the climate projection studies, the Centre organised 5 days hands on training on Linux and GrADS (Grid Analysis and Display System) at Paro from 10-14 June 2019 with experts from the Regional Integrated Multi-Hazard Early Warning System (RIMES), Thailand. The training was attended by the officials from Weather and Climate Services Division (WCSD) and other relevant divisions. The training was supported through the SPCR project implemented by the Center.



Figure 74: Training Participants with Experts from RIMES

24.5.10 Refresher Course on Aviation Meteorology

Aviation meteorology is a new mandate taken over by the Centre during the reorganization. NCHM is now the designated national aeronautical meteorological services provider within Bhutan by the Bhutan Civil Aviation Authority (BCCA). There are 12 regular staff currently working in the four airports in Bhutan. None of them are trained and certified to work in the airport as per the ICAO requirements. There is an urgent need to enhance their knowledge and technical skills to carry out their duties effectively.

Accordingly, a 5-day Aviation Meteorology Refresher Course was conducted in two batches from 18-29 March 2019 in NCHM, Thimphu and AMS, Paro. All the aviation met technicians from Paro International Airport and domestic airports attended the course. Both theory and practical hands-on training were imparted during the training to upgrade the knowledge and skills about the operations of the upgraded Automatic Weather Observation System (AWOS) and its function, routine maintenance, calibration and updates on standard observations and operational procedures.



Figure 75: Aviation staff with Director, NCHM

24.6 Debriefing Workshop

2-Days debriefing Workshop on Trainings availed under SPCR, NAPA-II and other projects implemented by NCHM for FY 2017-2018 was held on 7th and 8th August 2018 with the objective to reflect-on and share skills, knowledge and experiences gained with other officials of the Center. Training participants (individual and team) presented their experiences, achievements, outcomes, recommendations and way forward in the workshop.

The workshop was chaired by Director and attended by Division Chiefs, officials and staff stationed in HQ, Thimphu, Gross National Happiness Commission and officials from World Bank Office Bhutan.



Figure 76: During the De-briefing Session

25. Wellbeing of Centre Staff

25.1 NCHM Staff Welfare fund

After delinking from the Ministry of Economic Affairs, the Center has created a Staff Welfare fund to commensurate with RCSC Welfare fund with a noble objective to strengthen solidarity among the staff and provide *Semso* and physical assistance to the aggrieved family during unfortunate events of death to members or their family. The memberships are voluntary.

25.2 NCHM Rimdo

The Center works with *Jungwa shig* (four elements: earth, water, fire, air) and the nature. For all sentient beings, the Tsa-Wa-Sum and the welfare of all staffs the Center conducts annual *Rimdo* though personal donations. One *Rimdo* was held on 26 August 2018.



Figure 77: During Office Rimdo

25.3 NCHM HQ Potluck Lunch

In order to facilitate good relations among the staff and to build the team spirit, the Center instituted the Potluck lunch once a month (i.e. every last Friday of the month).



Figure 78: NCHM Monthly Potluck Program

26. Challenges and Issues

Being the new autonomous agency entrusted with technical and scientific mandates, the Center is facing a number of challenges from financial, human resources, office space to technical and scientific facilities. The following are three key issues and challenges that need immediate interventions.

26.1 Lack of Office Space and Scientific Facilities

The Center was delinked from the Ministry of Economic Affairs from February 2017. However, the Center is still occupying the same office space in the Energy building occupied by the erstwhile Department of Hydromet Services, MoEA despite increased number of staff with additional staff transferred from the Glaciology Division and Aviation Meteorological Services staff from Department of Geology and Mines and Department of Air Transport Services, MOIC respectively. Finance and Accounts Services of the Center is operating from the Directorate Services office of MoEA. The Center is grateful to the MoEA for their support.

Due to limited office space, there is no proper space for store and scientific facilities to properly setup sediment laboratory, calibration lab including the space for staff.

The Center is the national repository of hydrological and climatic data of Bhutan. It also host sophisticated Weather and Flood Warning Center (NWFWC) that operates by 24/7 including the satellite receiver station and other communication facilities. Therefore, due to the nature of job responsibilities it handled, the Center office cannot be located in the private building. The Center is planning to build a new office complex and with scientific facilities. To this Center has requested the National Land Commission Secretariat (NLCS) to identify and allocate appropriate land on the outskirts of Thimphu Thromde

for construction of office and its facilities in the 12 FYP. Approval and allocation of land from NLCS still awaited.

26.2 No Hydromet Policy and related Legislation

The Center is given huge mandate for data collection, monitoring and understanding of hydrology, weather, climate and cryosphere, for timely provision of information and services to protect lives and property and support national needs for ecologically balanced sustainable development. Importantly to provide evidence based science and knowledge to policy and decisions makers for strategic planning and development. However, currently there is neither a hydro-met policy nor a legal framework that provides a legal basis for the existence of the Center and its mandates for operation and delivery of hydro-met services in Bhutan. Considering the cross sectoral nature of hydromet functions, it often duplicate functions with other agencies working in the areas of environment, flood and disasters. It is therefore, often other agencies uses NCHM to implement their planned activities to fulfill their performance target and IWP. Non existence of policy and legal framework has a number of implications from poor data quality, no standardization on scientific instruments and data format and incompatibility, lack of basis for data exchange policy within country and international.

26.3 Nature of Work 24/7

The Center field staff works 365 days without weekends and holidays due to the nature of job for collection of hourly and daily data. In participation the National Weather and Flood Warning Center (NWFWC), HQ, Thimphu and Flood/GLOF Early Warning Control Room of river basins like Punatsangchu (Wangdue), Mangdehhu (Trongsa), Chamkharchhu (Kurjey) operates 24/7 on shift system. Currently no night shift allowance are provided. During the emergency, the relevant officials including the Director have to come NWFWC to monitor the situation and update the DDM and line agencies sometimes in the middle of the night, but over time allowance are eligible for the staff S5 and below.

Similarly due to the nature of the job, most of the employees have to work in remote, inaccessible, hazardous and risky areas during the glaciers and glacier lakes monitoring and hazard assessment, riverline survey, flow and discharge measurements for flood hazard mapping including the installation of hydro-met stations in the river bed and remote areas.

26.4 Limited Professional Capacity for effective Delivery of Hydro-met

Human Resources with professional capacity is one of the greatest challenges faced by National Meteorological and Hydrological Services (NMHS) in the developing countries. From the last decade the capacity of the Center has been enhanced through the donor supported projects and other international organization like WMO in areas of observations and data collection. The Center still lack professional capacity development of services in products in the areas of weather prediction and forecasting, flood modelling and forecasting, climate modelling and projection and studies.

Aviation meteorological services is one of the new mandates taken over the Center, the Center lack capacity in all levels from observation to service delivery due to lack of funding and manpower with required qualification. On the other hand aviation meteorology services is highly sensitive functions that has to fulfil not only the Bhutan Civil Aviation Authority (BCCA) legal requirement but also International Civil Aviation Organization (ICAO) requirement for the operation of flights.



NATIONAL CENTER FOR HYDROLOGY AND METEOROLOGY ROYAL GOVERNMENT OF BHUTAN