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July 2023



ANNUAL REPORT

2022-2023

National Centre for Hydrology and Meteorology
Royal Government of Bhutan
Thimphu: Bhutan
July 2023



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Acronyms:

12 FYP	Twelfth Five Year Plan
13 FYP	Thirteen Five Year Plan
AWLS	Automatic Water Level Station
AWS	Automatic Weather Station
BFL	Bhutan for Life
CDBMS	Centralized Database Management System
CSD	Cryosphere Services Division
CDCL	Construction Development Corporation Limited
DDM	Department of Disaster Management
DGPC	Druk Green Power Corporation
EWS	Early Warning System
GCF	Green Climate Fund
GFCS	Global Framework for Climate Services
GLOF	Glacier Lake Outburst Flood
GoI	Government of India
GTS	Global Telecommunication
HQ	Headquarter
HWRSD	Hydrology and Water Resources Services Division
ICT	Information Communication Technology
IFAS	Integrated Flood Analysis System
JICA	Japan International Cooperation Agency
LDCF	Least Developed Country Funding
MoENR	Ministry of Energy and Natural Resources
NAP	National Adaptation Plan
NCHM	National Center for Hydrology and Meteorology
NEC	National Environment Commission
NFCS	National Framework for Climate Services
NWFWC	National Weather Flood and Warning Centre
OEM	Original Equipment Manufacturer
PHPA	Punatsangchhu Hydropower Project Authority
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
TSDR	Technical Standard Research Division
UNDP	United Nation Development Programmed
WB	World Bank
WCSD	Weather and Climate Services Division
WIS	Weather Information System
WMO	World Meteorological Organization
WRF	Weather Research and Forecast.

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Figure 1: Rehabilitated Bjizam Hydrological Station with Automatic Water Level Station (AWLS), and Communication system for Flood EWS on Mangdechhu (October, 2022)

1 ORGANIZATION

The National Centre for Hydrology and Meteorology (NCHM) is a scientific and technical autonomous agency of the Royal Government of Bhutan created in 2016. The Centre is responsible for understanding the behaviour of the atmosphere, its interaction with the cryosphere and water bodies, the weather and climate, and distribution of the country's water resources. It is the nodal agency responsible for the generation of information and delivery of products and services on weather, climate, cryosphere and water resources in Bhutan.

The Centre was created to improve the efficiency and effectiveness in providing information and services of hydrology, meteorology, cryosphere and climate sciences that are required by various sectors and the public.

2 NCHM REPORTING

The National Centre for Hydrology and Meteorology (NCHM) as an autonomous agency was governed by a Governing Board (GB) and its members approved by the Cabinet vide letter C-3/118/527 dated 25 November 2016. The board provided strategic and policy direction for overall governance of the Centre. As part of civil service reform with the enactment of the Civil Service Reform Act of Bhutan 2022, the Governing Board of the Centre was dissolved. The last Governing Board meeting was held on 23 December 2022.

In accordance with the provision of the Civil Service Reform Act of Bhutan 2022, the RCSC vide letter no. RCSC/HRMD/7/2023/2830 dated February 13, 2023 approved that NCHM will have functional autonomy. The Secretary, Ministry of Energy and Natural Resources (MoENR) will oversee the oversight on governance and provide strategic policy direction and governance of the Centre.

3 SCIENTIFIC AND TECHNICAL ADVISORY COUNCIL (STAC)

NCHM being a scientific and technical agency, a Scientific and Technical Advisory Council (STAC) is established to advise and provide directives to the Centre in implementation of its technical mandate in weather, climate, water, cryosphere and related sciences, its applications and services. ToR of NCHM STAC along with members from the following agencies was submitted to the RCSC for approval by the Cabinet.

- a. The Department of Local Governance and Disaster Management, Ministry of Home Affairs;
- b. The Department of Agriculture, Ministry of Agriculture and Livestock;
- c. The Department of Water, Ministry of Energy and Natural Resources
- d. Director General, Department of Research and External Relations, Royal University of Bhutan and
- e. The Head/Director, NCHM as a Member Secretary

The Chairman of the STAC will be elected among its members during the first STAC meeting. Additional experts as an observer from other sectors will be decided by the Chair, STAC based on the agenda/issues.

The Head/Director of the Centre will serve as a Member Secretary.

4 VISION, MISSION AND CORE VALUES

4.1 VISION

Vision

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

4.2 MISSION

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.

4.3 CORE VALUES



Figure 2: NCHM Core values

4.4 GOALS

NCHM goals:

- 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.

5 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 and agro-meteorological services, and climate change information and services;
- d. Research 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 sub-basin and basin level;
- f. Capacity and human resources development through training and education;
- g. Data collection, Research and 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 organisations related to weather, climate, hydrology, cryosphere, and water resources for exchange of data, research and technology transfer.

6 ORGANISATION STRUCTURE AND STAFFING

6.1 ORGANISATION RESTRUCTURING

In accordance with the provision of the Civil Service Reform Act of Bhutan 2022, the RCSC vide letter no. RCSC/HRMD/7/2023/2830 dated February 13, 2023 approved that NCHM will have functional autonomy. The Head of the Centre will report to the Secretary, Ministry of Energy and Natural Resources.

Scientific and Technical Advisory Council (STAC) of NCHM shall advise and provide directives to the Centre in implementation of its technical mandate in weather, climate, water, cryosphere and related sciences, its applications and services.

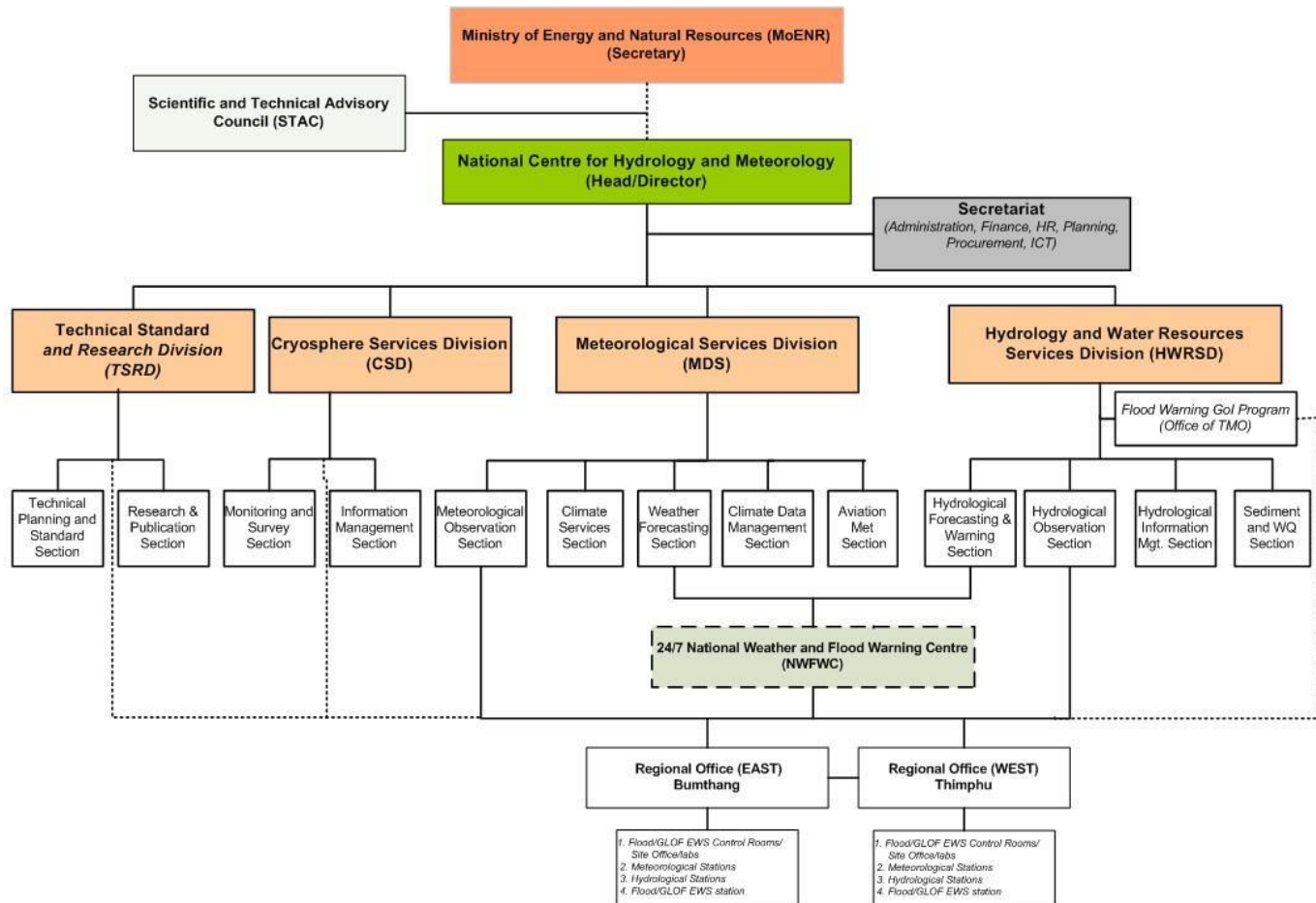


Figure 3: Updated Organogram of NCHM (February 2023 after Reform)

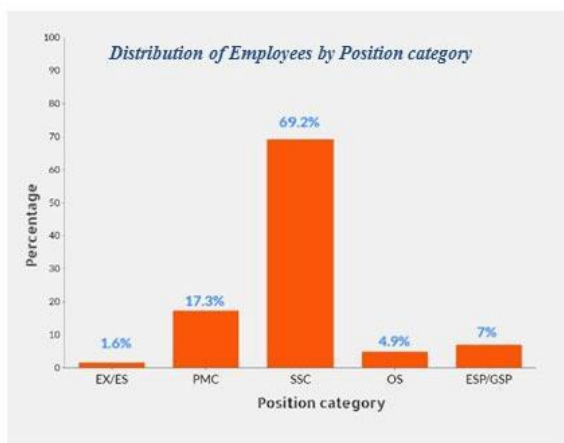
6.2 STAFFING

The Centre has an approved post of 209 employees but currently the Centre has 184 employees including 13 ESP/GSP under the Flood Warning Services (GoI Program). The detailed staffing strength and distribution is presented in table 1 below:

Table 1: Staff strength and distribution

Division/Secretariat	Approved	Existing	Gap	Remarks
Secretariat	21	17	-4	<i>Including 8 Drivers and 1 ESP</i>
Meteorological Services Division	57	51	-6	
Hydrology and Water Resource Services Division	116	105	-11	<i>Including 13 RGR under GoI Program</i>
Cryosphere Services Division	8	6	-2	
Technical Standard and Research Division	7	5	-2	
	209	184	-25	

Distribution of employees by positions is shown in the graph below. The Centre is responsible for monitoring and operation of national hydro-meteorological network stations covering the whole Bhutan (about 250 national hydro-meteorological stations), the maximum staff (about 70%) are under the Support and Supervisory category followed by Professional and Management level (17.3%).



Distribution of Employees by gender

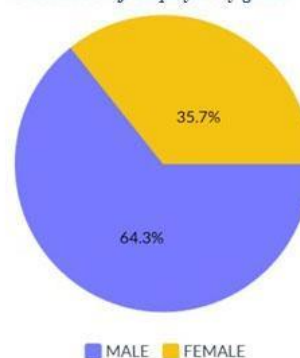


Figure 4: Distribution of Employees

Out of 184 regular employees, 118 (64%) are male and 66 (35.7%) are female. Male domination may be due to the technical nature of Centre's mandates, however, compared to the past years, the number of females joining the Centre are increasing every year.

6.3 STAFF SUPERANNUATED

Total of three staff superannuated after serving more than three decades of their dedicated services to the nation and others separated on voluntary resignation in the FY 2022-2023.



Figure 5: Employees superannuated in 2022-2023 (Mr. Indra Bdr. Ghalley (L), Sonam Dorji (R), Phurpa Singh Tamang)

6.4 NEW STAFF

A total of five employees joined the Centre during this financial year under four new appointments and four transfers (Redeployment from RCSC). The details of new staff are given in the table below.

Table 2: List of new employees joined during the FY 2022-2023

Sl#	Name	Employee ID	Position Title	Division	Date of Joining
1	Mr. Jamyang Phuntshok	200201064	Principal Met/Hyd Officer	HWRSD	13.9.2022
2	Ms. Dechen Lhamo Gyeltshen	202301922365	Met/Hyd Officer	MSD	24.2.2023

3	Mr. Sangay Tshering	202301923016	Met/Hyd Officer	MSD	24.2.2023
4	Mr. Sonam Tenzin Yoedtsel	202301923169	ICT Technical Associate	SECT.	24.1.2023
5	Mr. Ugyen Pema	202210922025	Driver	SECT.	1.10.2022

6.5 STAFF ATTRITION

A total of 23 employees left the Centre during the financial year 2022-2023. The overall attrition rate was calculated by dividing the number of employees who left the organisation by the average number of employees during that period. The attrition rate of the Centre for the 2022-2023 is 12.43%. The details as shown in the table below.

Table 3: Distribution of type of attrition during the FY 2022-2023

Sl#	Division	Type of attrition (Superannuation)	Type of attrition (Voluntary Resignation)
1	SECRETARIAT	1	3
2	HWRSD	3	6
3	TSRD	0	0
4	MSD	0	9
5	CSD	0	1
	TOTAL	4	19

A total of 4 staff has availed EOL during the financial year 2022-2023.

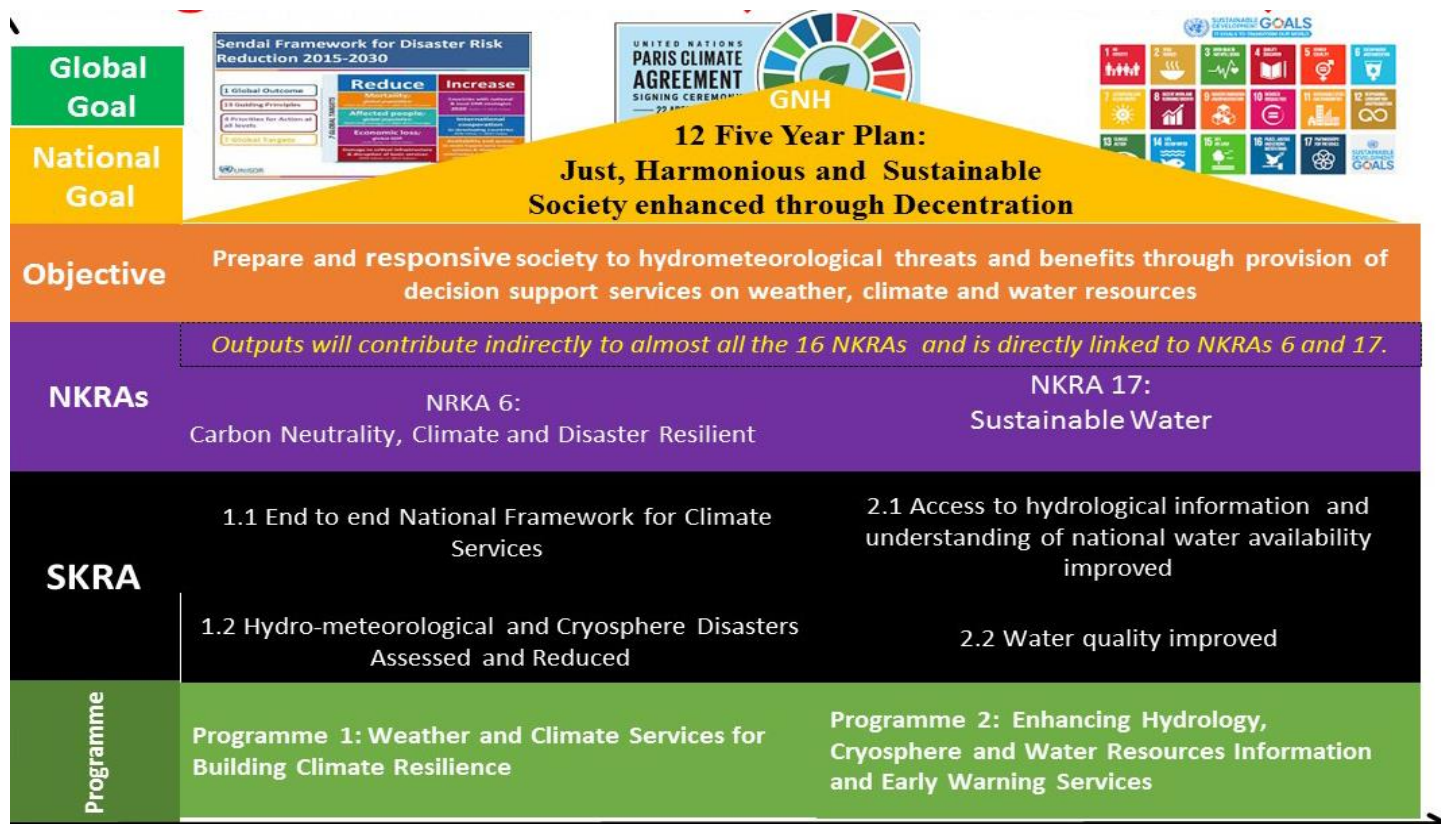


Figure 6: NCHM 12 FYP SKRA linked to NKRA, National and International goals

7 CENTER'S 12 FYP (2018-2023)

The Center's 12th Five Year Plan (2018-2023) has two main programs that are directly linked to NRKA 6 and NKRA 17 (Figure 8) and indirectly programs linked to all the NKRAs and SDG as weather, climate and water resources services are required by all the Sectors.

8 ANNUAL PERFORMANCE TARGET (APT) ACHIEVEMENT

The Centre has consistently performed more than 95% of the APT for the last 6 years from 2016-2017 to 2021-2022 and is rated in the Outstanding category. The details as shown in Table 4.

Table 4: APT Score of the Centre

Sl No.	Financial Year	NCHM APT Score
1	2016-2017	97.80%
2	2017-2018	99.45%
3	2018-2019	100%
4	2019-2020	99.75%
5	2020-2021	100%
6	2021-2022	98%
7	2022-2023	N.A

Table 5: KPI of NCHM (FY 2022-2023)

Sl No.	Action
1.	National Hydro-met Observation network enhanced and operational
2.	Hydrological data, flood early warning services provided
3.	Hydrological and flood hazard and risk assessed
4.	Cryosphere monitored and hazard assessed
5.	Research work/papers published, calibration facilities established and operational
6.	Weather monitored and public Weather Service (PWS) provided
7.	Airport weather monitored and aviation meteorological services provided
8.	Climate data, information and services provided to users
9.	Hydrology and water resources data, information generated and disseminated
10.	Sediment and ambient water quality monitoring network enhanced

The Centre's APT Outcome and KPI for the FY 2022-2023 with achievements are given in the **Annexure -I** of this report.

The Centre has also successfully implemented all the mandatory Organization Integrity Action Plan (OIP) for the FY 2022-2023.

9 SUMMARY OF FINANCIAL STATEMENT

9.1 BUDGET APPROPRIATION FOR THE PAST FOUR YEARS

The total budget allocated (RGoB + Donors) to the Centre for the last four years and its expenditure for the FY 2022-2023 is shown in table 3 and table 4 respectively.

Table 6: NCHM Budget summary from 2017-2018 to 2022-2023 (in million)

Sl. #	Funding	2017-2018	2019-2020	2020-2021	2021-2022	2022-2023
1	RGoB	76.87	110.06	115.89	101.19	126.64
2	Donors	117.93	64.29	48.53	81.37	87.96
	Total	194.80	170.353	164.426	182.562	214.60

9.2 FINANCIAL SUMMARY FOR FY 2022-2023

Table 7: Expenditure summary table for the FY 2022-2023

Sl. No.	Funding	2022-2023		Budget Utilisation in Percentage
		Approved	Expenditure	
1	RGoB	126.64	92.22	73%
2	Donors	87.96	56.67	64%
	Total	214.61	148.88	70%

Highlights of Accomplishments for the FY 2022-2023

10 NATIONAL FRAMEWORK FOR CLIMATE SERVICES (NFCS)

The Meteorological Services Division (MSD) of the Centre 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.

10.1 INSTALLATION OF WEATHER STATION IN GYALSUNG SITE

During the FY 2022-2023 the Centre in collaboration with Gyalsung Infra installed Automatic Weather Station (AWS) at Bongdeyma (Mongar), Tareythang (Sarpang), Pemathang (Samdrupchholing). However, for Jamtsholing (Sibsoo), it was agreed to upgrade and use the data from the existing Sibsoo Class A Met Station.

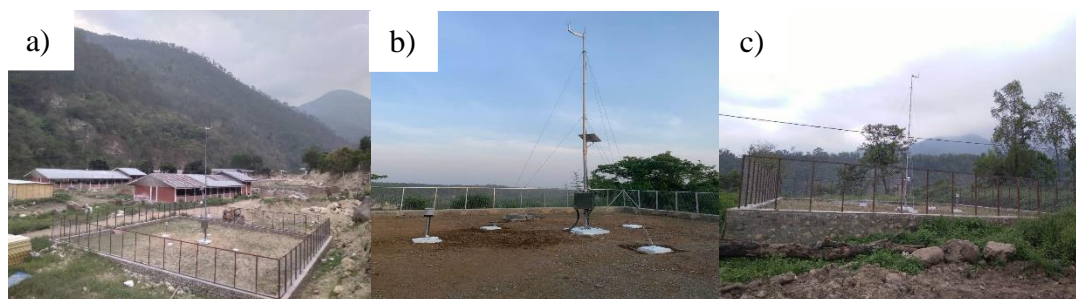


Figure 7: Installed Automatic Weather Stations at Gyalsung Project sites (a) Bongdema, (b) Tareythang (c) Pemathang

10.2 DAILY WEATHER FORECAST

The Weather Forecasting Control Room (WFCR) under the National Weather and Flood Warning Center (NFWFC), Thimphu operates 24/7 monitoring weather across the country. Daily weather forecast updates are disseminated through emails, NCHM website, Bhutan Broadcasting Television (TV), radio and social media.

- The daily 24-hour weather forecast for the 20 Dzongkhag includes rainfall outlook with maximum and minimum temperature which is provided at 4 pm
- Weather updates are provided at 8 pm and 4 am.
- Three-day weather forecast with detailed analysis and report is issued at 10:00 AM daily.

Table 8: Daily weather forecast

Forecast Type	Number of forecasts (1 July 2022- 30 June 2023)
Daily weather forecast at 16:00	364
Weather update at 20:00	364
Weather update at 04:00	364
Weather report and analysis at 10:00	364
Total number of forecasts issued	1456

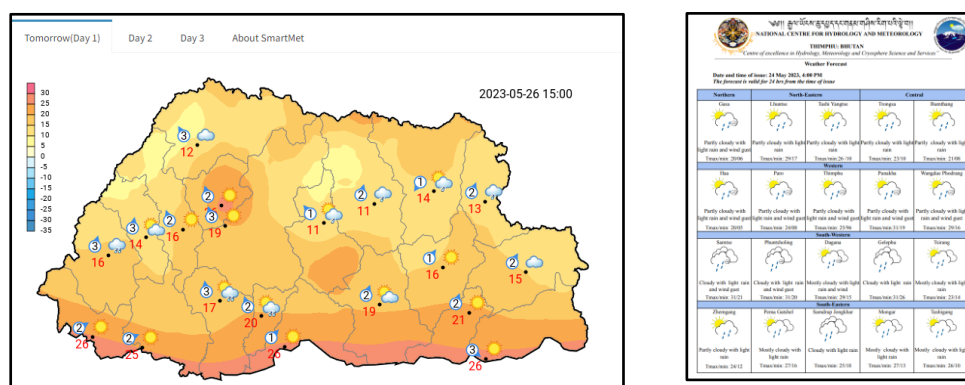


Figure 8: Daily weather forecast outlook

10.3 WEATHER ADVISORIES

NFWFC monitored 24/7 weather. Extreme weather remarks and advisories are disseminated through emails, NCHM website, Bhutan Broadcasting Television (TV), radio and NCHM Facebook page and dedicated social media WhatsApp groups. Details of weather advisories issued during the FY 2022-23 are given in the table below.

Table 9: Details of weather advisories

Weather remark on dry weather and above normal temperature	14 July 2022
Weather remark on light to moderate rainfall	2 October 2022
Weather advisory on Cyclone Sitrang	24 October 2022
Weather Remarks on Deep depression over the Bay of Bengal- Update 1: Cyclone Mandous	8 December 2022

Weather Remarks on Cloudy with moderate rainfall	20 February 2023
Weather Remarks on light to moderate rainfall	16 March 2023
Weather Remarks on light to moderate rainfall - Update 1 and 2	18 and 21 March 2023
Weather Remarks on developing Cyclone	8 May 2023
Weather Remarks on Cyclone “Mocha”- Update I	11 May 2023
Weather Remarks on Cyclone “Mocha”- Update 2	14 May 2023

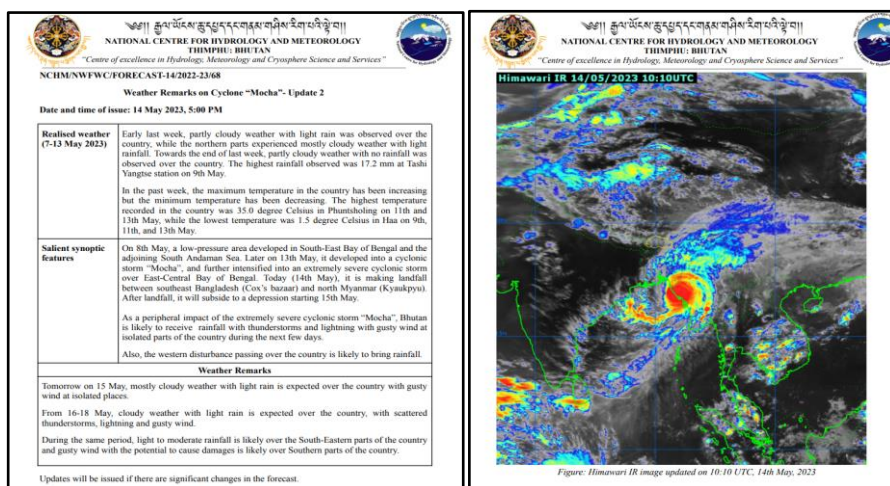


Figure 9: Weather advisories

10.4 AVIATION WEATHER FORECAST

NCHM through Aviation Meteorological Section (AMS) Office at Paro International Airport provided an interrupted 24-hour weather forecast for 364 days for both international and domestic airports for operation of flights and helicopters.

Table 10: Daily aviation weather forecast

Forecast type	No of forecasts (1 July 2022- 30 June 2023)
1 hr weather forecast issued to Aviation issued at 12:00 Noon	364
48 hrs weather forecast for Aviation at 18:00	364
48 hrs weather forecast for Aviation at 06:00	364
Total number of forecasts issued	1092

10.5 WEATHER FORECAST ON REQUEST

The Centre also provided weather forecasts on request through email, social media and over the telephone based on the user's needs and requirements. Email disseminated forecast requests are listed below.

Table 11: Weather forecast on request

Forecast request		Number of forecasts (1 July 2022- 30 June 2023)
Royal Body Guard (RBG)	Weather Forecast for Thanza, Tarina and Lunana	9 and 13 October 2022
	Thimphu and Lunana	15,18,19,20 October 2022
	Gasa and Lunana	4 October 2022
	Dochula and Lunana	10 October 2022
Snowman Race Secretariat	Gasa, Narithang, Lhedhi, Gheche wom, Lulay Tsho, Bumthang	8-17 October 2022
MoENR	Thimphu	24-28 October 2022
Druk Green Power Corporation Ltd	Bumthang and Tashigang	3 October 2023
Department of Public Health	Thimphu, Lunana	8 October 2023
Bhutan Foundation	Bumthang	15-25 May 2023
Gyalsung Infra	Gelephu and Samtse	9 April- 30 June 2023
Royal Body Guard (RBG)	Wangdi, Trongsa, Bumthang, Mongar, Tashigang, Merak Sakteng	1- 9 May 2023
Taj Tashi	Thimphu	3 and 6 May 2023

10.6 WEATHER FORECAST FOR SNOWMAN RACE

NCHM was engaged and entrusted to provide route weather forecasts for the Snowman Race of Bhutan held from 13th - 17th October 2022. The Centre deputed a forecaster to the Snowman Race Control Room set up at RBA, Lungtenphug, Thimphu for update of weather. The Centre was awarded an appreciation Certificate by the Snowman Secretariat.

Dr. Singay Dorji, Specialist, participated as a panellist from NCHM in Bhutan

Climate Concave, 2022 held at the end of Snowman race on 18 October 2022 in Bumthang.



Figure 10: Appreciation Certificate

10.7 CITY WEATHER FORECAST

NCHM also shared weather forecasts for eight identified dzongkhags to the World Meteorological Organization's Weather Information System (WWIS) through email. The forecast can be accessed from World weather WMO website link <https://worldweather.wmo.int/en/city.html?cityId=1274>

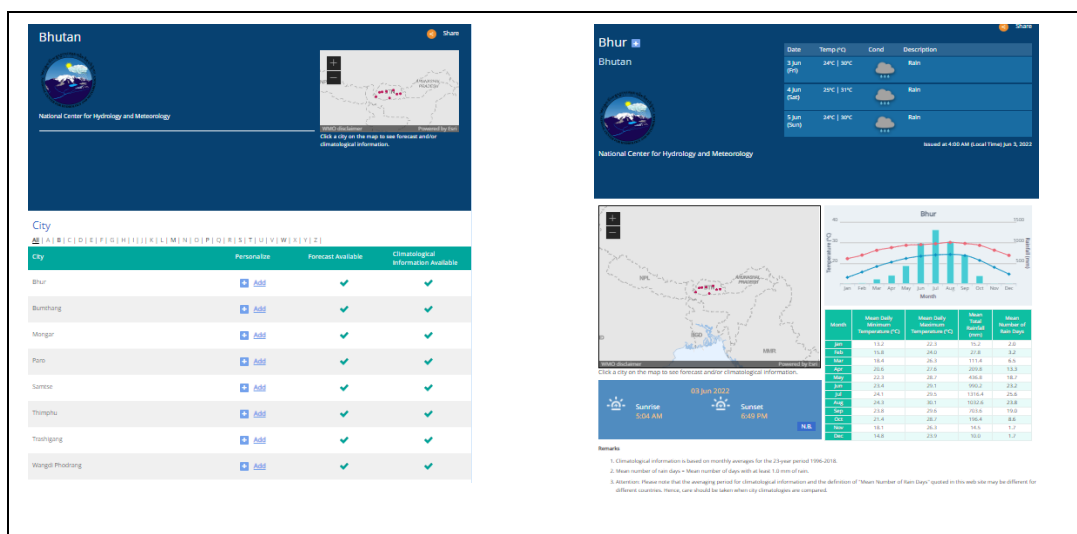


Figure 11: Selected 8 cities weather forecast in WWIS

Table 12: Daily selected 8 cities weather forecast issued

Forecast type	Number of forecasts (1 July 2022- 30 June 2023)
Weather forecast to WIS at 12 Noon	364
Weather forecast to WIS at 20:00	364
Weather forecast to WIS at 04:00	364
Total number of forecasts updated	1092

10.8 WEATHER FORECASTING SYSTEMS

The Weather Forecasting Room under NWFWC operates the Global Telecommunication System (GTS), Himawari Satellite system, SmartMET and Weather Research and Forecasting (WRF) Model. GTS is a coordinated global system of telecommunication facilities and arrangements for the rapid collection, exchange and distribution of observations and processed information within the framework of the World Weather Watch under WMO.

The Centre utilises the Himawari satellite data and images daily for weather analysis, forecast and severe weather monitoring, and contributes to prevention and mitigation of natural disasters, such as heavy rain and heavy snow. SmartMet is a Common Operating Platform for the weather forecasters to visualise

observation and model data to forecast analysis and edit forecast to produce the final product. The Weather Research and Forecasting (WRF) Model is a state-of-the-art atmospheric modelling system that provides meteorological research and numerical weather prediction capabilities. WRF runs four times a day at NCHM, and it is the main source of daily weather forecasting.

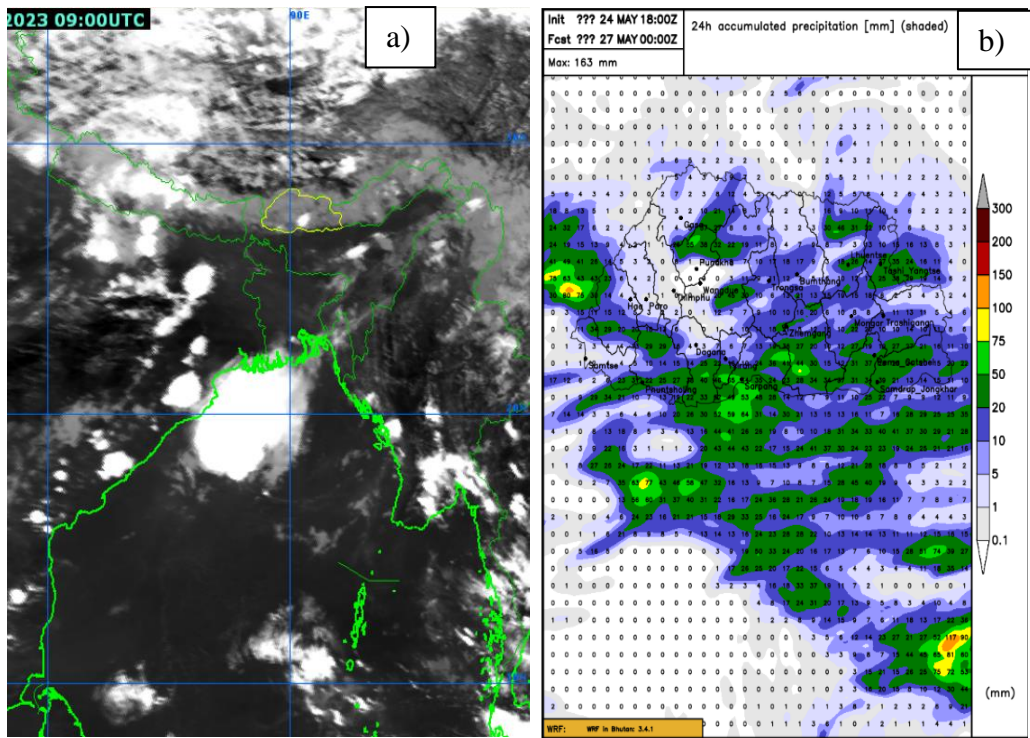


Figure 12: a) Himawari satellite images. b) Rainfall outlook image from WRF

10.9 VISITORS TO NFWFC

National Weather and Flood Warning Centre (NFWFC) is the supervisory and command centre for NCHM for monitoring and dissemination of weather and flood information and services.

The Centre receives many guests from schools and universities for learning about climate, weather observations and forecasting in Bhutan. The Centre also receives officials from both government and international organizations for learning and sharing experiences. List of some of the important visitors are shown below.

Table 13: List of official guests visits to NFWWC

College of Natural Resources student	18 May 2023
World Bank Group Mission Team	27 April 2023
Delegates from Taiwan	2 March 2023
World Bank Regional Director, South Asia Region	2 February 2023
World Bank Vice President visit	16 November 2022
JICA Chief Representative	12 October 2022



Figure 13: Visitors to NFWWC, Thimphu

10.10 NATIONAL CLIMATE OUTLOOK FORUM (NCOF-9)

NCHM in partnership with the Pangrizampa College for Astrology, Central Monastic Body organised the Ninth Session of National Climate Outlook Forum (NCOF-9) on 31 May, 2023 in Thimphu. The Centre issued a press release on the summer monsoon (rainfall and temperature) outlook for the 2023 monsoon and Pangrizampa College for Astrology shared the monsoon outlook for year 2023 from the astrology perspective. The program was attended by climate sensitive sectors from the Department of Environment and Climate Change (DoECC), Department of Energy (DoE), Department of Public Health (DoPH), Department of Surface Transport (DoST), Department of Air Transport (DoAT), and Department of Local Governance and Disaster Management (DoLGDM) and media.



Figure 14: NCOF-09, May 1, 2023

10.11 AGRO-METEOROLOGICAL SERVICES

Climate Service Toolkit

The Climate Information Services Forum (CISF) was organised by the Centre with support from the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) in Paro on 23 August 2022 to create awareness and understanding on climate services of sectoral agencies and local government officials. The workshop was attended by participants from Dzongkhag/Gewog agriculture, health, livestock sectors and Local Government members from Gewogs.

NCHM, WMO and RIMES jointly launched the [Climate Service Toolkit](#) (CST) during the forum in Paro. The CST portal was developed under the project “Developing capacities for effective climate services in Bhutan” of the World Meteorological Organization, funded by the Korean Meteorological Agency and

implemented by the National Centre for Hydrology and Meteorology with technical support from the Regional Integrated Multi-Hazard Early Warning System for Africa.

The same CISF forum was held in LGs of Wangdue Phodrang Dzongkhag on 25 August 2022 for dissemination of information and to seek feedback.



Figure 15: Climate Service Toolkit (CST) forum at Paro

10.12 CLIMATE DATA USERS

The Centre maintains the national repository of hydro-met data in Bhutan. Climate data are being shared with users based on the requests as per the “*Guidelines on the Exchange and Dissemination of Hydro-meteorological Data and Information (2019)*”. Main users based on the data requested for the year 2022 are given the graph below.

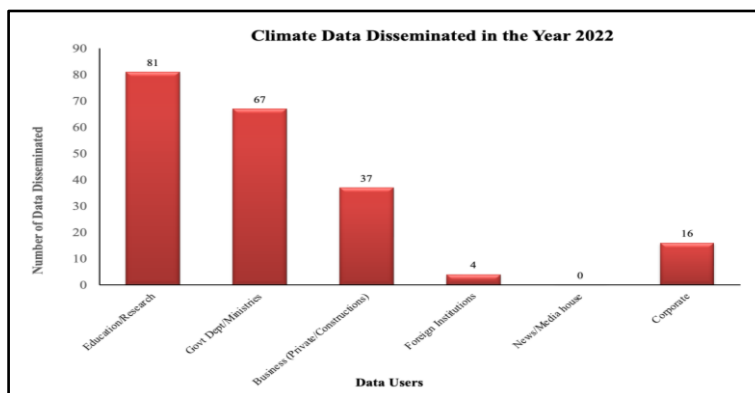


Figure 16: Climate data disseminated in the year 2022

11 HYDROLOGY AND WATER RESOURCES SERVICES

Hydrology and Water Resources Services Division (HWRSD) is mandated for water resources assessment, operation and maintenance of hydrological observation

network, forecasting, hydrological data management, dissemination of hydrological data and information and issue early warning services related to flood and GLOF.

11.1 FLOOD MONITORING AND INFORMATION DISSEMINATION

Flood Monitoring and Command Room (FMCR) of National Weather and Flood Warning Centre (NWFWC) is operational 24/7 for monitoring of the flood and dissemination of the flood and river status to the sectors. The daily water level status, hydrological outlook and flood advisory is disseminated to the relevant stakeholder. Flood warning and advisory are issued during the extreme events in order to inform the general public about the risk of flood and landslide.

Table 14: List flood advisories & information issued.

Information	No. Issued (1 July 2022- 30 June 2023)
Daily water level status	364
Hydrological Outlook	364
Flood Advisory and Warning	3

A flood advisory was issued on 15th June 2022, for the flash flood and landslide in the southern part of the country during the next three days.

Table 15: List flood events recorded

Event recorded on 17th of June 2022
Trashigang dzongkhag. <ul style="list-style-type: none"> ● Pangzam bailey bridge and retention wall collapsed ● Damages reported from the Tashitse school ● Road blocks due to landslide
Pasakha <ul style="list-style-type: none"> ● The Bridge and Road submerged ● No casualties recorded.
Samdrup Jongkhar <ul style="list-style-type: none"> ● Flash flood at Serithang which washed away two shops ● Landslide at Bengporog claimed 2 lives
Roadblocks reported from various parts of the country during the sametime.

11.2 CHANNEL RATING OF AWLS SITES

Stage-discharge rating curves, otherwise called rating curves, are used to produce most of the world's discharge data. NCHM monitors numerous AWLS across the country recording real-time water level data alone. To produce discharge data from the recorded real-time water level data, rating curve development was initiated. For FY 2022-23, channel rating of Dorokha AWLS on Ammochhu was carried out and validation of rating curve of Sadumadu AWLS on Pachhu (Tributary of Ammochu) was conducted.



Figure 17: Field data collection for development of rating curve at Dorokha AWLS

The field activities involved river cross-section surveys for collection of river channel information and characteristics such as channel geometry, bed slope and water surface slope; and flow measurement and river line survey for acquisition of data for calibration of the rating equations.

11.3 AMMOCHHU FLOOD CONTROL ROOM, PHUENTSHOLING

Amochu Interim Flood monitoring control room was established in 2020 and is operationalized from May-October, during the monsoon season. The control room is established at the CDCL/PTDP staff colony for 24/7 monitoring and dissemination of flood and water conditions of upstream catchment, with relevant stakeholders and vulnerable communities settled along the Ammochhu bank in Phuentsholing. Flood mock drill for the residents of Amochu Kidu Housing Colony was conducted on 7 July 2022 by Phuentsholing Thromde in collaboration with Royal Bhutan Army, Royal Bhutan Police, Desuung with the technical support of NCHM Control room to study the real time requirements for the evacuation and preparedness during the flood. Ammochu Flood Monitoring Control Room was set up from 30th April till 02 May 2023 and fully functional with staff temporarily transferred from head office Thimphu and two temporary staff. The Control room will be operational till the end of Monsoon until October 2023.



Figure 18: Amochhu Flood EWS Mock drill July 2022

11.4 DISSEMINATION OF HYDROLOGICAL DATA

The Centre maintains the national repository of hydro-met data in Bhutan. Hydrological data are being shared with users based on the requested as per the “*Guidelines on the Exchange and Dissemination of Hydro-meteorological Data and Information (2019)*”. Figure below shows hydrological data requested by different stakeholders from 2019-2022. The Ministry of Economic Affairs (MoEA) was the main user of hydrological data during the last four years.

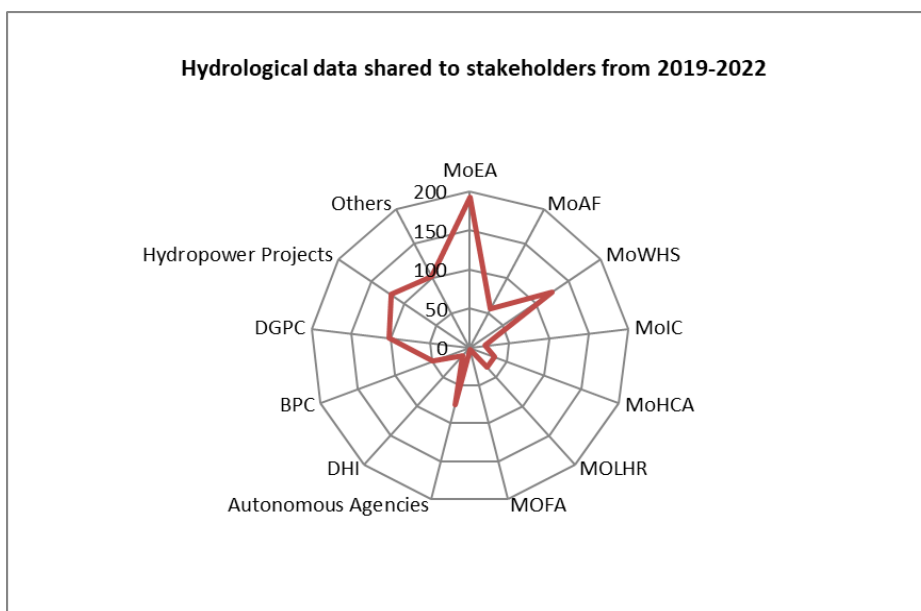


Figure 19: Hydrological data shared with stakeholders

12 NATIONAL HYDRO-MET OBSERVATION NETWORK

12.1 ANNUAL MAINTENANCE OF HYDRO-MET OBSERVATION NETWORK

The Center operates and maintains the National hydro-met observational network that consists of 289 stations across the whole country. The National hydro-met network includes the following:

- a. Meteorological Station Network
- b. Hydrological Station Network
- c. Flood/GLOF EWS
- d. Flood Warning network supported by GoI.

Table 16: Status and types of hydro-met station

Sl . No.	Type of Monitoring Station	Number
1	Meteorological Station	173
2	Hydrological Station	100
3	Sediment Sampling Station	16
	Total	289

The annual maintenance works of the stations includes, among others, troubleshooting, replacement of sensors/equipment, calibration of sensors,

installation and upgradation of selected hydro-met stations. In addition to the above activities, the hydrological station maintenance team also carries out discharge measurement and river cross-section surveys. Annual maintenance works for the national hydro-met observation network was completed and status shown in Table 6.

Table 17: List of stations maintained in 2022-2023

Sl No.	Station Category	Station Type	Total Maint. in 2019-2020	Total Maint. in 2020-21	Total Maint. in 2021-22	Total Maint. in 2022-23
1	GLOF-EWS	Automatic	15	15	15	dfgdfgfd
2	Hydrological Stations	Manual	19	20	14	15
		Automatic	42	36	21	19
3	Meteorological Stations	Manual	20	20	26	sadsa
		Automatic	82	15	25	sadsa



Figure 20: Annual maintenance works of Hydrological stations

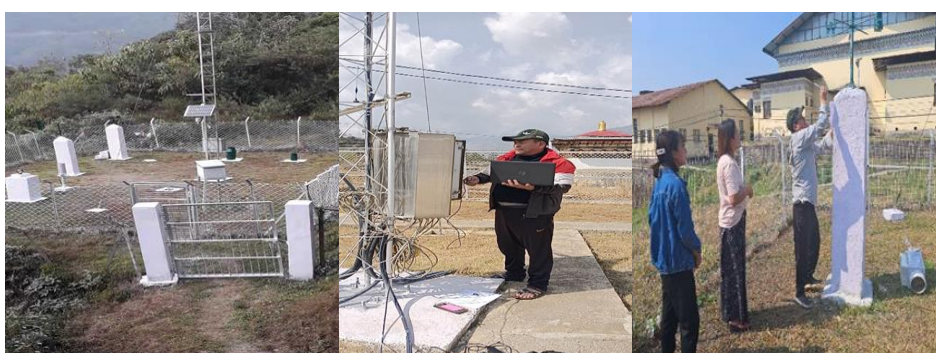


Figure 21: Annual maintenance works of Meteorological stations

12.2 REHABILITATION OF BJIZAM HYDROLOGICAL STATION ON MANGDECHHU

Flash flood from the Chamdey Gangchhu (small tributary) occurred on 2 October 2020 has dammed the main river. The artificial dam and backflow of the river submerged the Bjizam Hydrological station and its EWS monitoring station (AWLS) including the communication systems

The station was rehabilitated (civil work) with the support of MHPA and was completed in October 2022 during the FY 2022-2023. The rehabilitation work was started only after the artificial dam water was drained out by the Dzongkhag Administration.



Figure 22: Bjizam Hydrological Station rehabilitated after damaged by 2020 October Flood

12.3 CONSTRUCTION OF TINGTIBI FLOOD WARNING SITE OFFICE

The construction of a Sediment Lab with staff quarters for the Flood Warning Station on Mangdechhu at Tingtibi, Zhemgang implemented during the FY 2022-2023 under Government of India (GoI) Flood Warning funding. The work was awarded to M/s PS Construction, Zhemgang at contract amount of Nu. 2,999,616.164/ and construction were spilled over to the FY 2023-2024.



Figure 23: Flood Warning Site Office under Construction, Tingtibi

13 CRYOSPHERE MONITORING AND SERVICES

Throughout the globe, in most of the glacierized alpine and high-altitude regions, glaciers are retreating at an alarming rate that is attributed to the ongoing global climate change (Emmer, 2019). Glacier retreat is connected to various interrelated geomorphological, hydrological processes, and changes in hydrological regimes driven by Climate Change.

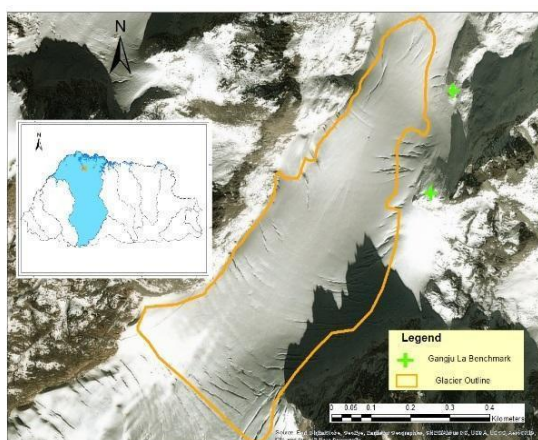
Since there is not much data and information on Bhutan glacial regime, the Centre has established three long term Benchmark glaciers in Bhutan for annual monitoring, viz *Gangju La* glacier in the headwater of Pho Chhu Sub-basin, *Thana* glacier in the headwater of Chamkhar Chhu Sub-basin and *Shodug* in the headwater of Wangchhu basin.

The Cryosphere Services Division is mandated to carry out annual glacier mass balance studies and associate hazards related to glaciers and glacier lakes across the country.

13.1 ANNUAL MONITORING OF BENCHMARK GLACIERS

13.1.1 GANGJU LA GLACIER

Cryosphere Services Division (CSD) team carried out time series monitoring of field activity from September 25, 2022 to October 24, 2022. In the glacio-hydrological year 2022-2023 (Autumn Net Balance), Gangju La Glacier continues to lose mass and also the terminus continues to retreat. The details on the methodologies, data processing, results, and recommendations are compiled in the technical report on Gangju La Glacier 2022-2023.



Gangjula Glacier facts:

Type: Clean type

Area: 0.3 km²

Location: 27°56'24.17"N,
89°56'53.70"E

Elevation: 5145m a.s.l

Maximum Elevation: 5200m a.s.l

Minimum Elevation: 4900m a.s.l

Basin: Headwater of Pho Chhu,
Punatsang Chhu basin.

Initial Survey: 2004

Status of Study: Ongoing

Figure 24: Gangjula Glacier details

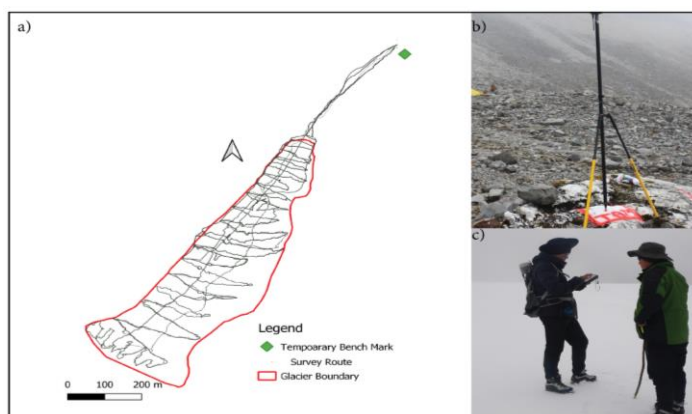


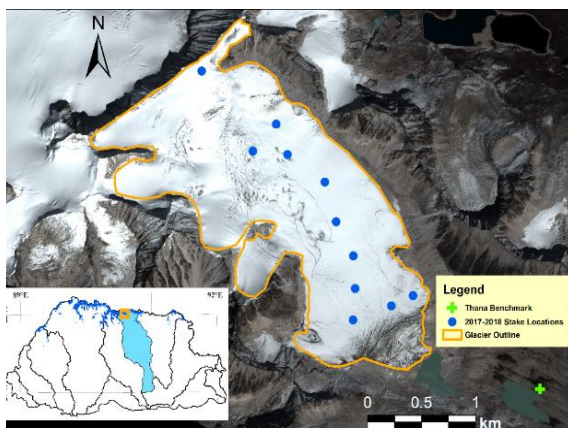
Figure 25: Gangjula Field Activities September to October, 2022.

Activities on Gangju la glacier

- Annual Glacier Mass Balance using Geodetic Method (dGPS)
- Snow Depth survey
- Repeat Photography from the predefined spot

13.1.2 THANA GLACIER

Time series monitoring field activity carried out from September 25, 2022 to October 27, 2022. The detailed methodologies, data processing, results, and recommendations are compiled in the technical report titled “Glacier Mass Balance studies on Thana Glacier 2022-2023”.



Thana Glacier Facts:

Type: Clean type

Area: 3.0 km²

Location: 28° 1'17.90"N, 90°36'39.16"E

Elevation: 5340m a.s.l

Maximum Elevation: 5600 m a.s.l

Minimum Elevation: 5250 m a.s.l

Aspect: South-East

Basin: Headwater of Chamkhar Chhu,
Manas Basin

Initial Survey: 2013

Status of Study: Ongoing

Figure 26: Thana Glacier details

Activities on Thana Glacier

- Annual Glacier Mass Balance Measurement using bamboo stakes (direct/glaciological method)
- Annual Glacier Mass Balance using Trimble R10-2 (in-situ geodetic method)
- Snow pit survey
- Repeat Photography from the predefined spot
- Discharge measurement at Churuthang



Figure 27: Retrieval of old stakes, Setting up of base for dGPS survey, Measuring old stakes above ice, Field survey works on Thana Glacier and Snow-pit Measurement.

13.1.3 SHODUG GLACIER

The Cryosphere Services Division (CSD) identified an additional benchmark glacier (Shodug glacier) in the headwater of Thim Chhu in Spring 2022 and the continuous monitoring was conducted in Spring 2023. The glacier mass balance research on Shodug glacier involving both glaciological and in situ method was conducted from April 10 to 30, 2023. The detailed methodologies, data processing, results and findings are compiled in the “Technical report spring mass balance on Shodug Glacier 2022-2023”.



Shodug Glacier Facts:

Glacier type: *Clean type glacier*

Location: 27.940 N, 89.950 E

Elevation: 5100 to 5300 m.a.s.l.

Area: 3.71 km²

Basin: Headwater of Thim Chhu,
Wang Chhu sub-basin

Initial Survey: 2021

Status of Study: Ongoing

Figure 28: Shodug Glacier in Thimchu basin (2021)

Activities conducted on Shodug Glacier

- Annual Glacier Mass Balance using Geodetic Method (dGPS)
- Installed bamboo stakes for glaciological method
- Snow Depth survey



Figure 29: Field survey work on Shodug glacier, 2023. a & b) Drilling and installation of bamboo stakes on glacier surface, c) Trimble GNSS base station, c) walking on the glacier surface caring rover on backpack to map the glacier surface elevation and e) Snowpit measurement

13.2 GEOTECHNICAL DATA COLLECTION FOR GLOF RISK ASSESSMENT AND AERIAL SURVEY ON KARMA LAKE IN THE HEADWATER OF PAA CHHU.

Under the World bank funded project for Strengthening Cryosphere Monitoring and Risk assessment, Cryosphere Services Division (CSD) carried out geotechnical data collection, bathymetry and aerial survey for GLOF Risk Assessment on Karma glacial lake from August 6 to 20, 2022. These geotechnical data collected will be used as input parameters to run GLOF Breach models so as to estimate and calculate probable flood volume in case of a GLOF event. The detailed methodologies, data processing, results and findings are compiled in the technical report “Geotechnical data collection and aerial survey for GLOF Risk assessment on Karma Lake, August 2023”.

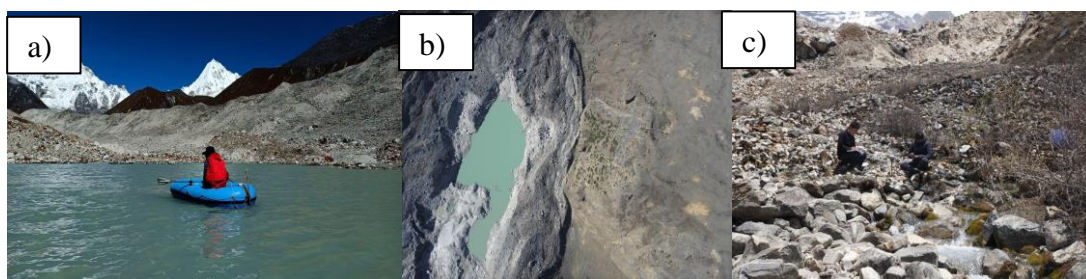


Figure 30: a) bathymetry survey on Karma Lake b) Orthomosaic image of karma lake created using UAS c) Geotechnical (soil) sampling from the moraine surrounding karma lake

13.3 ASSESSMENT OF GLACIAL LAKE FOR GLOF RISK ASSESSMENT ON BURTSHAM GLACIAL LAKE, CHAMKHAR CHHU

Under the annual time series monitoring program, CSD has conducted the assessment on Burtsham glacial lake, located in the headwater of Chamkhar Chhu in September to October, 2022. The team has carried out bathymetry surveys of lakes and surrounding moraines and a photography survey of the feeding glacier. The detailed findings on the particular glacial lake are compiled in the report titled “Assessment of Glacial Lake for GLOF Risk Assessment on Burtsham Glacial Lake, September - October, 2022”



Figure 31: GLOF Risk Assessment on Burtsham Glacial Lake

13.4 ASSESSMENT OF GLACIAL LAKE FOR GLOF RISK ASSESSMENT ON SINTAPHU LAKE, MO CHHU

Under the annual time series monitoring program, CSD has conducted the assessment on Sintaphu glacial lake, located in the headwater of Mo Chhu from May 8 to June 8, 2023, as per the recommendations from the 2015 field survey. The team has carried out lake bathymetry surveys on both the main lake and the upper lake, topographical survey on moraine dams separating the two lakes and the lower main lake, surrounding moraines and photography survey of the feeding glacier. The detailed findings on the particular glacial lake are compiled in the report titled “Assessment of Glacial Lake for GLOF Risk Assessment on *Sintaphu* Glacial Lake, May - June, 2023”



Figure 32: Field photos of Sintaphu Lake; a) Panoramic view of Sintaphu main lake and upper lake, b) Inflating rubber boats for bathymetry survey, c) Lake bathymetry survey, and d) moraine and outlet channel topography mapping using Trimble GNSS R10-2

14 TECHNICAL STANDARD AND RESEARCH DIVISION

The Technical Standard and Research Division (TSRD) was created in July 2022 with the primary objective of overseeing and developing guidelines and SOPs for adaptation and implementation of standards in line with regulatory requirements of WMO and ICAO for operation of national hydrology, meteorological, aviation and cryosphere services. The division is responsible for providing Technical Sanctions , calibration of instruments and coordinating research pertaining to Hydrology, Meteorology and Cryosphere sciences and its applications.

14.1 TECHNICAL PLANNING AND STANDARD SECTION

14.1.1 HYDRO-MET STANDARD MANUALS

The Technical Standards play an important role by ensuring quality data and services. Therefore, for adoption of standardized procedures, guidelines, and protocols that will enable consistent and reliable data collection, analysis, and dissemination. All the data collected by NMHS have to adhere to the quality control checklist provided by the World Meteorological Organization (WMO). This quality control checklist for National hydrological service, as defined by WMO, can be accessed at the following site:

<https://community.wmo.int/en/checklist-developing-quality-management-system-national-hydrological-service>

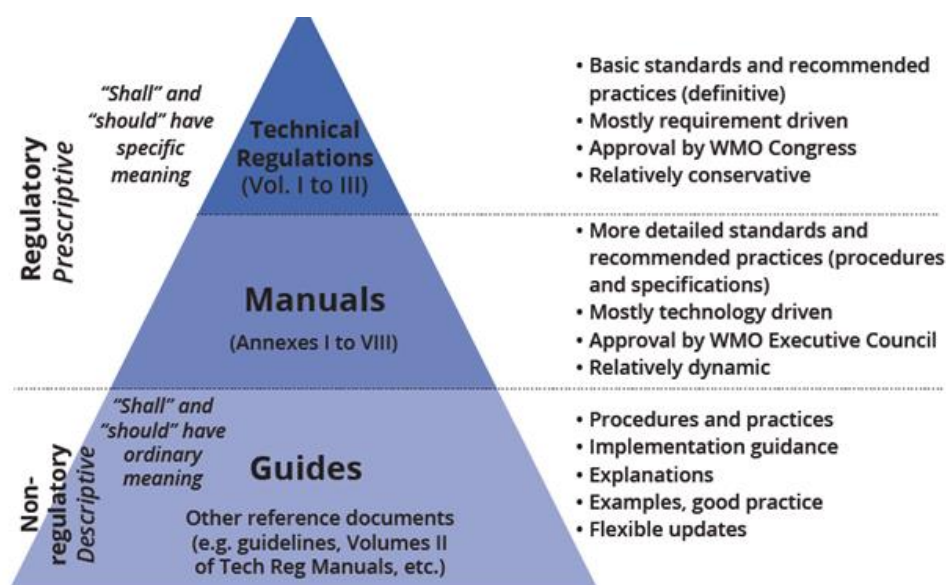


Figure 33: WMO Technical Regulations and other guidance material (Source WMO)

In the FY 2022-23, the TSRD developed two essential procedure manuals:

- Operational Manual for Hydrological Observation I (PR-HWRSD-01):
This manual provides comprehensive guidelines for conducting accurate and standardized hydrological observations. It covers various aspects, including measurement techniques, data collection and recording by field Technicians.
- Manual for Hydrological Instrumentation (PR-HWRSD-02):

The PR-HWRSD-02 (Hydrological Instrumentation) manual, on the other hand, outlines the site selection, network design and other instrumentation aspects related to water level, discharge and sediment observation.

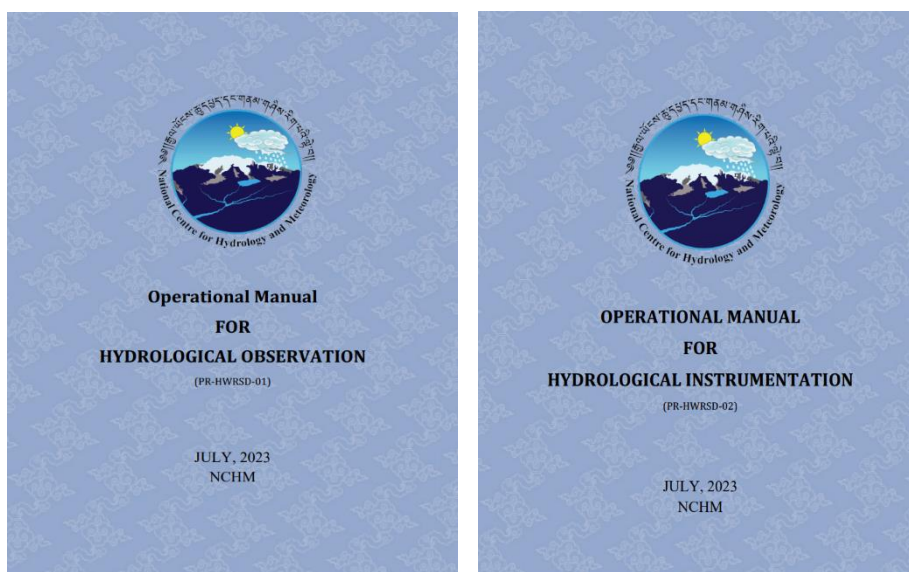


Figure 34: PR-HWRSD-01 (left) and PR-HWRSD-02 (right)

14.1.2 INSTRUMENTATION AND CALIBRATION

Calibration is the process of adjusting the accuracy of instruments and sensors used in the hydro-met data collection with the international standard to ensure reliable and precise data collection. With establishment of calibration lab and SOP for the temperature and pressure calibration by JICA, TSRD carried out and completed calibration of instrument for selected meteorological stations:



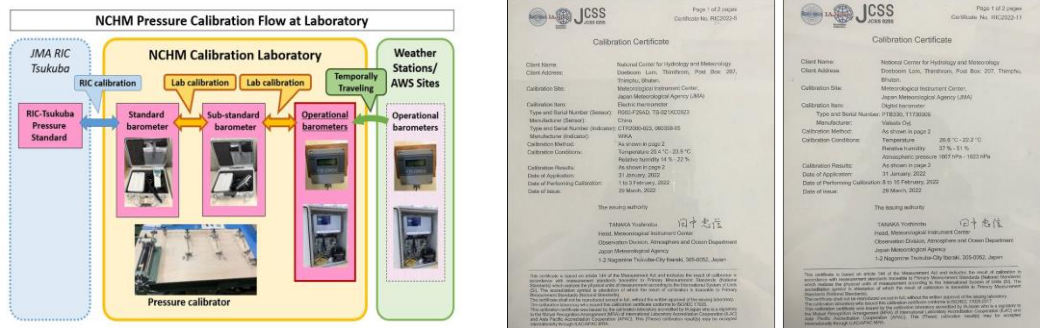


Figure 35: Pressure and Temperature calibration equipment, SOP and certificates

15 PUBLICATIONS AND REPORTS

The Center is responsible to collect scientific data and carry out research to provide information and services related to hydrology, water resources, meteorology, climatology and cryosphere to line agencies. Based on the field works and research the Centre published numerous reports and guidelines during FY 2022-2023. The reports can be accessed from the Center website page: www.nchm.gov.bt.

- Updated Standard Operating Procedures (SOP) for Division (2023)
- Public Service Delivery Charter for the National Centre for Hydrology and Meteorology (2022).

Scientific and Technical Publications include the following.

- Bhutan Hydro-Met Journal (2022)
- Climate Data Book of Bhutan 2022
- State of the Climate, 2022
- Surface Hydrology Data Book of Bhutan, 2022



Figure 36: NCHM Publications 2022-2023

16 PROJECTS

16.1 JICA TCP PROJECT PHASE II

JICA TCP Project for Capacity Enhancement of Weather Observation, Forecasting, Flood Warning and Disaster Preparedness and Response in the Thimphu and Paro River Basin started in August 2020 but the implementation got delayed due to COVID pandemic. The project period is extended to September 2024. The following are updates of the project activities.

- a) JICA TCP Project Expert team completed rehabilitation work for change of the DCP satellite antenna from METEOSAT to HIMAWARI satellite for the GLOF/Rainstorm Flood Early Warning System at Chamkharchhu and Mangdechhu basins installed during the first phase of TCP JICA project (2013-2016). The rehabilitation works were carried out by a technical team of JICA Experts and NCHM staff from 31st Oct to 13 November 2022. Site and System Acceptance Test (SAT) was signed between JICA Team and NCHM after the presentation.



Figure 37: Rehabilitation work of the GLOF/Rainstorm Flood Early Warning System at Chamkhar- Mangde chhu basins

- b) Figure 34: At the National Weather and Flood Warning Centre (NFWFC), Thimphu, JICA Expert has successfully upgraded the GTS system to WIS (WMO Information System) - a data sharing platform amongst WMO Member States.

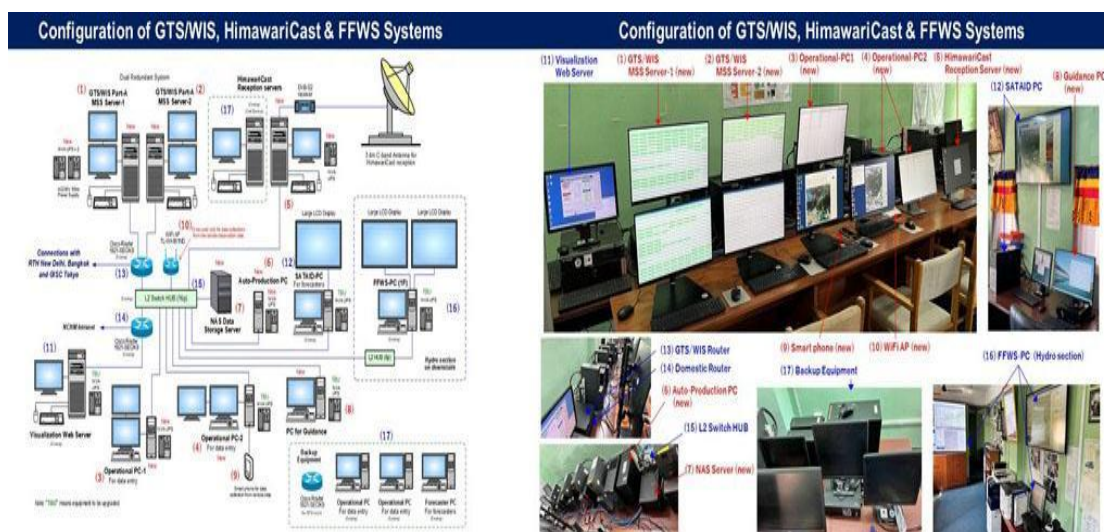


Figure 38: Updated ICT facilities of GTS/WIS, HimawariCast and FFWS systems

a. Calibration lab installed and operational

A WMO certified Calibration lab was established for calibration of Thermometers and barometers. TSRD and JICA experts developed SOP and provided training of operational staff for calibration of instruments.



Figure 39: Thermometer Calibration instrument in Lab

b. 2nd Joint Coordinating Committee (JCC) Meeting JICA TCP, 14 June 2023

The 2nd JCC meeting of the JICA TCP Project for Capacity Enhancement of Weather Observation, Forecasting, Flood Warning, and Disaster Preparedness and Response in the Thimphu and Paro River Basin was held on June 14, 2023, Thimphu. The project is jointly implemented by the National Centre for Hydrology and Meteorology (NCHM) and the Department of Local Governance and Disaster Management (DLGDM) of the Ministry of Home Affairs.

The meeting reviewed the project progress and implementation plan



Figure 40: Participants of Joint Coordinating Committee (JCC) Meeting

The meeting was attended by officials from JICA HQ in Tokyo, Japan (virtually), JICA Bhutan Office and JICA Expert Team from JICA side. Director of Department of Local Governance and Disaster Management(DLGDM), the Director of the Department of Human Settlement, Ministry of Infrastructure and Transport, and JCC members from line agencies (Department of Local Governance and Disaster Management, Department Human Settlement, Department of Infrastructure Development, GovTech Bhutan, Bhutan Construction and Transport Authority, National Land Commission Secretariat), Bhutan Broadcasting Services Corporation (BBS), Local Government from Dzongkhag Administration of Thimphu and Paro, and Thimphu Thromde attended the meeting from RGoB sides.

16.2 GCF PROJECT

The Centre is one of the implementation partners of the GCF project “Supporting Climate Resilience and Transformational Change in the Agriculture Sector” started in January 2020. The 5 years project is expected to end by 31 December 2025. Out of the total fund of USD 25.4 million, USD 1.7 million is allocated to NCHM to

enhance the climate and agro-met services. The following project activities were implemented for the FY 2022-2023

a. Development of Centralized Database Management System (CDMS) and Training

Through the support of the project the Centralized Database Management System (CDMS) was developed to integrate and bring all the hydro-met stations data into a single database system for easy and effective processing and delivery of services at the right time and place. The system was developed by M/s MicroStep MIS based in Slovakia. Onsite In house Training on Operation and SAT of the Centralized Database System was conducted from 13th July - 26 July, 2022 at NCHM.



Figure 41: CDMS Training at NCHM

b. SmartMET System Update and Training, 15-19 May 2023

With the support from the GCF/UNDP Project NCHM upgraded the SmartMet System- a Common Operating Platform for weather forecasts with experts from the Finnish Meteorological Institute (FMI), Finland. The advanced training on SmartMet with data server set-up, software upgrades, integration of additional weather models and observation data to SmartMet was conducted for weather forecasters and ITC staff from 15-19 May 2023.



Figure 42: Smart-MET Training at NCHM

c. Audio-visual clips for Awareness

Under the GCF/UNDP Project, the Centre has developed three audio visual programs to create education and awareness about the NCHM, Weather and Climate and GOLF.

- a. A profile video of NCHM
- b. About GLOF
- c. About Weather and Climate for Agro-meteorological Services

16.3 NCHM-ICIMOD PARTNERSHIP

ICIMOD assisted and implemented the following activities during the FY 2022-2023:

- a. ICIMOD provided an internship for 2 participants for the Centre to study Glacier Mass Balance Modeling through Machine Learning for a period of 3 months (November 2022- January 2023). Ms. Yeshe Choki (HWRSD) and Mr. Tshering Duba (CSD) attended the 3 months internship. During their internship, the participants successfully created a snow cover map of Bhutan spanning from 2003 to 2021. This accomplishment was made possible by utilizing the MOSID dataset and employing the R tool for data analysis. In addition to the snow cover map, the interns conducted an energy mass balance study of the Thana glacier. To carry out this analysis, they employed the DEBAM model. Furthermore, the interns had the unique opportunity to engage in a field visit to Ponkhar glacier. During this visit, they received hands-on experience in operating unmanned aerial vehicles (UAVs), using Ice RADAR technology, and installing stakes on a debris-

covered glacier. This practical experience provided them with a deeper understanding of the complexities involved in glacial research and monitoring. Overall, the internship proved to be a valuable learning experience, combining theoretical knowledge with practical skills in glaciology and remote sensing techniques.



Figure 43: Internship program at ICIMOD

- b. ICIMOD provided training on Spatial and Temporal Analysis of Climate Change Variables and Indices using CORDEX Dataset Over Bhutan, 19-23 December 2022, at ICIMOD, Kathmandu Nepal. The training was attended by NCHM officials and CNR college lecturers with aims to build knowledge and skills among professionals in Bhutan in analyzing climate change projections, selecting representative models for the defined area of interest, and then calculating and analyzing climate indices using CORDEX regional climate model simulations.

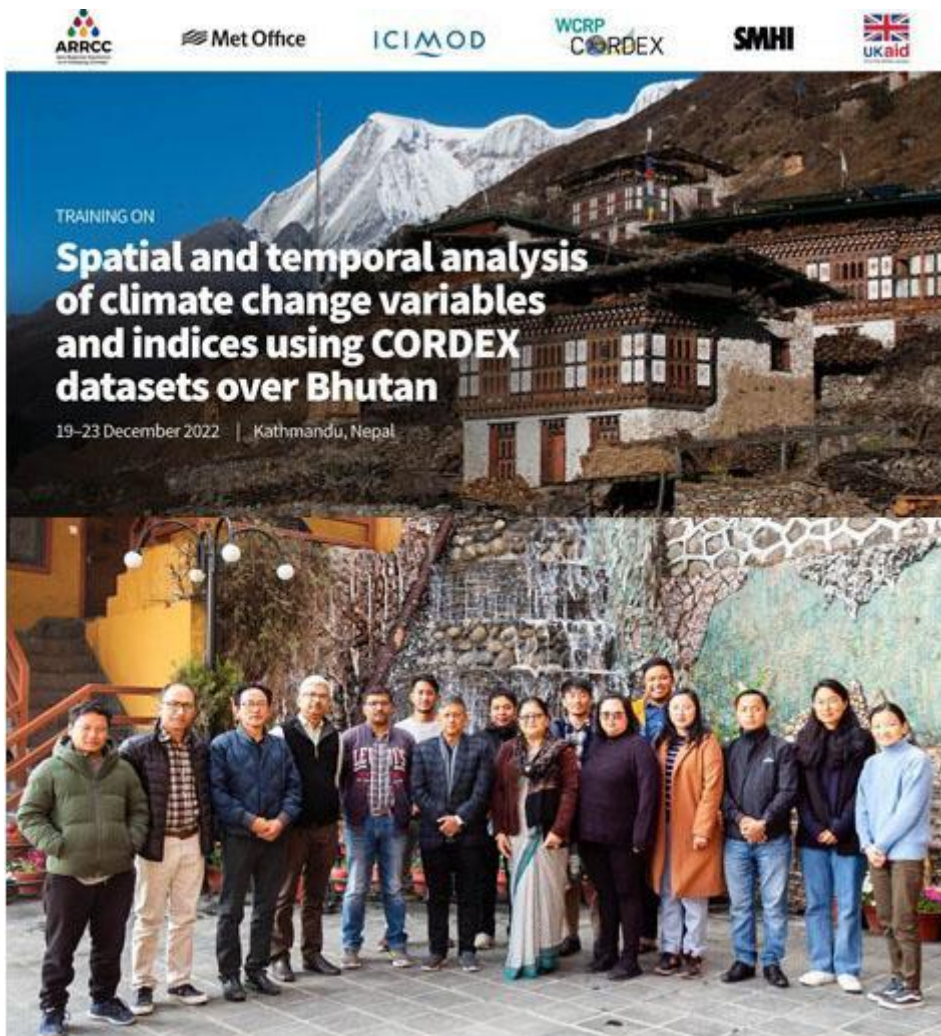


Figure 44: Training program at ICIMOD

16.4 WORLD BANK PROJECT

a. Status of project activities

Under the World Bank supported project “Strengthening Risk Information for Disaster Resilience in Bhutan (RIR, P175081, 2021-2023)” an amount of USD 651,000.00 fund is allocated for the Centre. The following are the status of project activities.

- a. Draft Hydromet Policy of Kingdom of Bhutan submitted to Cabinet Secretariat in May 2023 for approval.

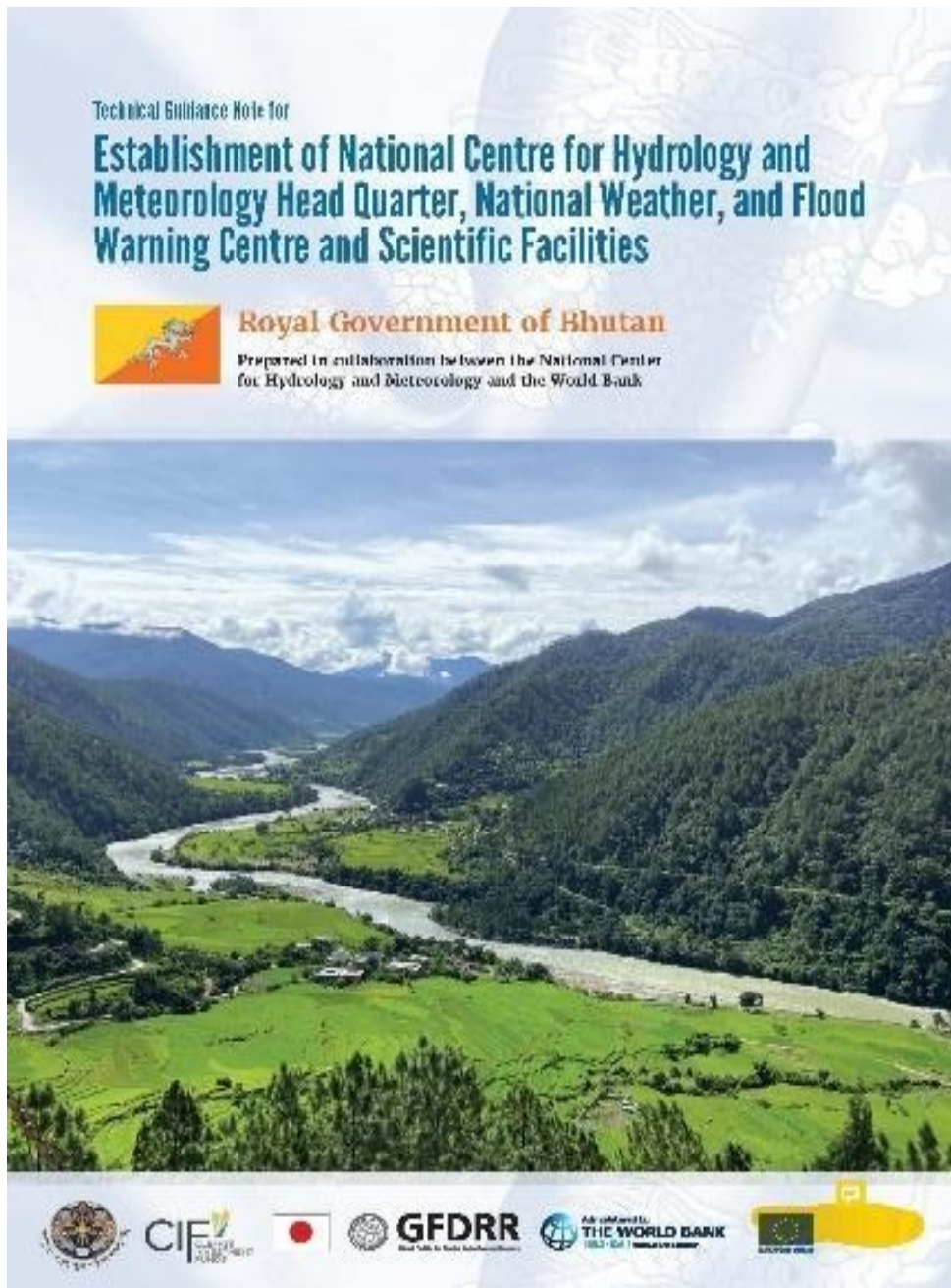


Figure 45: Technical Guidance note.

- b. The World Bank submitted the Final Technical Guidance for the Construction of NCHM HQ and Scientific Facilities report to NCHM in May 2023.
- c. NCHM Road Map for Institutional Strengthening Hydromet and Multi-hazard Early Warning Services in Bhutan developed by the Consultant and Draft final report submitted to NCHM in June 2023.
- d. Flood Risk Assessment (Ongong)
- e. Medium range weather forecast (Agro-met) -ongoing
- f. Cryosphere monitoring and risk assessment (ongoing)

b. Public Consultation on Draft Hydromet Policy and Flood Risk Assessment and Flood EWS

Formulation of the Hydromet Policy and Flood Risk Assessment is one of the two activities under the World Bank supported project. The Centre conducted stakeholders' consultation at both the Central and the Local Government levels. Based on the vulnerability to the hydromet related hazard and disasters Punakha, Wangduephodrang, Trongsa, Bumthang, Paro, Chukhha and Sarpang were selected for the consultation. The consultation at the Central agencies level in Thimphu was attended by officials from climate sensitive sectors like Hydropower, Agriculture, Disaster Management etc. Gewogs leaders and sector heads of Dzongkhag and Gewogs attended the consultation at Dzongkhag level. Details of Dzongkhag Stakeholders consultation are given below.

- a. Punakha Dzongkhag on 9 January 2023
- b. Wangdiphodrang Dzongkhag on 10 January 20023
- c. Bumthang and Trongsa Dzongkhag at Bumthang on 12 January 2023
- d. Paro Dzongkhag at Paro on 25 January 2023
- e. Chhukha Dzongkhag on 27 January 2023
- f. Sarpang Dzongkhag at Gelephu on 30 January 2023



Figure 46: Public Consultation on Draft Hydromet Policy

16.5 ESTABLISHMENT OF COMPREHENSIVE FLOOD FORECASTING AND EARLY WARNING SYSTEM FOR AMOCHHU BASIN

The site assessment for setting up comprehensive Flood EWS on Ammochhu basin was completed but the work got delayed due to COVID19 pandemic. The Center has acquired 13 decimal lands for the construction of a permanent Flood Monitoring Control Room at Phuntsholing.

Through the GCF NAP project, UNDP was awarded M/s Campbell Scientific to develop the Hydrological System for Flood Forecasting and Early Warning Services for Bhutan. This system will be used for flood forecasting and EWS for the Ammochhu basin.

The Centre has also carried out field surveys using drones to develop an updated flood hazard map of Ammochu Phuntsholing till Doyagang in May 2023.



Figure 47: Field works during aerial drone survey of Amochhu

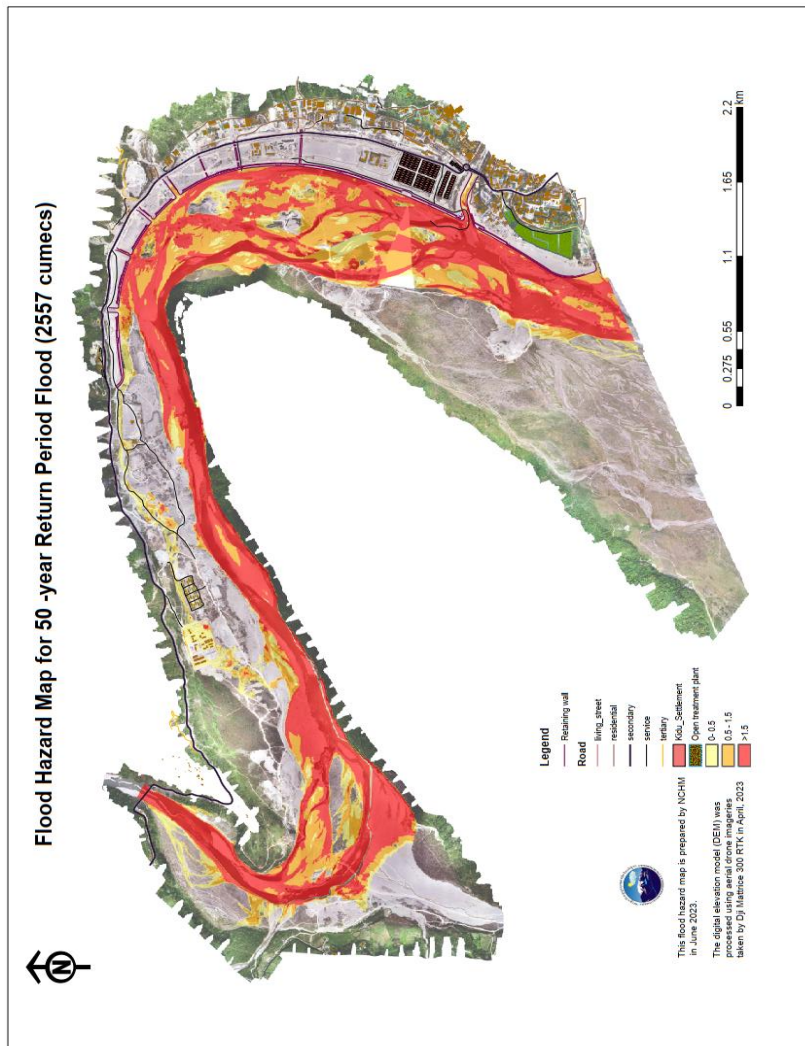


Figure 48: Flood hazard map of Amochhu Puntsholling, May 2023

16.6 FAO/DoA/NCHM GCF PROJECT CONCEPT NOTE

The NCHM has submitted SAP project Concept Note (CN) on “Building Resilience to High-Impact Hydro Meteorological Events through the Strengthening of Multi-Hazard Early Warning Systems in Bhutan” to GCF in November 2019.

With the support of FAO (AE), in collaboration with DoA, MoAL prepared project Concept Note (CN) Climate Resilient Water Resources Management and Enhanced Adaptive Capacity in the Drangmechhu River Basin was submitted to DNA (Department of Macro Fiscal and Development Finance, MoF). The NCHM project component will focus on hydrological monitoring and Flood/GLOF EWS for generation of data and information. The component is expected to

- Institutional strengthening and improved knowledge management:
- Water and Climate Information System:
- Basin-level forecasting capacities to produce early warning alerts, tailored to the specific needs of the diverse group of end users, for heavy rainfall, flood, and GLOF will be strengthened

16.7 AMBIENT WATER QUALITY MONITORING PROJECT

Through UNESCO support, HWRSD implemented an ambient water quality monitoring project "Integrated Water Resource Management for Bhutan's Future Water Security for Cities and Climate Resilient Development" which was funded by the Republic of Korea. The main aim of the project is to enhance the capacity for monitoring ambient water quality and develop effective protocols for monitoring, as well as knowledge sharing mechanisms.

Four pilot Ambient Water Quality Monitoring stations (AWQMS) were installed along with existing hydrological stations at Thimchu (Dodena and Lungtenphug stations) and Parochhu (Gunitsawa and Bondey station) in Wangchu basin.



Figure 49: Installation of WQMS at Parochhu

A workshop on Experience Sharing: River Water Quality Monitoring on 19th and 20th June 2023 in Thimphu was organized by NCHM in collaboration with UNESCO, New Delhi. The primary objective of this workshop was to facilitate the exchange of knowledge and experiences between experts from India and stakeholders in Bhutan regarding ambient water quality monitoring.

The program witnessed the active participation of various stakeholders, including the Department of Infrastructure Development, Department of Water, Department of Public Health, Department of Environment and Climate Change (DoECC), Dzongkhag Administrations of Thimphu and Paro, and the College of Natural Resources. This diverse group of attendees represented different sectors and institutions involved in water management, emphasising the importance of collaborative efforts. The workshop was supported by UNESCO through the project “Integrated Water Resource Management for Bhutan’s Future Water Security for Cities and Climate Resilient Development”.



Figure 50: Water Quality Monitoring Awareness Workshop

17 INSTITUTIONAL LINKAGES AND COLLABORATION

17.1 INTERNSHIP FOR STUDENTS

17.1.1: Sherubtse College Students

Five students (pursuing Bachelors of Environmental Studies) from Sherubtse College completed a month-long internship at NCHM. They started an internship at NCHM from 27 December 2022. During the final day of internship, they made presentations on the assigned works: Climate and Hydrological Data Analysis of selected stations. They also shared their experiences and knowledge gained to the NCHM management on 30 January 2023. The Director, NCHM awarded internship completion certificates to interns after the presentation.

Interns were introduced to different data analysis and programming tools. They also visited the hydrological and meteorological observation stations around Thimphu.



Figure 51: Sherubtse Interns at NCHM

17.1.2: CNR College Students

Six final year students studying B.Sc. Environmental and Climate Studies from the College of Natural Resources (CNR) completed a two-month internship at NCHM with presentations on the assigned works to the management on 03 February 2023. They also shared their experiences, knowledge and skills gained during the internship. The Director, NCHM awarded internship completion certificates to interns after the presentation.

Interns were attached with different technical divisions and assigned works on hydro-met data analysis using different data analysis and programming tools. Interns also visited the hydrological and meteorological observation stations around Thimphu.



Figure 52: CNR Interns at NCHM

17.2 STUDENT STUDY LEARNING VISIT TO NCHM

17.2.1 CNR students visited NCHM on 18th May 2023

26 first year students undergoing B.Sc Environment and Climate Studies at the College of Natural Resources (CNR) accompanied by faculty visited NFWFC and Babesa Class A Weather Station on 18 May 2023.

Students were briefed on NCHM structure, mandates, functions, hydro-met observations and services provided by the Centre. The students also visited the National Weather and Flood Warning Centre (NFWFC) to see and learn about the weather forecasting and flood monitoring. The educational visit concluded with a visit to Class A Meteorological Station at Babesa.



Figure 53: Photos CNR Study visit to NCHM, HQ and Meteorological Station

17.2.2 Little Dragon students visited NCHM and Weather Station on 29 June 2022

As a part of extended learning activity, school children from Little Dragons, Thimphu visited the National Weather and Flood Warning Centre (NFWFC) and Class A Meteorological Station at Babesa, Thimphu.



Figure 54: Little Dragon Students at Babesa Met Station

18 INSTITUTIONAL STRENGTHENING OF HYDRO-MET SECTOR

18.1 HYDRO-MET POLICY OF KINGDOM OF BHUTAN

The stakeholder consultation of the Draft Hydro-met Policy of Bhutan was conducted from 8th January to 31st January 2023 both at the central and local government level. The participants included policy makers, governing board members, representatives of central agencies, sector heads in the Dzongkhags, Gups, Mangmis and Tshogpas. A total of 40 Females and 120 males participated over a series of consultation workshops.

A National Legal Firm reviewed the draft policy and was reported that draft policy is found to comply not only with the existing national laws and regulatory frameworks but also with two most important international instruments, viz, the Chicago Convention and Convention of the World Meteorological Organization.

Upon which the Draft Final Hydro-met Policy was submitted to the Cabinet Secretariat for review and comments. The Draft Final Hydro-met Policy of Kingdom of Bhutan was submitted through the Ministry of Energy and Natural Resources to the Cabinet Secretariat for submission to LZ for approval on 18 May 2023.

18.2 LAND ACQUISITION FOR NCHM OFFICE AND SCIENTIFIC FACILITIES

For the establishment of permanent campus and scientific facilities, NCHM has acquired 5.0 acres of land at Yusipang under Chang Gewog, Thimphu Dzongkhag. The National Land Commission has issued Land User Certificate and Environment Clearance (EC) was obtained from the National Environment Commission Secretariat (NECS) for the construction of NCHM Office and facilities vide letter NECS/EACD/Dzo-Thimphu/4148/2022/1994 dated November 24, 2022.

The World Bank under the project “Strengthening Risk Information for Disaster Resilience in Bhutan Project (2021-2025)” allocated USD 80,000.00 for development of Guidance Note for the Construction of NCHM HQ and scientific facilities. A World Bank submitted the Technical Guidance Note for Establishment of NCHM HQ and Scientific Facilities in May 2023.

The Construction of Centre’s campus and facilities is planned to start during the 13 FYP with funding support through GoI and World Bank.

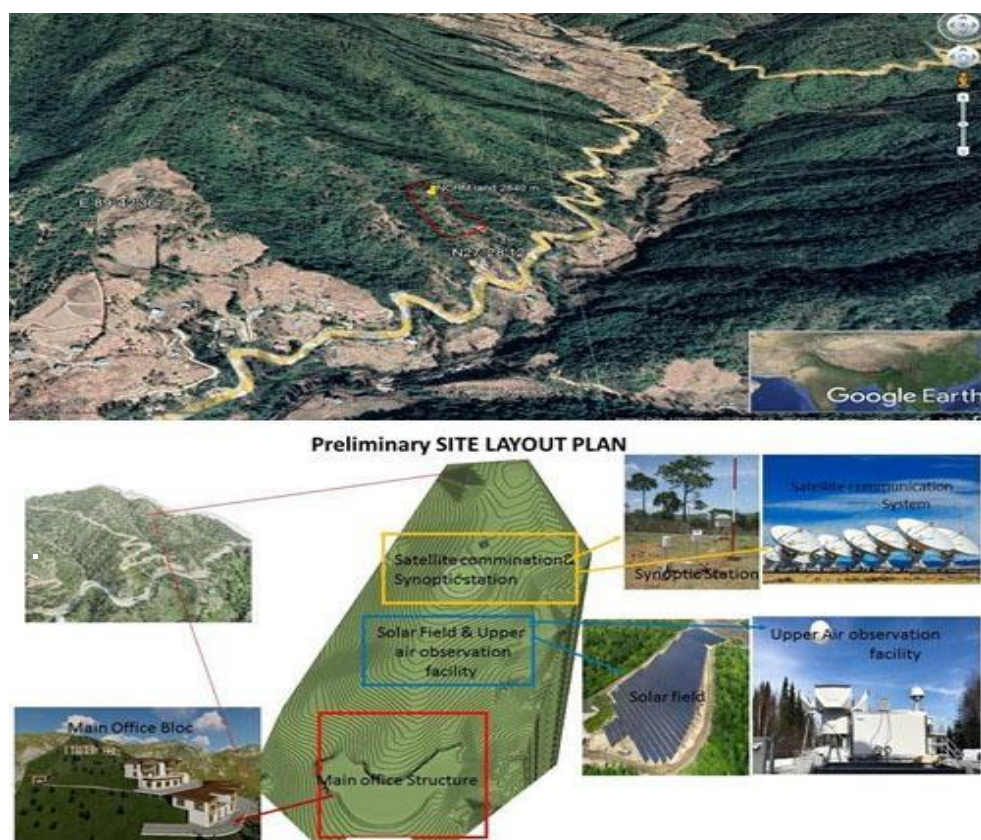


Figure 55: Conceptual Plan for NCHM HQ and NFWFC facilities

19 GOVERNING BOARD MEETING

19.1 9TH GOVERNING BOARD MEETING

The 9th Governing Board (GB) NCHM was held in Thimphu on 23 December 2022.

The meeting reviewed the progress of the planned activities for the FY 2022-2023 and endorsed NCHM Public Service Delivery Charter (2022), which was formulated to inform users about the various services provided by the Centre, how and where services can be accessed. The Charter was developed with the objectives to promote effective service delivery and ensure accountability.

The Annual Performance Agreement for the FY 2022-2023 was signed between the Chairman and the Director during the meeting.

Since this was the last Governing Board meeting of the Centre, Dasho Sonam P Wangdi, Chairman and Board members appreciated the Centre's management and commended for work and achievements after its establishment in 2016. Board members also provided recommendations for further development of the Centre in line with ongoing reform.

The last Governing Board meeting was held on 28 June 2022.



Figure 56: 19: 9th GB meeting, 23 December 2022, Thimphu, Bhutan

20 WMO AND IPCC MEETING

20.1 WMO REGIONAL CONFERENCE (RECO), RA II ASIA

The Director, the PR of Bhutan along with Mr. Tayba Buddha Tamang, Chief attended the Regional Conference (RECO) of WMO Regional Association II of Asian region on Early Warning for All: An initiative of UN and WMO held at Abu Dhabi, United Arab Emirates from 13-16 March 2023.



Figure 57: WMO RECO Abu Dhabi, United Arab Emirates from 13-16 March 2023

20.2 INTERGOVERNMENTAL PANEL FOR CLIMATE CHANGE (IPCC)

The National Center for Hydrology and Meteorology (NCHM) as the designated National Focal of Bhutan with IPCC attended the following meetings during the FY 2020-2021 with funding from the IPCC Trust.

Table 18: List of IPCC meeting

Sl. No	IPCC Meeting	Date
1	<p>Mr. Karma, Specialist attended the Fifty-Eighth Session of the IPCC (IPCC-58) was held from 13-17 March 2023 at Interlaken, Switzerland.</p> <p>The session adopted the Synthesis Report of the IPCC Sixth Assessment Report (AR6). On Monday, 20 March 2023, the IPCC released the Summary for</p>	13-17 March 2023

	Policymakers of the Synthesis Report for the Sixth Assessment Report in Interlaken, Switzerland.	
2	NCHM could not depute delegation to the Fifty-Seventh Session of the IPCC (IPCC-57) held from 27 to 30 September 2022 at the Centre International de Conférences Genève (CICG), Geneva, Switzerland.	7-30 September 2022

21 IMPORTANT EVENTS

21.1 UNDP REGIONAL DIRECTOR FOR ASIA AND THE PACIFIC VISIT TO LUNANA SEPTEMBER 18, 2022

Mr. Karma, Specialist, Cryosphere Services Division (CSD), NCHM, accompanied UNDP Regional Director for Asia and the Pacific Mrs. Kanni Wignaraja to Lunana on 18 September 2022 to witness firsthand how glaciers are melting fast due to climate change and the looming threat of glacial lake outburst flood (GLOF). She was accompanied by UNDP Resident Representative Azusa Kubota.



Figure 58: Visit to Lunana by UNDP Regional Director

The visit comes almost a decade after the draining of Thorthomi glacial lake through Bhutan's first National Adaptation Programme of Action (NAPA) project supported by GEF and UNDP together with partners. The project also helped put in place early warning systems, leading to improved disaster preparedness of communities in Lunana and downstream. The NCHM continues to monitor glaciers and glacial lakes.

During the visit, Ms. Wignaraja interacted with Glaciologist Karma, local leaders and community members to understand the impact of NAPA I project and current GLOF situation. She reaffirmed UNDP's commitment towards supporting national efforts to make Bhutan resilient to climate shocks.

21.2 36TH JOINT EXPERTS TEAM (JET) MEETING BETWEEN BHUTAN AND INDIA, 28-29 SEPTEMBER 2022

The 36th Meeting of Joint Experts Team (JET) between Govt. of India (GoI) and the Royal Government of Bhutan (RGOB) was held at Darjeeling, West Bengal, India on 28-29 September, 2022 after a gap of more than 3 years due to Covid19 pandemic. JET is responsible for overseeing the “Comprehensive Scheme for Establishment of Hydro-meteorological Observation and Flood Forecasting Network on Rivers Common to India and Bhutan” established in 1955.

JET reviewed the progress of the Flood Warning GoI program implemented by NCHM for the FY 2019-2020, 2020-2021, 2021-2022. The meeting approved the new activities for the FY 2022-2023. GoI reaffirmed support for modernization of the flood warning network in Bhutan and construction of NCHM HQ and scientific facilities in the 13 FYP.

JET meetings are held twice a year alternatively in Bhutan and India before and after monsoon. The next JET meeting will be held in Bhutan in the month of March/April 2023.



Figure 59: 36th JET meeting, Darjeeling, West Bengal, India on 28-29 September, 2022

21.3 NEW JICA CHIEF REPRESENTATIVE VISITED NCHM ON 12 OCTOBER 2022

Mr. Tomoyuki Yamada, Chief Representative, JICA Bhutan Office along with Mr. Masayoshi Kawai, Project Formulation Advisor visited the National Centre for Hydrology and Meteorology (NCHM) on 12 October 2022. Mr. Yamada was welcomed by the Director and Management of NCHM. Centre made a brief presentation about NCHM and updated on JICA assisted projects and its impacts on institutional and professional capacity of NCHM in delivery of hydro-met services in Bhutan.



Figure 60: JICA Representatives visit to NCHM HQ

21.4 37TH JOINT EXPERTS TEAM (JET) MEETING BETWEEN BHUTAN AND INDIA, 11-12 APRIL 2023

The 37th Meeting of the Joint Experts Team (JET) between the Government of India (GoI) and the Royal Government of Bhutan (RGoB) was held at Punakha, Bhutan on 11-12 April 2023.

The meeting reviewed the progress of the Flood Warning GoI program implemented by NCHM for the FY 2022-2023 and approved the proposed new activities for the FY 2023-2024. JET visited flood warning sites located along the Puna-Wangdi valley. GoI reaffirmed their continued support for the modernization of the flood warning network in Bhutan and the construction of NCHM headquarter and scientific facilities in the 13th FYP (2024-2029).



Figure 61: 37th JET meeting, Punakha, Bhutan, 11-12 April 2023

21.5 HANDING OVER OF HISTORICAL DATA

Based on the request of NCHM, the Centre Water Commission (CWC), Government of India handed over the available hydro-met historical data of flood warning Stations in Bhutan during the 37th JET meeting on 11 April 2023.

Hardcopies data was handed over by Chief Engineer/ Head of GoI delegation of JET to the Director, NCHM



Figure 62: Historical hydro-met data (hard copy) handing taking between CWC and NCHM

21.6 ORIENTATION PROGRAM

Mr. Sangay Tshering and Ms. Dechen Lhamo Gyeltshen joined the Centre as Meteorology/Hydrology Officer on 4 January 2023. They are second batch graduates with bachelor degrees in meteorology & climate and atmosphere science joined the Centre. They have completed Bachelors of Science in Meteorology and Climate Studies from the University of Reading, United Kingdom. The Centre conducted the onboarding programme from 4th - 6th January 2023 to orientate them on NCHM's visions, missions, organisational structures, mandates and functions as well as civil services rules and regulations.



Figure 63: Orientation program for new technical graduate, 4th January 2023

21.7 WORLD BANK VICE PRESIDENT VISITED NCHM, 16 NOVEMBER 2022

Mr. Martin Raiser, Vice President, World Bank for the South Asia Region and Officials visited the Centre on 16 November 2022. The Vice President met with NCHM management and visited the 24/7 National Water and Flood Warning Centre (NFWFC).

Mr. Martin Raiser appreciated the work and services provided by the NCHM and he stressed the importance of dissemination of information to the last mile and regional collaboration. Mr. Martin assured the World Bank continued support to strengthen

the hydro-met sector in Bhutan for climate-resilient sustainable development and disaster risk reduction.



Figure 64: NCHM Management with World Bank Vice President South Asia Region, 16 November 2022

21.8 WORLD BANK REGIONAL DIRECTOR, VISITED NCHM, FEBRUARY 2023

Ms. Cecile Fruman, Regional Director, World Bank for South Asia Region visited the Centre on February 2, 2023. Director met with NCHM management and visited the 24/7 National Water and Flood Warning Centre (NWFWC). The Centre also made a brief presentation about the Centre and its roles in hydro-met observations, data management, modeling and prediction and research for effective delivery services for planning appropriate adaptation and mitigation measures against climate change impacts and associated challenges and issues. The World Bank and NCHM also discussed the impacts of World Bank-supported projects implemented by the Centre and the future potential projects



Figure 65: NCHM Management with World Bank, Regional Director South Asia Region, February 2, 2023

21.9 WORLD BANK REGIONAL DIRECTOR, VISITED NCHM, 27 APRIL 2023

A mission team led by Mr. John Roome, Regional Director, South Asia Region (SAR), World Bank Group visited National Centre for Hydrology and Meteorology (NCHM), 3 May 2023 and met with NCHM management and visited the 24/7 National Water and Flood Warning Centre (NFWFC). The Centre also made a brief presentation about the organization and its roles in hydro-met observations, data management, modelling and prediction and research for effective delivery services for planning appropriate adaptation and mitigation measures against climate change impacts and associated challenges and issues. The World Bank and NCHM also discussed the impacts of World Bank-supported projects implemented by the Centre and the future potential projects that required financial and technical support in the following areas.

- a. Construction of dedicated NCHM HQ, National Weather and Flood Warning Centre (NFWFC) and Scientific facilities;

- b. Strengthening Agro-met and Aviation Meteorological Services and
- c. Hydrological observation, forecasting and early warning services



Figure 66: NCHM Management with World Bank officials

21.10 CIVIL SERVICE AWARD CEREMONY 2021

The Civil Service Award Ceremony for the National Centre for Hydrology and Meteorology (NCHM) for the year 2022 was held on 13 December 2022. The ceremony was graced by Director, Management and JICA experts. Along with the Dedicated Civil Service Award for 24 employees, the Centre also awarded:

- a. An appreciation certificate for five Outstanding Employees for the appraisal period 2021-2022
- b. Promotion orders for 26 employees promoted with effect from 1 January 2023
- c. The Civil Service Awards were conferred to the recipients in keeping with the Royal Command issued to the Royal Civil Service Commission for recognition of their dedicated service to the TSA-WA-SUM.
- d. The Director also handed over the promotion order of Mr. Karma, Specialist III who has been promoted to Specialist II (ES2) with effect from 1 January 2023 to 16 December 2022.



Figure 67: Recipients of Awards and Promotions 2022

21.11 OBSERVING ZERO WASTE HOUR

Pursuant to the launch of the Zero Waste Hour on 2 June 2019 by Her Majesty the Gyalsuen, coinciding with the Coronation Day of His Majesty the Fourth Druk Gyalpo, every second day of the month is observed as the Zero Waste Hour. The Center has made it mandatory for the HQ and all the site's offices to observe the Zero Waste Hour every month by cleaning the office surroundings and hydro-met stations throughout Bhutan.



Figure 68: Selected photos Zero Waste Hours from NCHM HQ and field office/Station

22.1 IN-COUNTRY TRAINING

22.1.1 OPERATIONAL HYDROLOGY AND METEOROLOGY REFRESHER COURSE, 1-12 MAY 2023

NCHM conducted a two weeks refresher course on “Operational Hydrology and Meteorology” for the field technicians from 1-12 May 2023 with funding support through the Flood Warning GoI program. The course was conducted by in-house resources persons/experts from different divisions. A total of 22 participants attended refresher courses. The participants include staff from the Hydrology and Flood warning Stations, new staff working in HQ, Thimphu and new staff deployed by RCSC from other agencies in April 2023.

The objective of the course is to provide participants, the fundamental concepts and principles of hydrology, meteorology, and cryosphere science, as well as the proper methods for collecting and utilizing hydro-met data. Training included hands-on practical training on observation, maintenance and operation of hydro-met equipment and instrumentation. Course also included a field visit for practical sessions to carry out discharge, sediment lab sampling and analysis and calculations. The courses included use of online eDATS (MoF), BSCR 2018 and use of MAX (RCSC), Asset declaration etc.



Figure 69: Operational Hydrology and Meteorology refresher course

22.1.2 FLOOD FORECASTING AND FLOOD RISK ASSESSMENT TRAINING

NCHM with technical support from RIMES (Regional Integrated Multi Hazard Early Warning Systems) based in Thailand conducted a training workshop on Flood Forecasting, Flood Decision Support System (FDSS) and Flood Risk Assessment in Thimphu from August 22 to September 2, 2022.

The training was supported through the World Bank project: Strengthening Risk Information for Disaster Resilience in Bhutan project implementation by the Center with experts from RIMES.

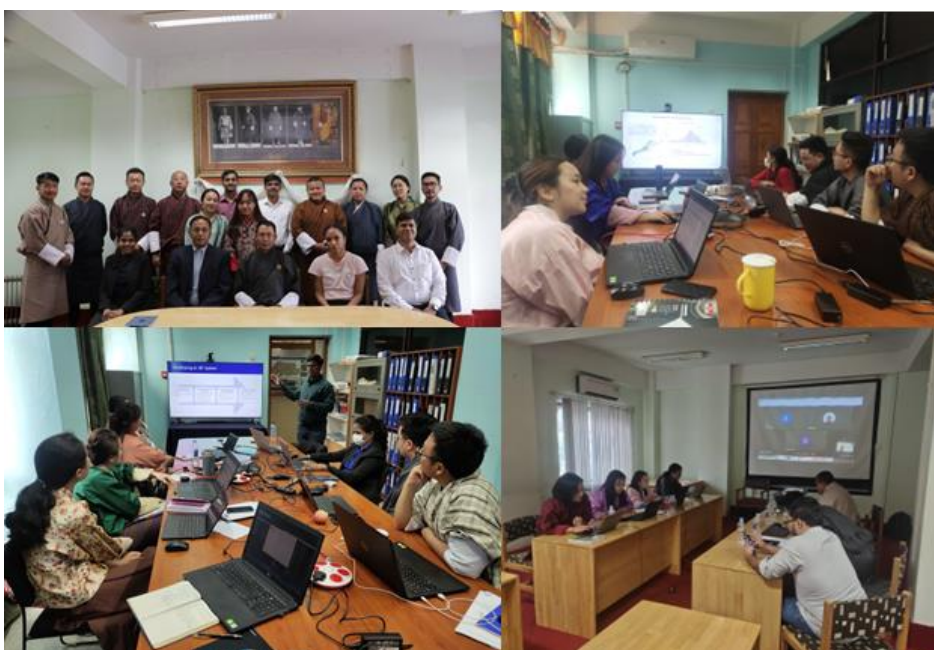


Figure 70: Training Program on Flood Forecasting, Flood Decision Support System (FDSS)

22.1.3 AVIATION-MET REFRESHER COURSE 14-19 NOVEMBER 22((1ST BATCH) AND 28 NOV 2 DECEMBER 2022 (2ND BATCH)

National Centre for Hydrology and Metrology (NCHM) is the designated National Aeronautical Meteorological Service Provider (AMSP) within Bhutan by the Bhutan Civil Aviation Authority (BCCA) as per the Civil Aviation Act of Bhutan. NCHM is responsible for operation and maintenance of airport weather stations and provides aviation weather forecast services for operation of flights and air navigation. Skilling, reskilling and certification is mandatory requirement of staff working u

The refresher course was conducted to enhance knowledge and skills of the staff working at Paro International Airport and domestic airports for effective delivery of aviation weather services. The course covered both theoretical and practical sessions on Mesoscale meteorology, GTS and satellite, Aviation meteorology, HF communication, observation and maintenance.

Refresher course was conducted by the NCHM technical team under RGoB funding.



Figure 71: Aviation-met refresher course

22.1.4 HANDS ON TRAINING ON OPERATION OF ICE RADAR, E-BEE PLUS RTK, DJI MATRIX AND DGPS 14-20 DECEMBER 2022

To enhance the capacity through transfer of knowledge and skills, the Centre conducted hands-on training for staff working under the Cryosphere Services Division (CSD) and Hydrology and Water Resources Services Division (HWRSD). The hands-on training was provided by certified experts (NCHM Staff) who have attended the training before. The training program includes both theoretical and practical sessions covering following:

- a. Operation of Ice Penetrating Radar (IPR)
- b. eBee Plus & DJI Matrix 300 RTK Unmanned Aircraft System
- c. GPS-GNSS connection using base and multiple rovers

The training was supported through the World Bank supported Project "Strengthening Risk Information for Disaster Resilience in Bhutan" implemented by the Centre.



Figure 72: Training on operation of Ice Radar, eBEE Plus RTK, DJI matrix and dGPS

22.1.5 WORKSHOP ON CROP WEATHER CALENDAR, 23-25 NOVEMBER 2023

NCHM conducted a 3 days' Workshop to develop Crop Weather Calendar from 23-25 November 2022 in Thimphu under the GCF/UNDP supported Project "Supporting Climate Resilience and Transformational Change in the Agriculture Sector in Bhutan".

Officials from Agriculture Research and Development Centre (Bajo, Wengkhar and Samtenling), National Centre for Organic Agriculture (Yusipang), National Plant Protection Centre (Semtokha) and Department of Agriculture, MoAL attended the workshop.

The participants from DoA and NCHM jointly developed the Crop Weather Calendar for major crops such as chilli, potato, rice, maize, etc. The Weather Calendar will serve as one of the products to improve climate knowledge and application in the agriculture sector.



Figure 73: Workshop on crop weather calendar

22.1.6 KNOWLEDGE SHARING WORKSHOP ON CDMS AND AWS

The NCHM operates a National meteorological observation network consisting of both manual and automatic stations covering the whole of Bhutan with application systems for service development. With high attrition of trained staff, the Centre conducted an internal knowledge transfer workshop for five days, from 24-28 April 2023, for new employees for succession planning. The workshop aimed to impart comprehensive knowledge and abilities in Centralised Database Management System metadata management, installation and setup of Automatic Weather Stations, data collection and analysis, calibration and maintenance, advanced operations and troubleshooting. The program concluded with the field visits to actual AWS sites to provide learning experiences. The program was supported by the GCF Project.



Figure 74: CDMS and AWS knowledge sharing workshop

22.1.7 TRAINING ON WRF

The internal workshop took place at the NCHM's mini conference hall in Thimphu for 3 days from November 21 to 23, 2022. The GCF project "Supporting Climate Resilience and Transformational Change in Bhutan's Agriculture Sector," which the centre is currently implementing, has as one of its goals improving forecasting abilities. The program aimed to assist in understanding the installation of the WRF model and verification of new WRF.

22.1.8 TRAINING ON SMART-MET

With the support from the GCF/UNDP supported Project "Supporting Climate Resilience and Transformational Change in the Agriculture Sector in Bhutan, WFCR conducted training on SmartMet which is a Common Operating Platform for weather forecasts and Weather Research and Forecasting Model, by inviting experts from the Finnish Meteorological Institute in May and June.

The advanced training on SmartMet with data server set-up, software upgrades, additional weather models and observation data to SmartMet will improve the accuracy of the weather forecast. The training will have capacity and knowledge to produce automated tailored forecast information for the NCHM weather app, website and social media and produce tailored forecasts for the stakeholders.

The Weather Research and Forecasting (WRF) Model is a state-of-the-art atmospheric modelling system that provides meteorological research and numerical weather prediction capabilities. WRF runs four times a day at NCHM,

and it is the main source of daily weather forecasting. The training will set up a new version of the model in a new server with higher specs and memory for long-term operation use.

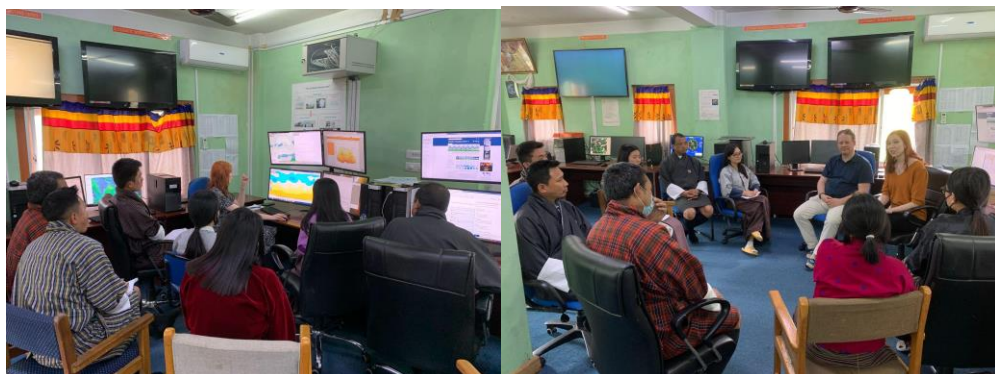


Figure 75: Smart-MET Training at NCHM HQ

22.2 SHORT TERM TRAINING (STT)

During the FY 2022-2023 the employees of the Centre have attended various training, meetings and seminars with the support from international, bilateral, regional partners and projects both in person and virtually to enhance the professional capacity and to keep abreast with emerging technology. The Centre during the span of one year has facilitated 52 STT where 93 individual employees attended the training as detailed below. As for the mode of delivery of the STT's 30 STT programs were conducted in person while 22 were done virtually.

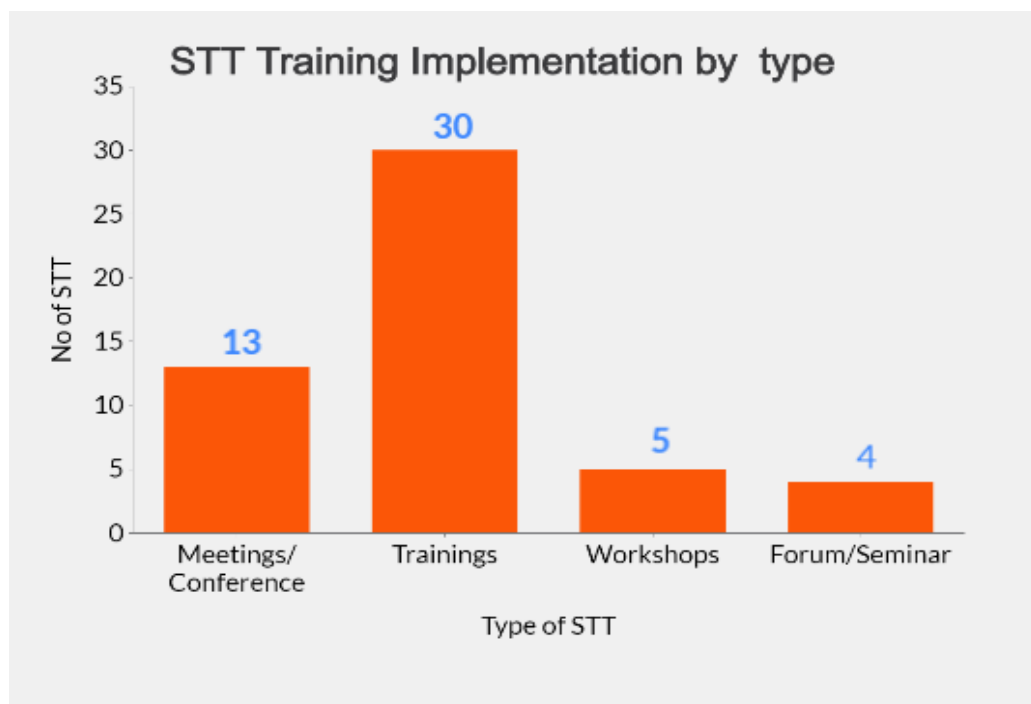


Figure 76; Types of STTs attended for the FY 2022-2023

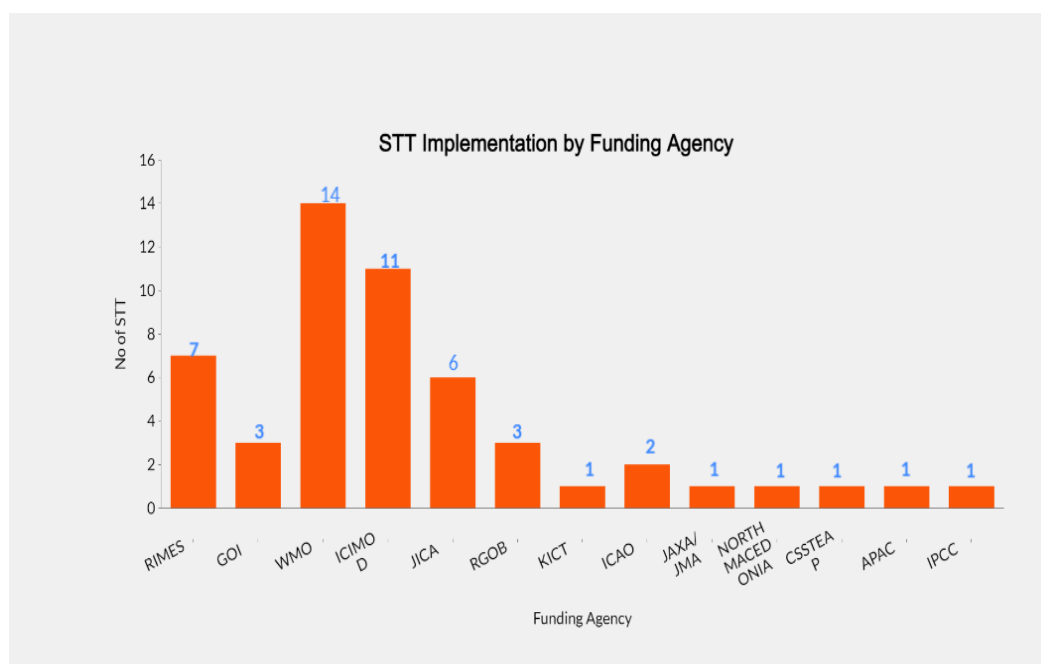


Figure 77: STT with donors/funding agency

22.3 MANDATORY MEETING/WORKSHOP/CONFERENCE

The NCHM is designated as the national focal point of Bhutan with WMO, IPCC, ICAO and other regional organisations. The Centre officials attended mandatory meetings/seminars and workshops of IPCC, WMO, RIMES and ICAO for financial year 2022-2023 as detailed in the table below.

Table 19: List of Mandatory Meetings/Conference Attended

Sl. No.	Name of Participants/ Delegation	Position	Title of Meeting/ Conference	Dates	Funding Sources
1	Karma Dupchu	Director	36th Joint Expert Team (JET) Meeting	28-29 Sept, 2022	GoI
	Tayba Buddha Tamang	Chief M/H Officer			
2	Karma Dupchu	Director	Second Meeting of the Governing Board of the BIMSTEC Centre for Weather and Climate (BCWC) and Scientific Advisory Committee of the BCWC	1-2 Nov, 2022	RGOB
3	Karma Dupchu	Director	Regional Conference (RECO) in the Regional Association II (Asia)	13-16 Mar, 2023	WMO
	Tayba Buddha Tamang	Chief M/H Officer			
4	Karma	Specialist II	Fifty-Eighth Session of the IPCC (IPCC-58)	13-17 March 2023	WMO/ IPCC
5	Ugyen Lhamo	Met/Hyd Officer	ICAO Asia and Pacific (APAC), Twenty-first Meeting of the Meteorological Information Exchange Working Group and ICAO Asia and Pacific (APAC),.	27-31 Mar, 2023	RGoB

22.4 SHORT TERM TRAINING (EX-COUNTRY)

With the funding support of the Flood Warning Program (GoI), 15 (Fifteen) Hydro-met Technicians from Site Offices attended 12 days Hydro-meteorological Observation training at North Eastern Regional Institute of Water and Land Management (NERIWALM), Tezpur, Assam, India from 6 to 17 February, 2023 and Land Management (NERIWALM), Tezpur, Assam, India from 6 to 17 February, 2023

February, 2023 and Land Management (NERIWALM), Tezpur, Assam, India from 6 to 17 February, 2023

The tailor-made training was organized by NERIWALM based on the request of NCHM through Center Water Commission (CWC), Ministry of Water Resources, River development and Ganga Rejuvenation, Government of India.

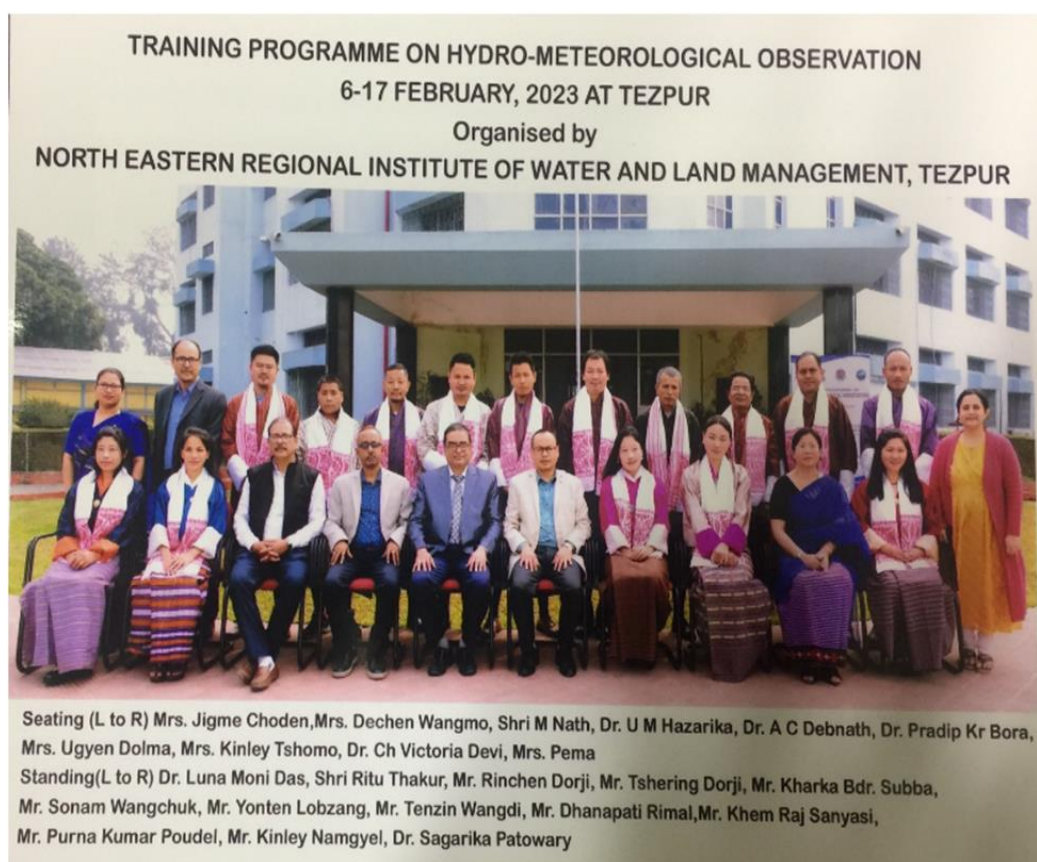


Figure 78: Training program of hydro-met technicians at Tezpur, India

22.5 LONG TERM TRAINING

Currently, the following officials are pursuing long-term studies under various scholarships as detailed in table below.

Table 20: List of Employees on long-term trainings for FY 2022-2023

Sl#	Name/P Title	Course	Institute /Country	Funding
1	Mr. Tandin Wangchuk (Sr. Met/Hyd Officer)	Master in Flood Disaster Risk Reduction	National Graduate Institute for Policy Studies, Japan.	JDS
2	Mr. Trashi Namgyel ¹ (Dy. Chief Met/Hyd Officer)	Masters of Technology (Water Resources and Development)	Indian Institute of Technology Roorkee (India)	Nehru Wangchuck Scholarship

23 INSTITUTIONAL PARTNERSHIP AND TECHNICAL BACKSTOPPING SERVICES

23.1 TECHNICAL BACKSTOPPING TO DHI

Based on the request of Druk Holding and Investment Limited (DHI), NCHM provided technical backstopping services of aerial drone survey for following areas for the FY 2022-2023.

- a. Jigmeling industrial area, Gelephu under Sarpang from November 24 to 30, 2022.
- b. Phuentsholing area from April 9 to 15, 2023.

Upon completion of the aerial drone surveys, final products in the forms of high resolution digital elevation model (DEM), digital terrain model (DTM), orthomosaic and contours were delivered.

¹ Mr. Trashi Namgyel joined back on 2 July 2023 upon successful completion of course.

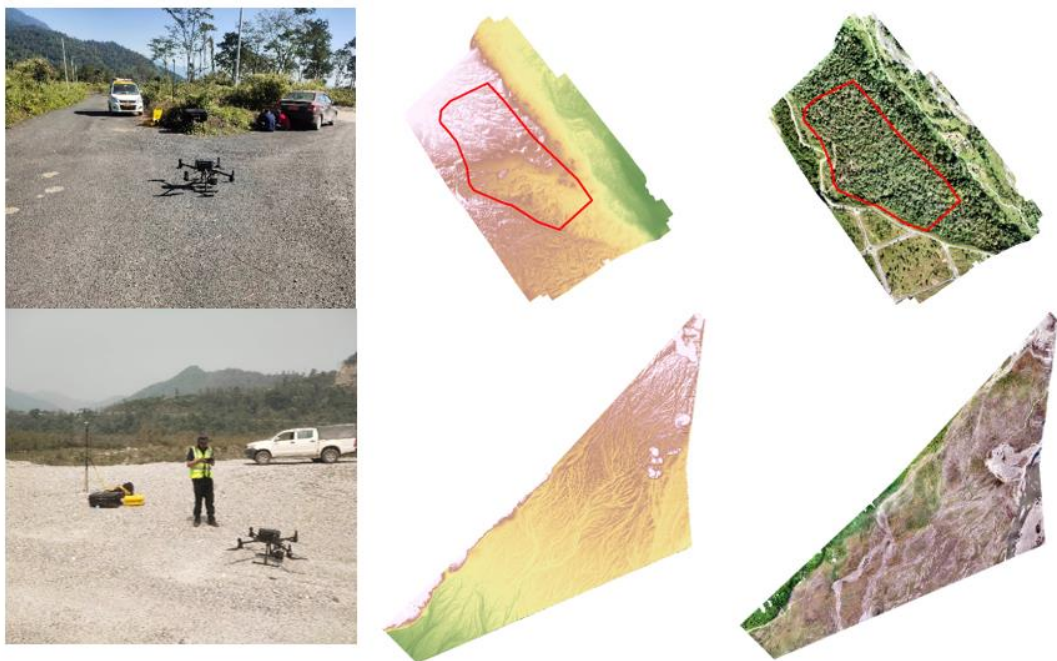


Figure 79: Aerial drone survey and products

23.2 TECHNICAL BACKSTOPPING SERVICES TO DGPC

With request from the Tangsibji Hydro-Energy Limited (THyE) NCHM provided technical backstopping services to carry out river cross-section profiling and lean flow measurement for Nikachhu at the downstream of Dam. The work was carried out by Mr. Sangay Tempa, Mr. Sonam Dorji and Mr. Tashi Tenzin carried in the month of January. The flow measurements for the remaining three months (February, March and April 2022) were carried out by Mr. Tashi Tenzin, Hydromet Technician at Bjizam Hydrological Station.

Since, there was no feasible and accessible site for flow measurement of Nikachhu from Dam to Nikachhu-Mangdechhu confluence stretch, the team took a separate flow measurement for Mangdechhu Dam Outlet at confluence and combined flow measurement (Nikachhu-Mangdechhu) at upstream of Kela bailey bridge, upon which the flow for Nikachhu was computed after deducting the discharge of Mangdechhu Dam outlet from the combined discharge.



Figure 80: Lean flow measurement carried out for THyE

23.3 NCHM AND JIGME NAMGYEL ENGINEERING COLLEGE

Based on the request of Jigme Namgyel Engineering College, NCHM deputed Mr. Sangay Tenzin and Mr. Jamyang Zangpo as adjunct lecturers to conduct practical applications of aerial drone survey for the fourth-year students of Bachelor of Survey and Informatics from May 9 to 16, 2023.

During the course of one week, students were provided hands-on practical in automatic as well as manual piloting of drones, mission planning, ground control points distribution, data collection and finally processing the collected data to generate different survey-grade products such as DEM, DSM, DTM, orthomosaic and contours.



Figure 81: Adjunct lecture at JNEC on aerial drone application in survey

23.4 NCHM AND SHERUBTSE COLLEGE

Based on the request of the college, the NCHM has deputed Ms. Sonam Lhamo, Executive Geologist, Cryosphere Services Division as a guest lecturer for a period of week to teach first year Bachelors of Science in Environmental Science students on basic Hydrology, Hydrogeology and General Geology.

The guest lecture session is a good opportunity for the Specialist of the scientific agency to share the knowledge and research works with the students.



Figure 82: Guest lecture session delivered to Sherubtse College, RUB

24 WELL BEING OF STAFF

24.1 NCHM STAFF WELFARE FUND

To strengthen solidarity among the staff and provide financial support in times of need, the Center established a Staff Welfare Scheme in 2017 with monthly contributions from the members. The membership is open to all the staff of NCHM on a voluntary basis. The Welfare Scheme is managed by the Committee nominated from the members during the Annual General meeting.

24.2 FAREWELL FOR OUTGOING STAFF, FY 2022-23

The NCHM family bids farewell to following employees on Separation (Voluntary Resignation and Superannuation) for the FY 2022-2023

1. Mr. Ganesh Bahadur Pradhan upon attending superannuation on 18 October 2022.
2. Mr. Indra Bdr. Ghalley Meteorology/Hydrology Technician superannuated on 14/03/2023.
3. Mr. Sonam Dorji, Driver, superannuated on 16/09/2022
4. Ms. Tshewang Zangmo, Meteorology/Hydrology Technician voluntarily resigned on 10/03/2023.
5. Mr. Tshewang Dorji Doya Meteorology/Hydrology Technician resigned voluntarily on 14/03/2023.
6. Mr. Janchub Chophyel Dorji, Sr. Hydromet Officer resigned voluntarily on 01/02/2023.
7. Mr. Karma Wangda, Sr. Technician resigned voluntarily on 01/02/2023.
8. Mr. Sonam Tashi, Met/Hyd Technician resigned voluntarily on 16/09/2022.
9. Mr. Chhado, Met/Hyd Technician V resigned voluntarily on 16/09/2022.



Figure 83: NCHM bids farewell to outgoing employees

25 MONTHLY POTLUCK LUNCH

To promote friendship and solidarity among the employees of different divisions of the Center, a monthly potluck lunch was restarted after the COVID19 pandemic from January 2023. Monthly potluck is held on last friday at the end of every month.



Figure 84: Potluck Lunch within NCHM HQ employees

26 CHALLENGES AND ISSUES

Being a 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 the key issues and challenges that need immediate interventions.

- a. Lack of office space and scientific facilities
- b. No legislation
- c. Technical nature of job and 24/7 functions
- d. Limited trained technical professional for effective delivery of hydro-met services.
- e. High attrition of trained technical professionals leaving the Centre and
- f. No dedicated ICTO to look after the ICT infrastructure of the Centre.

Annexure - I: Table 21: NCHM APT for the FY 2022-2023 and Achievement

FYP Outcomes (AKRA)	AKRA KPIs	Unit	Baseline	Target	Achievement
1. Hydro-meteorological & Cryosphere disaster assessed & reduced	National Hydro-met Observation network enhanced and operationalized	Number	240	247	<p>AWS Installed Gyalsung Sites</p> <ol style="list-style-type: none"> 1. Bongdeyma, Mongar 2. Pemathang, Samdrup Choling, S/Jongkhar 3. Tareythang , Gelegphug, Sarpang 4. Jamtsholing (Upgraded at Sibsoo Class A Met Site), 5. Annual Maintenance of Meteorological Network station for the FY 2022-2023 completed. 6. Flood Monitoring office of Ammochu Ghakiling/Sombaykha , Haa completed. 7. Rehabilitation of Bjizam Hydrological station (Civil works) on Mangdechhu, Trongsa completed. 8. Renovation of the Flood Warning Site office and Sediment lab started but spilled over to next FY. 9. Tendering for Construction of Flood Warning and Cryosphere Research Facility at Lunana completed under BFL funding support. 10. Procurement of Hydro-met equipment and spare parts for the FY 2022-23 completed. 11. Rehabilitation of the Cableway system on Nye Amari Bangtar completed.
	Flood/GLOF Early	Number	6	8	1. Rehabilitation work for Bjizam Hydrological/GLOF

	Warning Services (EWS) provided				<p>EWS station damaged by flood in October 2022 completed through support of MHPA (Civil) and JICA (equipment). Satellite communication from METEOSAT to HIMAWARI satellite (Japanese Satellite) all the five GLOF EWS stations for Mangdechhu and Chamkharchhu basins were completed in November 2022.</p> <ol style="list-style-type: none"> 2. Site assessment of EWS system Ammochhu completed and tendering work under process by UNDP through GCF/NAP Project. 3. Setting up of Flood Forecasting Decision Support System (FDSS) of Ammochu Basin under development 4. Site survey and assessment of Flood EWS system of Thimphchhu and Parochu completed through the JICA TCP project 5. Annual Maintenance of GLOF EWS along the Punatsangchhu, Mangdechhu and Chamkarchhu completed and operational; 6. 24/7 Flood/GLOF monitored for 365 days and advisory and warning services provided. through different websites and social media.
	Hydrological and flood hazard and risk assessed	Number	15	18	<ol style="list-style-type: none"> 1. Socio-economic Data collection of Lunana for flood hazard and risk assessment of Punatsangchu basin implementation

					<ol style="list-style-type: none"> 2. Flood Hazard assessment of Thimchu and Pachu completed and hazard mapping under implementation through JICA TCP project. 3. Ammochhu flood hazard map updated
	Cryosphere (Glaciers, galcier lakes, permafrost and snow) monitored and hazard assessed	Number	38	44	<ol style="list-style-type: none"> 1. Assessment and monitoring of benchmark glacier (<i>Thana</i>) Chamkharchu for the year 2022 Completed in October 2022. 2. Assessment and Monitoring of benchmark glacier (<i>Gangju La glacier</i>) Phochhu head water completed in October 2022. 3. Assessment and Glacial Lake monitoring program on <i>Burtsam lake</i> at Gangkhar Phuensum, Chamkarchhu headwater for the year 2022 completed in October 2022. 4. Time series monitoring of lakes in Lunana for the year 2022 completed in October 2022; 5. Geotechnical Data collection for GLOF Risk Assessment and Aerial Survey of <i>Karma Lake</i> in the Headwater of Pachhu completed in August 2022. 6. Assessment and monitoring of a new benchmark glacier (<i>Shodug glacier</i>) in the headwater of Thimchhu conducted from April 10 to 30, 2023. 7. Assessment of Glacial Lake for GLOF Risk Assessment on <i>Sintaphu</i> Glacial Lake head water of Mochhu conducted from May - June, 2023

					(Technical Reports for the all the field activities submitted)
	Research work/papers published, standardisation and calibration facilities established and operationalized	Number	0	3	<ol style="list-style-type: none"> 1. Four Research Papers published in Bhutan Hydro-met Journal for the FY 2022-2023: <ol style="list-style-type: none"> a. Glacier Variation (terminus & surface area) in Bhutan Himalaya from 1990-2020 as deduced from three benchmark glaciers (Shodug, Gangju La and Thana) and their relative changes with other glaciers in the Himalaya. Karma and Tseten Namgay, CSD, b. Assessment and Mapping of Water Sources in Bhutan: A comprehensive inventory and status of water sources used by the communities by Jamyang Phuntsho (NCHM) and et al. c. Development and validation of channel rating equations for Automatic Water level station sites by Jamyang Zangpo and Chimi Namgyel and d. Verification of 24-hour Surface Maximum and Minimum Temperature Forecast in Bhutan for the year 2022 by Cheki Wangchuk (CNR), Dr. Singay Dorji, Saroj Acharya, Pema Sylton (MSD, NCHM) 2. Standard and Calibration <ol style="list-style-type: none"> a. WMO certified Instrument Calibration lab setup in

					<p>Thimphu under JICA support.</p> <p>b. Operation Manual for Hydrological Observation developed and published (2023) by TSRD</p> <p>c. Operation Manual for hydrological instrumentation developed and Published (2023) by TSRD</p> <p>d. SOP for Calibration Developed and Published (2023) by TSRD</p> <p>e. SOPs for Divisions Revised (2023) and published</p>
2. End-to-end operational National Framework for Climate Services (NFCS)	Public Weather Service (PWS) provided	Number	0	4	<p>1. National Weather and Flood Warning Centre (NWFC) operated 24/7 and weather forecast /advisories issued on daily basis through BBS TV/Radio, social media Facebook, WhatsApp's Groups, and Website;</p> <p>2. Global Telecommunication System (GTS) updated for data exchange for weather forecasting.</p> <p>3. A dedicated Weather Studio setup under NWFWC to enhance weather information dissemination;</p> <p>4. SmartMet System- a platform for weather forecasting upgraded</p> <p>5. WRF Model system upgraded</p>

	Aviation meteorological services provided	Number	5	6	<ol style="list-style-type: none"> 1. Aviation weather forecast issued for operation of both international and domestic flights on a daily basis. 2. Refresher Course on Aviation Meteorology two batches completed (14- 18 November 2022, and November 2022 – 2 December 2022) 3. Weather Briefing System of Pilot under development
	Climate data, information and services provided	Number	9	10	<ol style="list-style-type: none"> 1. Climate Summary Data Book for Year 2022 published 2. State of Climate Report 2022 Published 3. Monsoon Outlook for year 2023 issued during the National Climate Outlook Forum (NCOF-9) 4. Medium Range Weather Forecast for Bhutan (Pilot Phase) for next ten day issued every week (on Friday) 5. Climate observation and data collection from both manual and automatic stations continued on a daily basis. 6. Climate data shared with users based on the request. 7. Climate Services Took Kits of Bhutan launched 8. Central Database for Management System (CDMS) of Hydro-met Data developed and operation

3. Access to hydrological information and understanding of national water availability improved	Hydrology and water resources data, information generated and disseminated	Number	3	4	<ol style="list-style-type: none"> 1. Hydrological/Flood observation and data collection from both manual and automatic stations continued on a daily basis. 2. Data shared with users based on the request. 3. Surface Hydrological Data Book for year 2022 published
4. Water quality improved	Sediment and ambient water quality monitoring network enhanced	Number	18	19	<ol style="list-style-type: none"> 1. Setting up of a Sediment lab at Tamchhu hydrological Site office on Wangchhu completed in Nov 2022. 2. Tendering for supply Automatic Water Quality Monitoring Station completed in Nov 2022. 3. Automatic Water Quality Monitoring (AWQM) installed at Begena, Thimpchu 4. Automatic Water Quality Monitoring (AWQM) installed at Lungtenphu, Thimpchu 5. Automatic Water Quality Monitoring (AWQM) installed at Gunitsawa, Parochhu 6. Automatic Water Quality Monitoring (AWQM) installed at Bondey, Parochhu

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