ANNUAL REPORT
2023-2024

NATIONAL CENTRE FOR HYDROLOGY AND METEOROLOGY
ROYAL GOVERNMENT OF BHUTAN
THIMPHU: BHUTAN
JULY 2024

ANNUAL REPORT
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National Centre for Hydrology and Meteorology
Royal Government of Bhutan
Thimphu: Bhutan
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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
DGPC	Druk Green Power Corporation
EWS	Early Warning System
GB	Governing Board
GCF	Green Climate Fund
GFCS	Global Framework for Climate Services
GLOF	Glacier Lake Outburst Flood
GoI	Government of India
GTS	Global Telecommunication
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
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
SOFF	Systematic Observation Financing Facilities
STAC	Scientific Technical Advisory Council
TSRD	Technical Standard Research Division
UNDP	United Nation Development Programmed
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: New GLOF Monitoring and Cryosphere Research Office, Lunana (Constructed under BFL Project funding)

1 About Organization

The National Centre for Hydrology and Meteorology (NCHM) is a scientific and technical autonomous agency of the Royal Government of Bhutan under the Ministry of Energy and Natural Resources created in 2016. The Centre is responsible for understanding the behaviors of the atmosphere, its interaction with 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 established 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 Vision, Mission and Core Values

2.1 Vision

Vision

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

2.2 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.

2.3 CORE VALUES

Figure 1: NCHM Core values

2.4 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.

2.5 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 functions of NCHM are:

a. Establish and operate National Observation network and telemetry system for weather, climate, cryosphere, hydrology and water resources;
b. Maintain national database (repository) of hydrology, meteorology, cryosphere and related environmental data and information
c. Provide Public Weather Services (PWS), climate services, ago-meteorology, climate projection and
d. Aviation meteorological observation and provide aviation meteorological services.
e. Provide hydrological forecasting (flow and flood), water resource availability assessment.
f. Assessment and mapping of hydro-meteorological and GLOF hazards, and provide Early Warning Services.
g. Study and monitoring of snow, glaciers and glacial lakes in the country. Conduct scientific studies on cryosphere to make inventory and assess its potential in terms of water resources. Carry out hazard assessment and recommend suitable measures to address risk and hazard associated with this field.
h. Promote and conduct research on cryosphere, meteorology (weather and climate), hydrology and water resources;
i. Enhance human resources development and professional capacity in the field of hydro-meteorology and cryosphere services;
j. Promote and facilitate standardization of hydro-met instruments, methods of observation and recording.
k. Establish collaboration and linkage with national, regional and international organisations.

3 Organisation Structure and Staffing

3.1 Organisation

The Centre 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. The Governing Board of NCHM was dissolved upon enactment of the Civil Service Reform Act of Bhutan 2022. The last Governing Board meeting of the Centre was held on 23 December 2022.

As per the RCSC vide letter no. RCSC/HRMD/7/2023/2830 dated February 13, 2023, the NCHM is identified as the one of the autonomus agency under the Ministry of Energy and Natural Recourse (MoENR). The Head of the Centre reports to the Secretary, Ministry of Energy and Natural Resources. The Secretary, MoENR provides oversight on policy and strategic direction and governance of the Centre.

As per the Guiding Principles: For Autonomous Agencies that are highly technical in nature, provide services across many agencies and not affiliated or under a particular Ministry, shall be governed by Scientific and Technical Advisory Councils.

NCHM as a technical autonomous agency is governed by the Scientific and Technical Advisory Council (STAC) and its members approved the Cabinet during the 156th session of *Third Lhengye Zhungtshog* held on October 30, 2023. The STAC shall advise on the agency's scientific and technological activities, programs and plans, to promote scientific vision and downstream trends as the primary drivers of innovation, and to develop new and improved technical services.

The following are the council members approved by the Cabinet:

a. Chairperson : to be appointed from amongst the members
b. Member: Director/Specialist, Department of Energy, MoENR
c. Member: Director/Specialist, Department of Public Health, MoH
d. Member: Director/Specialist, Department of Human Settlement, MoIT
e. Member: Director/Specialist, Department of Local Governance and Disaster Management, MoHA
f. Member: One eminent specialist/Expert member from outside the Civil Service agency
g. Member: Director/Head, NCHM

The update organogram of NCHM with reporting structure is given in figure 2.

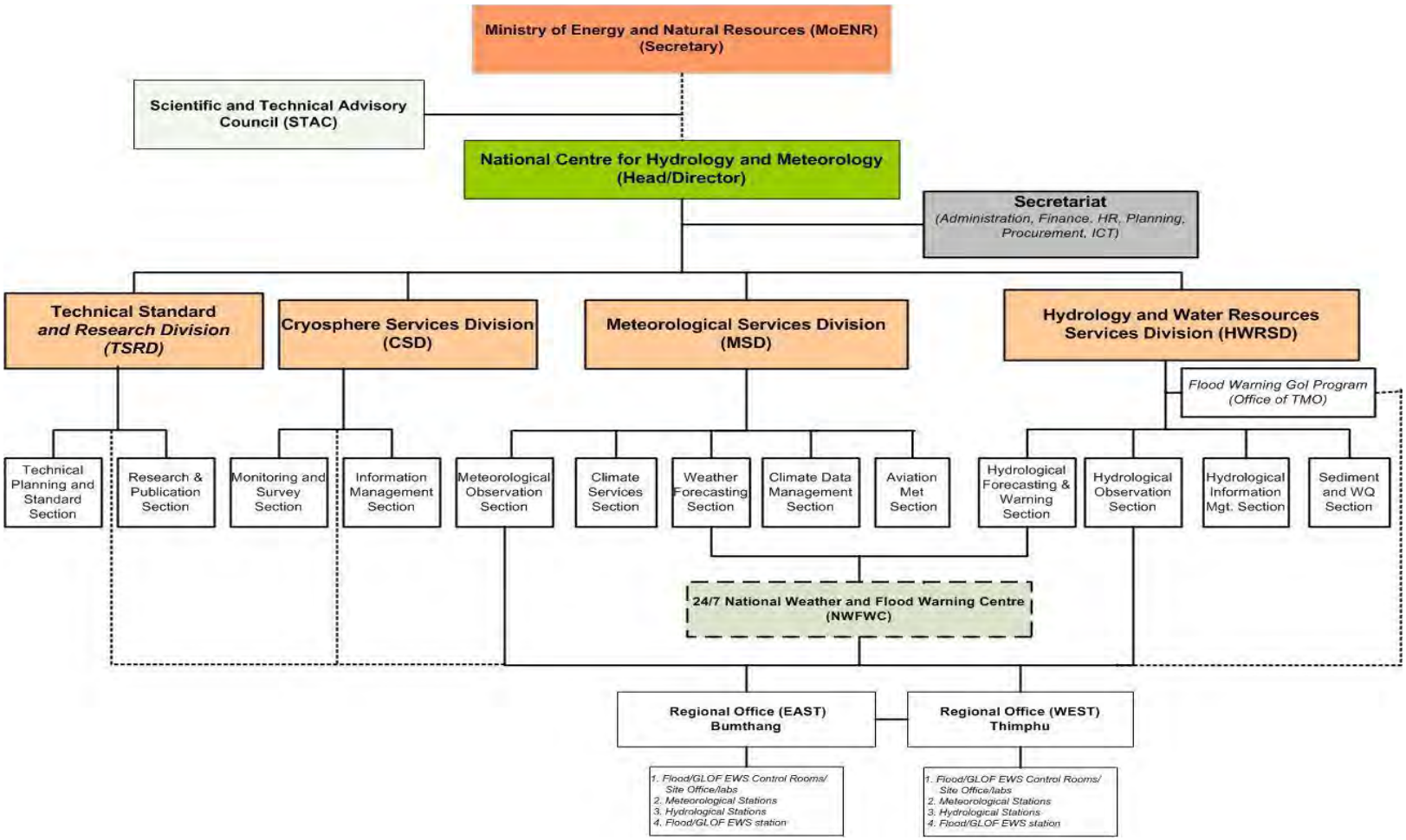


Figure 2: Updated Organogram of NCHM (February 2023)

3.2 STAFFING

Currently, the NCHM has 194 employees including staffing by standard and 12 ESP/GSP under the Flood Warning Services (GoI Program). The detailed staffing strength and distribution is presented in the table 1 below:

Table 1: Staff strength and distribution by Division

Sl#	Division	Approved	Existing	Gap/ Excess	Remarks
1	Secretariat	21	21	0	*Including staff by standard*
2	TSRD	7	5	-2	
3	CSD	8	7	-1	
4	MSD	57	54	-3	
5	HWRSD	116	107	-9	*Including interim post under GoI, FWS*
Overall Total		**209**	**194**	**-15**	

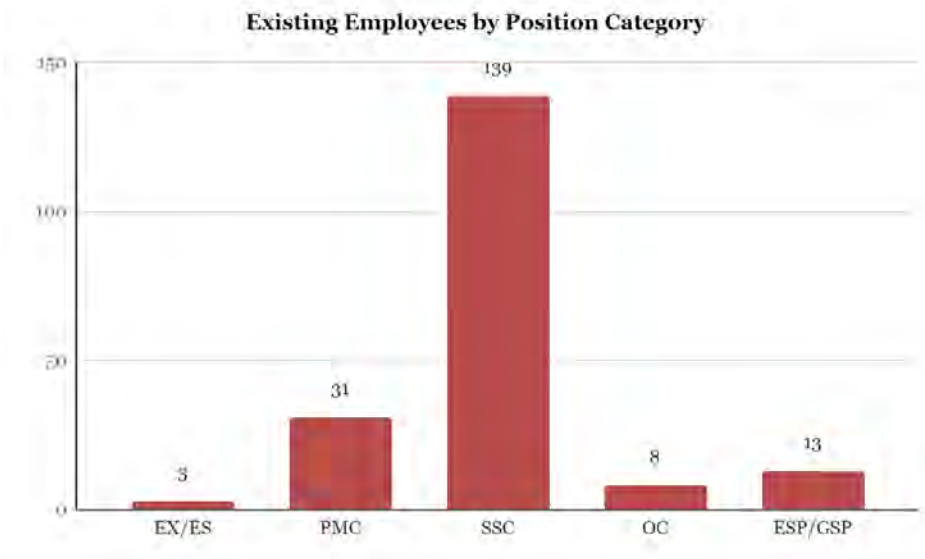


Figure 3: Distribution of Employees by Positions Category

The Centre is responsible for observation, monitoring and operation of national hydro-meteorological stations across the nation. The maximum existing staff are under Support and Supervisory Category (71.64%) who are responsible for observational works followed by PMC with 15.97% and least in EX/ES category as shown in figure 5 above;

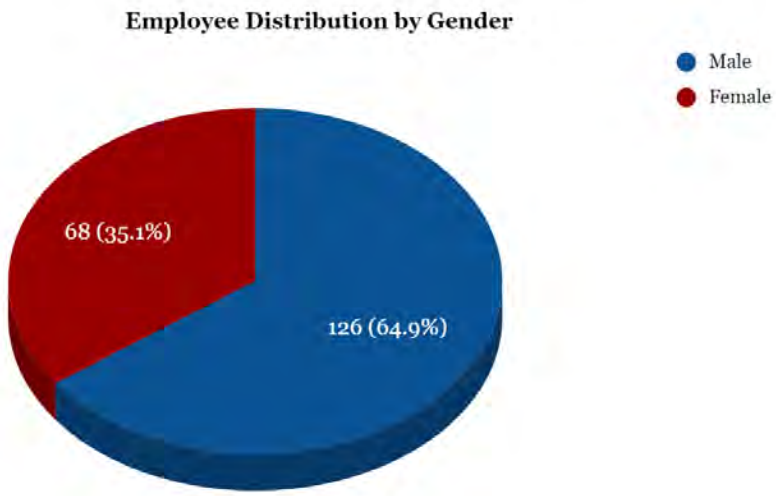


Figure 4: Distribution of employees by gender

Out of 194 existing employees, 64.90% are male and remaining female. Male dominance may be due to the technical nature of Centre's roles and responsibilities which involves physical works, exposure to extreme weather conditions and risk travelling to high altitude areas. However, compared to the past years, the number of female candidates joining the Centre has increased.

3.3 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 during the FY 2023-2024.

3.4 NEW RECRUITS AND APPOINTMENTS

For the last one year, a total of 28 new employees have joined Centre through recruitment, appointment and transfer. Out of which 6 officials at PMC level and remaining at SCC level joined the Centre majority of them as a replacement for the past

separations, transfers and long-term leave. The details of new staff were given in table 2 below.

Table 2: List of new employees who joined the Centre during the FY 2023-2024

Sl#	Category	Position Title	Emp Type	Nos. of Head	Remarks
1	Recruitment/ Appointment	Met/Hyd Officer	Regular	4	*Through BCSE (RCSC)*
		Asst Program Officer	Contract	1	
		Asst Procurement Officer	Contract	1	*Recruited by MoF (PA)*
		Jr. Engineer	Regular	1	
		Met/Hyd Technicians	Regular	18	
		ICT Technical Associate	Regular	1	*Recruited by GovTech (PA)*
2	Transfer	Driver	Regular	1	*From Dratshang Lhentshog*
		Admin Asst	Regular	1	*From Sarpang Dzongkhag*

Figure 5: Photos from the joining session of new recruits for FY 2023-2024

3.5 SEPARATIONS AND STAFF ATTRITIONS

The total of 13 employees has been separated on voluntary resignations for the financial year 2023-2024, out of which 2 were at PMC level and remaining in SCC and below category. 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 for financial year 2023-2024 calculated as of June 2024 stands at 6.7%. This attrition rate is an important metric for understanding the scale of employee turnover for the Centre.

As for the type of attrition 4 staff superannuated while 19 staff voluntarily resigned from the Centre. The following table 3 shows the division wise distribution of staff leaving the Centre:

Table 3: Employee Separation for FY 2023-2024 by Position Category

Separation Type	Position Category	Nos. of Separation
Voluntary Resignation	PMC	2
	SSC and below	11
Total		**13**

Total of 8 employees are on Extraordinary Leave (EoL) as of June 2024.

4 NCHM 13 FYP (2024-2029)

Observation, data management, modeling, research and predictions are core activities of the Centre for effective delivery of services. Hydro-met data, information and services are required by all four clusters and directly and indirectly to all the national programs. All the activities of NCHM are planned under the project *"Enhancement of National Hydrological and Meteorological Services"* linked to two national programs and outcomes of the 13 FYP (Figure 6).

Global Goal	SUSTAINABLE DEVELOPMENT GOALS  SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION 2015-2030
National Goal	**HIGH INCOME GNH ECONOMY**
Strategic Objectives	**BHUTAN IS A HIGH-INCOME COUNTRY DRIVEN BY INNOVATION AND SUSTAINABILITY**
Outcome	**Economy Outcome:** By 2029, Bhutan has enhanced productivity and diversified products and markets driving sustainable economic growth **Security Outcome:** Safety and security threats and disaster risks to the country, its economy, infrastructure, institutions, and people are mitigated and managed.
National Program	**a. Climate Resilient and Ecological Diversity (Economic Cluster)** **b. Transformational Governance (Governance Cluster)**
Project	**Enhancement of National Hydrological and Meteorological Services**
Activity	1. Construction of 24/7 National Weather and Flood Warning Centre (NWFWC) and Scientific and Communication Facilities 2. Enhancement of National Hydro-met Observation Network and Infrastructure 3. Enhancing Weather and Climate Service 4. Strengthening Aviation Meteorological Services 5. Enhancing Hydrological and GLOF Early Warning Services 6. Enhancing Cryosphere Monitoring and Research in Bhutan Himalayan 7. Strengthening Technical Standards and Research Capacity

Figure 6: NCHM 13 FYP linkages to Clusters, National and International goals

Nu. 1704.08 million is allocated for the "Enhancement of National Hydrological and Meteorological Services" in the 13th FYP (2024-2029).

4.1 KEY PERFORMANCE INDICATORS

The Centre has identified 13 Key Performance Indicators (KPI) for monitoring the achievements of the Centre's 13 FYP planned activities.

Table 4: KPI of NCHM for 13 FYP

Sl. No.	Output	Key Performance Indicators	Baseline	Target 2029
1	Hydromet Infrastructure and Early Warning Facilities Enhanced	National Hydro-met Network enhanced	278	300
		Number of Infrastructure and scientific facilities established	0	3
		Flood/GLOF EWS System install/upgraded for all the river basins/sub-basins.	3 Basins	8 Basins
2	Hydro-met data and Services delivery for Climate Resilient Development and Disaster Preparedness Enhanced.	Weather forecasting accuracy improved	60%	65%
		Climate Projection of Bhutan Report updated	2018	2024/25
		Flood/GLOF hazard assessment and maps of river basin developed/updated	3	8
		Number of benchmark glaciers and annual monitoring completed	2	3
		Glaciers and glacier lake inventory of Bhutan updated every five years	2018/2019	Update 2025/2026
		Fresh Water Lake inventory of Bhutan completed	NA	2025
		Increased lead time for river flow forecasting	1 day	3 days
3	Innovation, Research, Standards and Application of Hydro-met Science Promoted.	Number of Hydro-met Operational Manual and Guidelines developed	0	5
		Number of hydro-met research paper/technical study report completed/published/year	10	20
		Calibration Lab facilities expanded	0	1

5 SUMMARY OF FINANCIAL STATEMENT FOR THE FY 2023-2024

5.1 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 5: NCHM Budget summary from 2020-2024 (in million)

Sl. #	Funding	2020-2021	2021-2022	2022-2023	2023-2024
1	RGoB	115.893	101.191	126.64	114.399
2	Donors	48.533	81.371	87.96	127.030
	Total	**164.426**	**182.562**	**214.60**	**241.429**

5.2 FINANCIAL SUMMARY FOR THE FY 2023-2024

Table 6: Expenditure summary table for the FY 2023-2024

Sl. #	Funding	2023-2024		Budget Utilization in Percentage
		Approved	Expenditure	
1	RGoB	114.399	112.528	98%
2	Donors [1]	127.03	76.642	60%
	Total	**241.429**	**189.17**	**78%**

[1] Donors includes GoI, World Bank, UNDP/GCF, CDCL (DHI), and others

Lunana covered with 7 cm (07:30 AM) of snowfall (8 December 2023)

Highlights of Accomplishments for the FY 2023-2024

6 National 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:

Table 7: Status and types of hydro-met station

Sl . No.	Type of Monitoring Station	Number
1	Meteorology Observation Station	106
2	Hydrology and Flood/GLOF EWS network	90
3	Ambient Water Quality and Sediment Sediment Sampling Station	21
	Total	**289**

6.1 Meteorological Observation Network

The National Meteorological observation network consists of the following as on June 2024.

Table 8: Status of Meteorological network

Sl. No.	Types of Station	Number	Remarks
1	Class A (Agro-Meteorological) Station	20	20 Dzongkhags
2	Class C (Climatological) Station	47	
3	Automatic Weather Station (AWS)	89	
4	Snow Station	17	
	Total station	173	

6.2 New Meteorological Station

A new AWS was installed at Yangbari BHU under Mongar Dzongkhag through support of Kuri-Gongri DRP study project during the FY 2023-2024.

Figure 7: Installation of AWS at Yangbari, Mongar

6.3 ANNUAL MAINTENANCE OF METEOROLOGICAL OBSERVATION NETWORK

Annual maintenance meteorological network for the FY 2023-2024 completed. Maintenance of Western region was done from 3-14 September 2023. Maintenance of the Central and Eastern region was done from 12 January to 5 February 2024. Southern region done in June 2024.

Figure 8: Annual Maintenance Team at field

6.4 HYDROLOGICAL AND FLOOD/GLOF OBSERVATION NETWORK

National hydrological and flood/GLOF EWS observation network consists of the following as on June 2024.

Table 9: Existing Hydrological and Flood Waring Network

Sl. No.	Types of Station	Number	Remarks
1	Principal Hydrological Station	18	
2	Secondary Hydrologic Station	22	
3	Automatic Water Level Station (AWLS)	35	
4	GLOF EWS Station	15	
5	Sediment Sampling Station	21	
6	Sediment Lab	18	
7	Ambient Water Quality Monitoring Statins	4	*Integrated with the existing AWLS*
	Total station	92	

6.5 THORTHOMI LAKE AWLS REHABILITATION

The Automatic Water Level Station (AWLS) on Thorthomi lake used for monitoring of GLOF EWS was damaged by 30 October 2023 GLOF. AWLS was rehabilitated to new location in the FY 2023-2024 under the Emergency fund provided after the GLOF.

Figure 9: Rehabilitation of Thorthomi lake AWLS in June 2024.

6.6 ANNUAL MAINTENANCE OF OBSERVATION NETWORK

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. Annual maintenance works for the national hydro-met observation network was completed and status shown in Table 8.

Table 10: List of station maintained from 2021-2024

Sl No.	Station Category	Station Type	Total Maint. in 2020-21	Total Maint 2021-22	Total Maint. in 2022-23	Total Maint. in 2023-24
1	GLOF-EWS	Automatic	15	15	15	15
2	Hydrological Stations	Manual	20	14	15	37
		Automatic	36	21	19	28
3	Meteorological Stations	Manual	20	26	32	84
		Automatic	15	25	36	89

6.7 ANNUAL LEAN FLOW MEASUREMENTS

The Centre completed annual lean flow measurements of 59 un-gauged streams covering the whole country in the month of March and April 2024.

Figure 10: Selected Photos from Annual Maintenance 2023-2024

7 HYDRO-MET INFRASTRUCTURE AND FACILITIES

7.1 RENOVATION OF SITE OFFICES

The following constructions and renovations were carried out by the Centre during the FY 2023-2024.

a. **Construction of a Sediment lab and staff quarters at Tingtibi, Zhemgang** completed under FWS GoI funding. Work was awarded to M/s PS Construction, Panbang at contract price of Nu. 2.97 million were taken over by the Centre on February 9, 2023.

Figure 11: Flood Warning Office and Sediment Lab, Tingtibi on Mangdechhu

b. **Re-electrification of office and staff quarters at Dorokha, Samtse:** Work was awarded to M/s Shala Construction, Dagana and completed on 27th December, 2023 at the contract price of Nu. 0.30 million.

Figure 12: Flood Warning Office, Dorokha on Ammochu

c. **Construction of GI Chain link Compound Fencing at FWS Sunkosh:** The work was executed by M/s TD Builders.

Figure 13: GIS Chain fencing of FWS Site Office, Sankosh, Dangna

d. **Construction of Community Drinking Water Supply to FWS Site Office at Jampani, Jomotshangkha Dungkhag**

Work was executed by local Community Contractor (M/s Jampani Community Contract) at a contract amount of Nu.1.003 million. The supervision of the work and verification of the bills was done by Langchenphu Gewog Administration.

Figure 14: Water supply at Jampani FWS Site Office

e. Concreting work from take-off point (road point) to the office gate of FWS Tingtibi, Zhemgang:

The work was coordinated by Station Incharge and carried out as per the requirement of Department of Surface Transport (DoST) to comply with the Road Act in force.

Figure 15:Flood Warning Site Office, Tingtibi on Mangdechhu

f. Rehabilitation and upgradation of AWLS, Dodena, Thimphu

Dodena Flood Warning Station was upgraded to install real time AWS as part of JICA TCP project to install Flood EWS on Thimchhu with 4G modem communication and duty room facilities.

Figure 16: Dodena Flood Warning Station on Thimchu with duty room

7.2 SEDIMENT LABORATORIES

A new sediment lab was set up in the Hydrology Site Office at Haa during the FY 2023-2024. Earlier the daily sediment samples from the site were transported monthly to Sediment Lab Thimphu for analysis.

Figure 17: Installation of new sediment lab, Haa

8 WEATHER AND CLIMATE SERVICES

The Meteorological Services Division (MSD) under the Centre is responsible for operation of national meteorological observation and aviation meteorological network for data collection. The division is responsible for studying and providing public weather services, severe weather warnings, meteorological data management, aviation meteorology, agro-meteorology and climate change information and services.

8.1 DAILY WEATHER FORECAST

The Weather Forecasting Control Room (WFCR) under the National Weather and Flood Warning Centre (NWFWC), Thimphu operates 24/7 and monitors weather conditions across the country. NCHM issues daily weather forecasts through emails, 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 16:00 hours.
- Weather forecast are updated and provided at 04:00, 10:00 and 16:00 hours
- Three-day weather forecast with detailed analysis and report is issued at 10:00 hours.

Table 11: Daily Weather forecast for the FY 2023-2024

Forecast type	Number of forecasts (1 July 2023-30 June 2024)
Weather update at 4:00 AM	364
Weather report and analysis at 10:00 AM	364
Daily weather forecast at 16:00	364
Weather update at 22:00	364
Total number of forecasts issued	**1456**

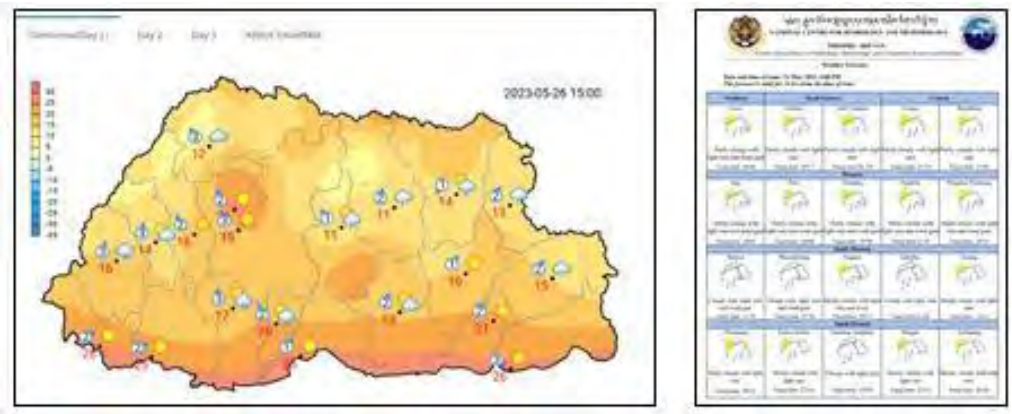


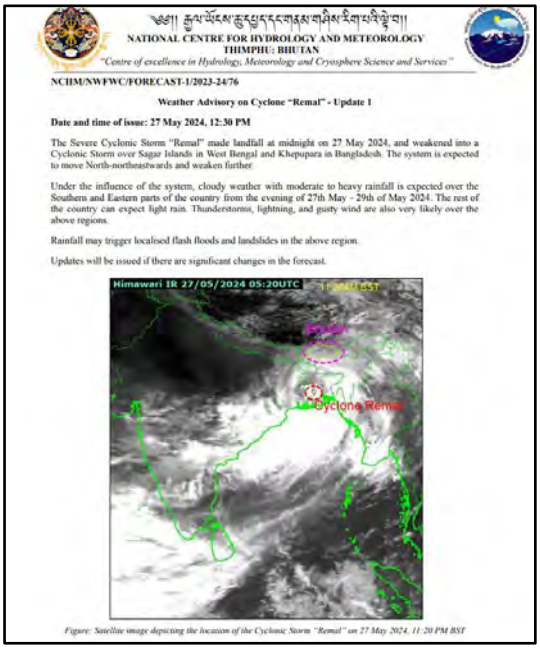
Figure 18: Daily Weather forecast outlook

8.2 WEATHER ADVISORIES

NWFWC monitors the weather round the clock. During extreme weather conditions, WFCR issues weather remarks and advisories through emails, NCHM website, Bhutan Broadcasting Television, radio and NCHM Facebook page and dedicated social media WhatsApp groups. Details of weather advisories issued during the FY 2023-2024 are given in the table below.

Table 12: No. of Weather Advisories

Sl No.	Title	Issued date
1	Remarks on Heavy Rainfall and Flood	10 July 2023
2	Weather Remarks on Rainfall	1 August 2023
3	Weather Remarks on Rainfall	11 August 2023
4	Weather Advisory on Heavy Rainfall	21 August 2023
5	Weather Remarks on Rainfall	19 September 2023
6	Weather Remarks on Rainfall	29 September 2023
7	Weather Remark on Snowfall	29 January 2024
8	Weather Remarks on Gusty Wind	2 February 2024
9	Weather Remarks on Rainfall/Snowfall	19 February 2024
10	Weather Remarks on Cyclonic Storm	25 May 2024
11	Weather Advisory on Cyclone “Remal” - Update 1	27 May 2024
12	Weather Remark on Heavy Rainfall	18 June 2024



NATIONAL CENTRE FOR HYDROLOGY AND METEOROLOGY
THIMPHU: BHUTAN
"Centre of excellence in Hydrology, Meteorology and Cryosphere Science and Services"

NCHM/NWFWC/FORECAST-1/2023-24/76

Weather Advisory on Cyclone "Remal" - Update 1

Date and time of issue: 27 May 2024, 12:30 PM

The Severe Cyclonic Storm "Remal" made landfall at midnight on 27 May 2024, and weakened into a Cyclonic Storm over Sagar Islands in West Bengal and Khepupara in Bangladesh. The system is expected to move North-northeastwards and weaken further.

Under the influence of the system, cloudy weather with moderate to heavy rainfall is expected over the Southern and Eastern parts of the country from the evening of 27th May - 29th of May 2024. The rest of the country can expect light rain. Thunderstorms, lightning, and gusty wind are also very likely over the above regions.

Rainfall may trigger localised flash floods and landslides in the above region.

Updates will be issued if there are significant changes in the forecast.

Figure: Satellite image depicting the location of the Cyclonic Storm "Remal" on 27 May 2024, 11:20 PM BST

Figure 19: Sample of Weather remark

8.3 AVIATION WEATHER FORECAST

NCHM through Aviation Meteorological Section (AMS) Office at Paro International Airport provided an interrupted 24-hour weather forecast for 365 days for both International and domestic airports for the operation of flights and helicopters.

Table 13*: Daily Aviation Weather forecast*

Forecast type	**No. of forecasts (1 July 2023-30 June 2024)**
1 hr weather forecast issued to Aviation issued at 12:00pm	364
48 hrs weather forecast for Aviation at 6:00 pm	364
48 hrs weather forecast for Aviation at 6:00 am	364
Total number of forecasts issued	**1092**

8.4 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 14:Weather forecast on request

Forecast on Request		Date of forecast
GovTech	Weather forecast for Thimphu	1,4,7,10,13,16,19 July 2023
Ministry of Foreign Affairs	Weather forecast for Thimphu, Paro, Punakha, Bumthang, Phobjikha	28 August, 1 September2023
Aviation	Weather forecast for Paro and Gelephu	18 September 2023
Go Go Adventures Bhutan	Thimphu,Paro,Punakha and Chukha	5 October 2023
Blue poppy tours and treks	Paro,Thimphu and Punakha , Haa	11, 15 October 2023
Cabinet Office	Thimphu and Punakha	20, 27 October 2023
Election Commission of Bhutan	Gasa and Lunana	12,17,22,27 November 2023 3,5,8 January 2024
Bhutan Soul Tour & Travel	Paro, Thimphu, Punakha and Phobjikha	7, 10, 13, March 2024
PM Modi visit	Paro and Thimphu	18- 21 March 2024
Azhi ADC	Paro	21 March 2024
Bhutan Himalaya	Bumthang and Northern parts	10 May 2024
Chhukha Hydroproject	Chhukha and Tala Dam	13 May 2024
Azhi ADC	Thimphu	2 June 2024
World Bank	Gelephu	13-14 June
Ministry of Home Affairs	Thimphu	19 June

8.5 CITY WEATHER FORECAST

NCHM also shared weather forecasts for eight identified dzongkhags to the World Meteorological Organisation'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

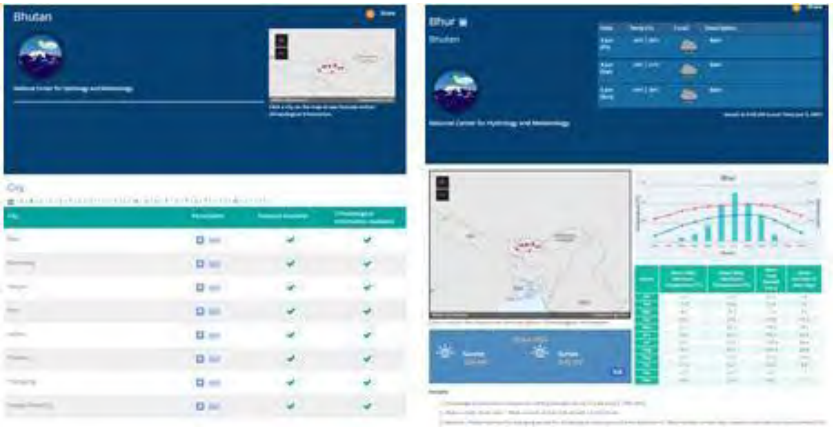


Figure 20: WMO City Weather Forecast of Bhutan (Bhur, Sarpang)

Table 15: Daily selected 8 cities Weather forecast issued

Forecast type	**Number of forecasts (1 July 2023- 30 June 2024)**
Weather forecast to WIS at 12 pm	364
Weather forecast to WIS at 8 pm	364
Weather forecast to WIS at 4 am	364
Total number of forecasts issued	**1092**

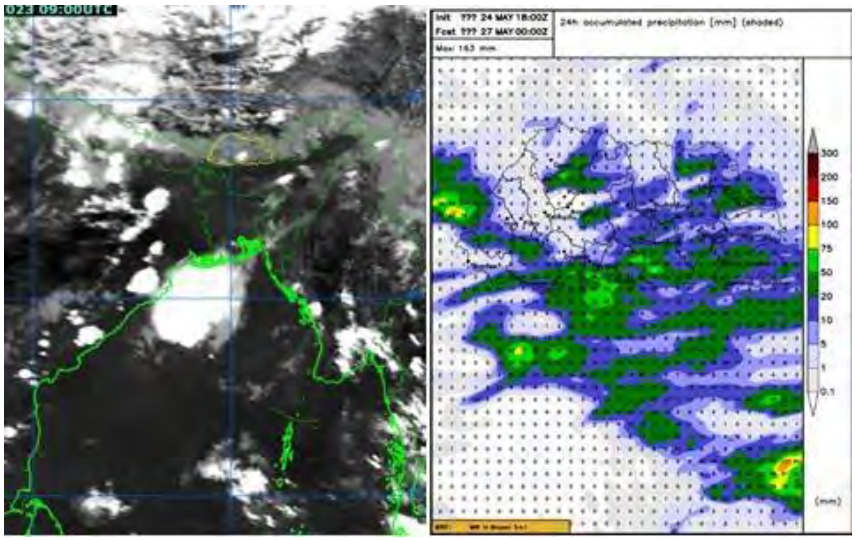


Figure 21: Satellite image and forecast image from SmartMet

8.6 CLIMATE DATA AND INFORMATION SERVICES

The Centre provides climate data and services including climate data processing, quality control, analysis and archival. The data is provided to user sectors and individuals as per their request. The Center produced monthly and annual climate monitoring reports, and seasonal forecasts. All the reports are updated on NCHM website.

8.7 NATIONAL CLIMATE OUTLOOK FORUM (NCOF-10)

NCHM in partnership with the PangriZampa College of Astrology, Central Monastic Body organised the Tenth Session of National Climate Outlook Forum (NCOF-10) on 22nd May, 2024 in Thimphu. The Centre issued a press release on the summer monsoon (rainfall and temperature) outlook for JJAS, 2024 and Pangri Zampa College of Astrology shared the monsoon outlook for the year 2024 from the Astrological perspective. The workshop was attended by all the climate sensitive sectors and media houses.

NATIONAL CENTRE FOR HYDROLOGY AND METEOROLOGY
THIMPHU: BHUTAN
"Centre of Excellence in Hydrology, Meteorology and Cryosphere Science and Services"

22 May 2024

Press Release
Precipitation and Temperature Outlook for Southwest Summer Monsoon
(June – September 2024)

The National Centre for Hydrology and Meteorology (NCHM) releases the outlook for precipitation and temperature for the summer season, for the months of June - September 2024.

The national outlook is based on the consensus outlook of the South Asian Climate Outlook Forum (SASCOF-28) held from 29 April - 1 May, 2024, outlook from Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) Forecast Customization System (FOCUS), outlook from World Meteorological Organization (WMO) Global Producing Centres (GPCs) and various other international sources based on May Initial Condition. The summer monsoon outlook has to be used and interpreted along with the extended, medium, daily weather forecasts and other advisories released by the Centre. The stakeholders and users are advised to follow the NCHM website and Facebook pages for advisories and updates.

Rainfall Forecast for June - September 2024 Summer Season

The summer rainfall for Bhutan during the 2024 JJAS monsoon season is most likely to be slightly above normal. Normal is the average rainfall for the summer season (JJAS) of Bhutan from 1996 to 2023.

Temperature Forecast for June - September 2024 Summer Season

The maximum and minimum temperature in Bhutan during the 2024 JJAS monsoon season is likely to be slightly above normal. Normal is the average temperature (maximum and minimum) for the summer season (JJAS) of Bhutan from 1996 to 2023.

Post Box No.207, Tel: +975 2 324999; Fax: + 975 2 335578
Email: nchm@druknet.bt; Website: www.nchm.gov.bt

Figure 22: NCOF -10 at Thimphu

8.8 AGRO-METEOROLOGICAL SERVICES

8.8.1 WEATHER AND CLIMATE SERVICES FOR AGRICULTURE PLANNING

A workshop on Capacity Building on Weather and Climate services on Agriculture planning was organised by the Centre in partnership with the Department of Agriculture, MoAL in two batches. First batch for western dzongkhag was held at Paro on 28-30 August 2024 and similarity second batch for Central and eastern dzongkhag was held in Bumthang on 2-4 October, 2024 with the following objectives:

a. Outreach of the weather and climate services and informations to the gewog level
b. Enhance the agriculture staffs' understanding of weather and climate and its uncertainties
c. Enable participants to make better informed decisions

The workshop was conducted under the support of GCF project "Supporting Climate Resilience and Transformational Change in the Agriculture Sector in Bhutan.

Figure 23: Workshops at Paro and Bumthang

8.8.2 WEATHER AND CLIMATE SERVICES ADVOCACY

The Awareness Workshop on the Weather and Climate products and services for the officials for the five selected gewogs from Tsirang, Dagana, Sarpang and Samtse dzongkhags were conducted from 8th April to 3rd May, 2024. Under the GCF project "Supporting Climate Resilience and Transformational Change in the Agriculture Sector in Bhutan".

Figure 24: Advocacy Workshops at gewog offices.

8.8.3 HYDRO-MET SCIENCE WORKSHOP FOR MEDIA

The Centre has the core mandates of providing weather services, severe weather warnings, climate services, hydrological forecasts, and weary warning services related to floods and glacial lake outburst floods. As such, the Centre has always been working in close collaboration with various media houses that have been facilitating and supporting the effective dissemination of essential information to the public.

The hydro-met science workshop was organised on 15-17 April, 2024 to assess and promote effective science communication through partnership under support of GCF project "Supporting Climate Resilience and Transformational Change in the Agriculture Sector in Bhutan". The workshop was moderated by Ms. Chimi Seldon, Communication officer, Integrated Center for Mountain Development (ICIMOD), Nepal.

Figure 25: Hydromet Science Workshops at Paro.

8.8.4 CLIMATE DATA SERVICES

The Centre provides meteorological data to Government agencies, the private sector, academic researchers and students, the corporate sector, foreign institutes and others

as per the request.

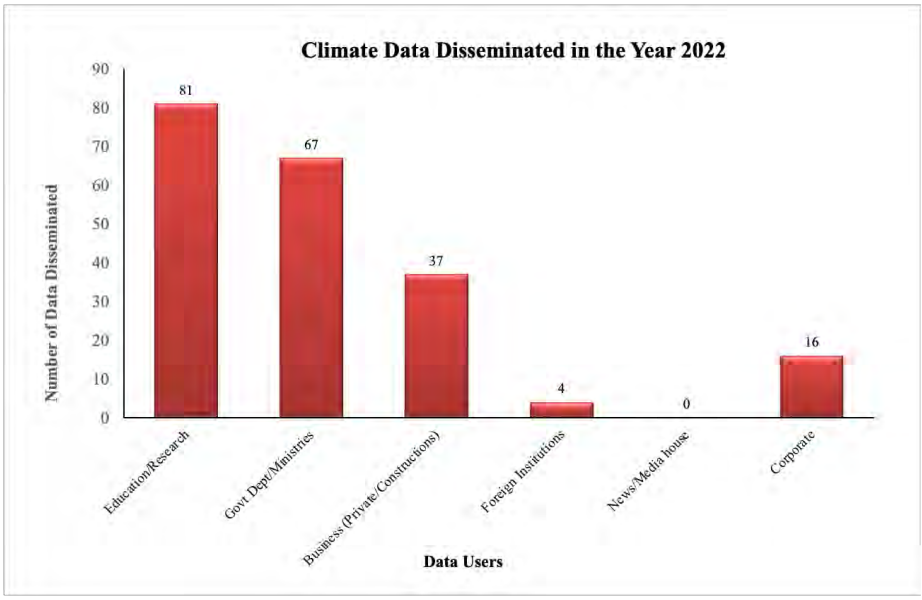


Figure 26: Climate data disseminated in the year 2022

8.9 AVIATION METEOROLOGICAL SERVICES

Aviation or Aeronautical Meteorology (MET) is the most important data stream for Air Traffic Management (ATM) services given its impact on both safety and efficiency. NCHM is designated as the Aeronautical Meteorological Services Provider within Bhutan by the Bhutan Civil Aviation Authority (BCAA) vide letter BCAA/ANS-MET/010/196 dated August 29, 2017 in pursuant to the Section 13 (1) (e) & 57 of Civil Aviation Act of Bhutan 2016. Therefore, NCHM is mandated to provide aviation meteorological services for air traffic management (ATM) services for air navigation in accordance with Bhutan Civil Aviation Authority (BCAA) and International Civil Aviation Organization (ICAO) legal requirements.

The Aviation Met Section under the MSD maintains and operates weather stations at all aerodromes of the country (Paro and Gelephu International Airport and Bumthang and Yonphula domestic airports) to provide meteorological information and services for international and domestic flights as well as for helicopter services.

8.9.1 CERTIFICATION OF NCHM

Based on technical competencies and services performance, BCCA renewed Certification of NCHM Aeronautical Meteorological Services Provider from 29 October 2023 to 26 October 2026.


AERONAUTICAL METEOROLOGICAL SERVICE PROVIDER CERTIFICATE/ SERVICE PROVISION CONDITIONS

NATIONAL CENTRE FOR HYDROLOGY AND METEOROLOGY has obtained the privilege to provide the following scope of the service/functions at Paro International Airport:

Services	Scope of service/Function	Limitations
Meteorological services (MET)	Aerodrome Meteorological office	
	Aeronautical Meteorological station	

Date of Issue: 27.10.2023
Valid Until: 26.10.2026

Director
Bhutan Civil Aviation Authority

Figure 27: BCCA handing over Certificate to NCHM

8.9.2 MAINTENANCE OF AWOS

Aviation Meteorological Section successfully completed the routine as well as ad hoc maintenance of all the weather observation stations in the airports for the FY 2023-2024.

8.9.3 RELOCATION OF INSTRUMENT IN BHUTAN AIRPORT

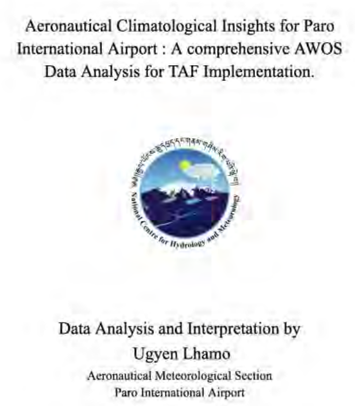
With the approval of BCAA, relocation of Automatic Weather Observation System (AWOS), ceilometer and windsocks in Bumthang Domestic Airport was completed

within 23 days at contract price of Nu. 1,60,000/. The Aviation Met Office located at the control tower was shifted to the ground floor of the new office building for seamless delivery of aviation met service.

Figure 28: Installation of Instrument in Bumthang Domestic Airport

8.9.4 FOUNDATION ANALYSIS OF TAF

NCHM is mandated to provide essential meteorological services for the aviation industry in Bhutan. Currently, the centre lacks the capability to deliver one of the most critical services: the Terminal Aerodrome Forecast (TAF). The TAF product currently available in Traditional Alphanumeric Code and IWXXM format is used to communicate expected weather conditions to make critical flight decisions and enhance safety. Recognizing the severity of this gap, the NCHM has prioritised the initiation of TAF services within the framework of the 13th Five Year Plan. However, the implementation of TAF is a complex task due to limited resources, manpower and technical capacity. Report was prepared as an initial step towards establishing a robust foundation for TAF services.


Aeronautical Climatological Insights for Paro International Airport : A comprehensive AWOS Data Analysis for TAF Implementation.

National Centre for Hydrology and Meteorology

Data Analysis and Interpretation by
Ugyen Lhamo
Aeronautical Meteorological Section
Paro International Airport

Figure 29: Analysis Report

8.9.5 AERONAUTICAL CLIMATOLOGY SUMMARY

The Aviation Meteorology Section has produced an Aeronautical Climatological Summary and developed Standard Operating Procedures to produce the summary.


Aeronautical Climatological Summary

2019-2023

Aviation Meteorology Section
National Centre for Hydrology and Meteorology
Paro International Airport
Submitted by: Ugyen Lhamo

AERONAUTICAL CLIMATOLOGICAL SUMMARY

AERONAUTICAL CLIMATOLOGICAL SUMMARY

National Center for Hydrology & Meteorology

February

FREQUENCIES OF OCCURRENCE OF CONCURRENT WIND DIRECTION (IN 30° SECTORS) AND SPEED WITHIN SPECIFIED RANGES												
WIND	WIND SPEED (KT)											
DIRECTION	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	>50	TOTAL
CALM												45
VARIABLE												
35-36-01	341	21	3	2								367
02-03-04	330	4										334
05-06-07	135											135
08-09-10	71		1									72
11-12-13	86	34	21	5	1							147
14-15-16	300	380	303	207	47	3						1240
17-18-19	398	270	84	48	11							811
20-21-22	259	49	5									313
23-24-25	80											80
26-27-28	62	1										63
29-30-31	149											149
32-33-34	256	17			1							274

Figure 30: Aeronautical Climatological Summary Report

8.9.6 PILOT BRIEFING SYSTEM

A Pilot Briefing System (PBI) for delivery of aviation meteorological information and services was successfully developed under the National Adaptation Plan (NAP) project supported by UNDP/GCF. The PIB system is a sophisticated technological solution designed to provide comprehensive meteorological information and support to aviation personnel, primarily pilots and meteorological observers. It serves as an essential tool for pre-flight planning, in-flight decision making and post flight analysis, ultimately enhancing aviation safety and efficiency. The system was developed by M/s MicroStep, a software development company and encompasses data processing algorithms, user interfaces, and database management systems tailored to the specific needs of aviation meteorology.

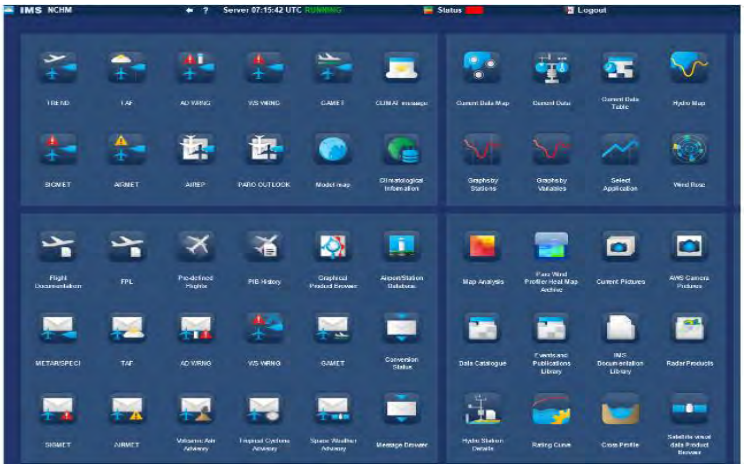


Figure 31: PBI System

9 HYDROLOGY AND WATER RESOURCES SERVICES

9.1 CHANNEL RATING OF AWLS SITES

Stage-discharge rating curves are essential for producing discharge data. The shape of these curves depends on the channel's shape that controls flow. These curves change over time due to temporary factors (e.g., vegetation, ice, debris) or persistent changes (e.g., aggradation, degradation) in the rated channel, which can be natural or man-made. To establish a rating curve, a one-time low flow measurement of the river was conducted, along with a channel section survey.

During the fiscal year 2023-2024, the Hydrology and Water Resources Services Division (HWRSD) carried out field activities at the following AWLS stations:

a. Dodena at Thimchu, Thimphu
b. Hejo at Thimchu, Thimphu
c. Gunitsawa at Pachu, Paro
d. Doteng at Pachu, Paro

These activities involved conducting river cross-section surveys to collect information on river channel characteristics such as channel geometry, bed slope, and water surface slope. Additionally, flow measurements and river line surveys were performed to acquire data for calibrating the rating equations.

9.2 HYDROLOGICAL DATA USERS

The Centre provides hydrological data to government agencies, private sector entities, academic researchers and students, the corporate sector, and other private parties upon request, in accordance with the "Guidelines on the Exchange and Dissemination of Hydrometeorological Data and Information."

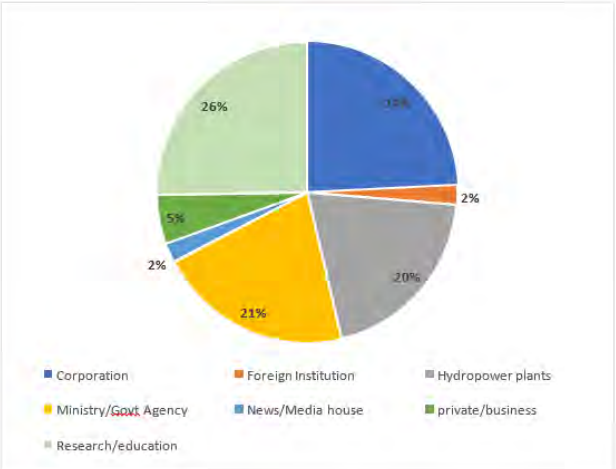


Figure 32: Graph showing hydrological data users

9.3 DRONE SURVEY FOR FLOOD HAZARD MAPPING

Under the World Bank RIR project, NCHM successfully completed the detailed drone survey work for selected river basins to create high-resolution Digital Terrain Models (DTMs) to prepare hazard maps. Team used Mattrice 300 RTK drone equipped with Lidar technology to capture detailed 3D point clouds, crucial for identifying subtle elevation changes and terrain features.

Drone survey raw images processing of the following river basins/sub-basin were completed using DJI Terra and Agisoft Metashape Professional software. These high resolution DTMs generated will be used for preparation of flood hazard and risk maps. Based on the hydrological modelling and usin the DTMs generation hazard maps for the following river basins/sib-basins were completed in the current FY 2023-2024

1. Kurichhu basin (Autsho, Sumpa, Lingmethang, Gyelpozhing)
2. Mangde chhu basin (Bjizam)
3. Amochhu basin (updated)

Figure 33: Flood hazard map of Kurichhu basin

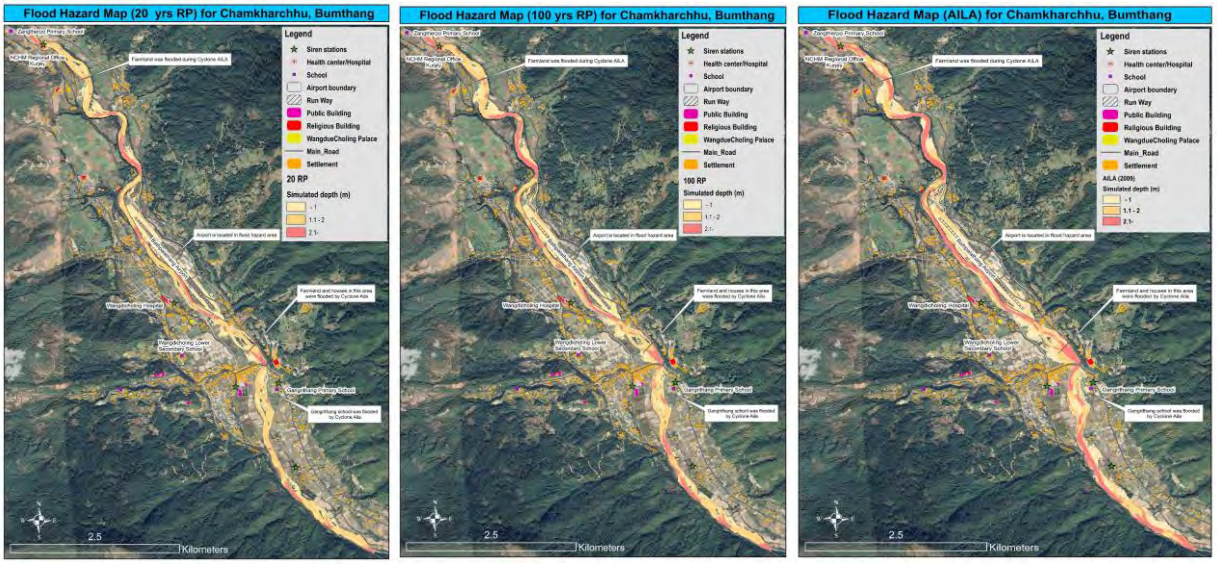


Figure 34: Flood hazard map of Chamkharchhu

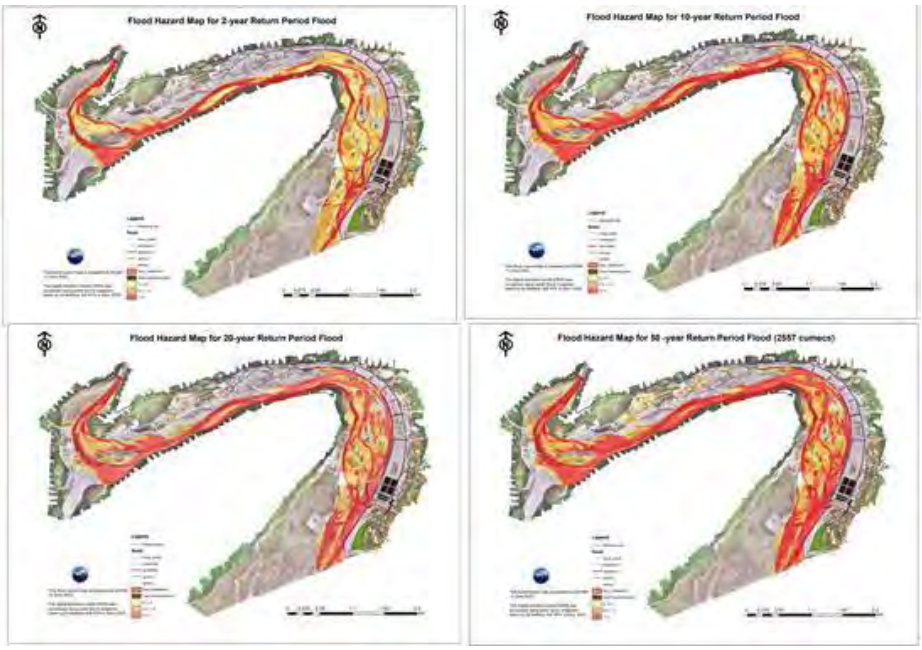


Figure 35: Updated Ammochhu Flood hazard (2023)

Figure 36: Photos from drone field survey 2023-2024

9.4 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 16: List flood advisories & information issued

Activity	No. Issued (2023-2024)
Daily water level status 364	365
Hydrological Outlook 364	365
Flood Advisory and Warning	3
Early warning Siren activation	1

10 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.

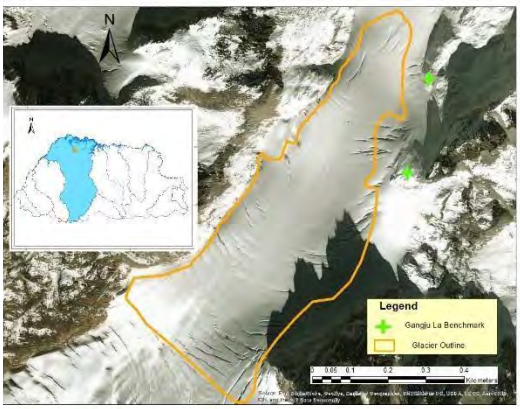
Since there is limited data and information on glacial regime in Bhutan Himalayas, the Centre has established three long term monitoring Benchmark glaciers in Bhutan viz., *Gangju La* glacier in the headwater of Pho Chhu Sub-basin, *Thana* glacier in the headwater of Chamkhar Chhu Sub-basin and *Shodug* glacier in the headwaters of Thim Chhu sub basin.

The Cryosphere Services Division is mandated to study and carry out annual glacier mass balance and time series monitoring and associated hazards related to glaciers and glacier lakes across the country.

10.1 ANNUAL MONITORING OF BENCHMARK GLACIERS

10.1.1 GANGJU LA GLACIER

Annual glacier mass balance monitoring on Gangju La glacier was conducted from August 30, 2023 to September 15, 2023. 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 2023-2024.



Gangjula Glacier facts:
Type: Clean type
Area: 0.3 km²
Location: 27°56'24.17"N, 89°56'53.70"
Elevation: 5145m a.s.l
Maximum Elevation: 5200m a.s.l
Minimum Elevation: 4900m a.s.l
Basin: Headwater of Pho Chhu, Punatsa
Chhu basin.
Initial Survey: 2004
Survey Status: Ongoing

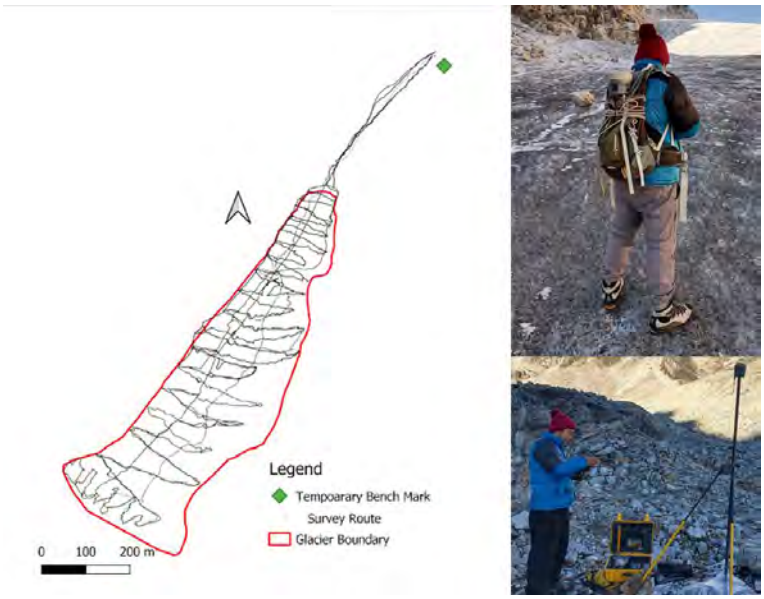


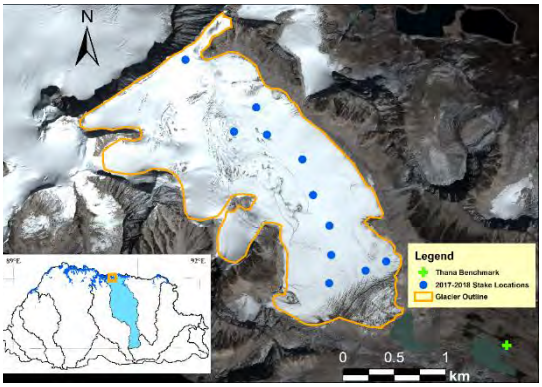
Figure 37: Ganju La Field Activities August - September, 2023.

Activities on Gangju la glacier

- Data collection for Annual Glacier Mass Balance using *in-situ* Geodetic Method (dGPS)
- Snow Depth survey
- Repeat Photography from the predefined spot

10.1.2 THANA GLACIER

The data collection for annual glacier mass balance studies on Thana Glacier was carried out from September 27, 2023 to October 28, 2023. The detailed methodologies, data processing, results, and recommendations are compiled in the technical report titled "Glacier Mass Balance studies on *Thana* Glacier 2023-2024".



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
Survey Status: Ongoing

Activities on Thana Glacier

- Data collection for annual Glacier Mass Balance Measurement using bamboo stakes (direct/glaciological method)
- Data collection for 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 38:: a) Retrieval of old stakes, b&c)Snow-pit Measurement. d) Setting up of base for dGPS survey.

10.1.3 SHODUG GLACIER

NCHM started monitoring *Shodug* glacier as a benchmark glacier from Spring 2022. Data collection and annual glacier mass balance studies for the glacio-hydrological year 2023-2024 was conducted from April 15 to May 11, 2024. The detailed methodologies, data processing, results and findings are compiled in the "Technical report spring mass balance on *Shodug* Glacier 2023-2024".

Shodug Glacier Facts:
Glacier type: *Clean type glacier*
Location: 27.940 N, 89.950 E **Elevation:** 4900 to 5200 m.a.s.l.
Area: 3.71 *km2*
Basin: Headwater of Thim Chhu, Wang Chhu sub-basin
Initial Survey: 2021
Survey Status: Ongoing

Activities conducted on Shodug Glacier

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

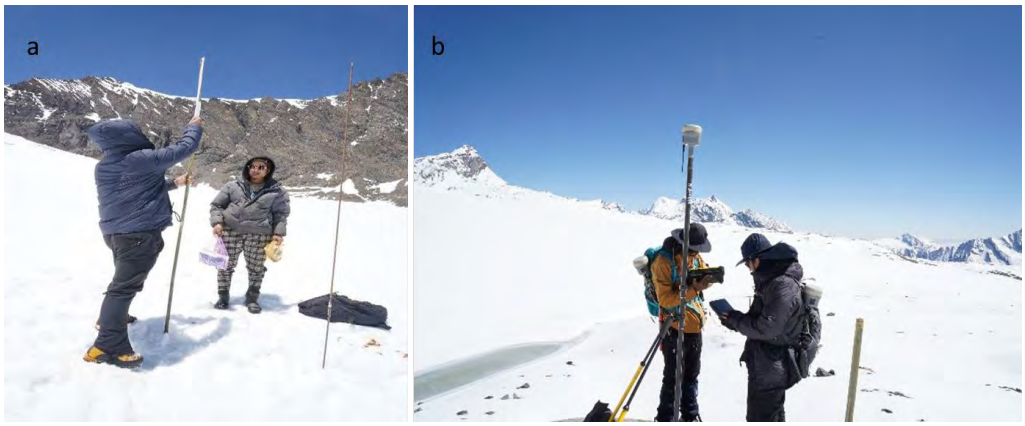


Figure 39: Field survey work on Shodug glacier, 2023. a) Drilling and installation of bamboo stakes on glacier surface, b) Trimble GNSS base station

10.2 GLOF RISK ASSESSMENT AND AERIAL SURVEY ON CHUBDA LAKE

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 Chubda glacial lake in the headwater of Chamakharchhu from September 27, 2023 to October 28, 2023. Study team collected geotechnical data that is required as input parameters to run GLOF Breach models 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 Chubda Lake,2023".

Figure 40: Figure showing topographical mapping at the outlet (a) and lake bathymetry survey (b)

10.3 RESEARCH STUDY TO UNDERSTAND THE INFLOWS CONTRIBUTIONS

Under the GCF Readiness funded Project ''Building the Capacity of Bhutan's National Stakeholders to Address Climate and Disaster Related Risks", the CSD is conducting the research work to understand the flow contribution sources, seasonal variation and climate induced water flows into the Mo Chhu sub basin area. For the study water samples collection from different points in river sub-basin for different seasons: monsoon, post monsoon, lean season and pre monsoon were completed. Collected water samples in three batches were sent to the Laboratories facilities at the Indian Institute of Science Education and Research, Kolkata, India for isotopic analysis. The last batch of water samples will be sent in July, 2024 for isotopic analysis. Upon completion of analysis, CSD in partnership with the Indian Institute of Science Education and Research will prepare a scientific report containing analysed data and information on the dominant sources of surface runoff of Mo Chhu river on seasonal timescale.

Figure 41: Water Sample collection in the Mo Chhu sub-basin

10.4 DATA COLLECTION FOR FRESH WATER LAKE INVENTORY OF BHUTAN

Currently Bhutan has no information or inventory of freshwater lakes in the mountains. NCHM has planned in 13 FYP to prepare freshwater lakes inventory together with updates of Glacier lakes inventory.

The data collection on lake shoreline mapping on selected waterbodies in the western high-altitude regions in the Wang Chhu headwaters was carried out along with the annual *Shodug* glacier mass balance studies from April 15 to May 11, 2024. The team mapped shorelines of five water bodies using trimble R10-2 RTK

GNSS systems. Bathymetry surveys were also conducted. The collected lake shoreline data will be used for validating the fresh water bodies mapped through remote sensing techniques.

Figure 42:Lake Shoreline mapping using Trimble R10-2 GNSS System

10.5 Rapid Assessment of Thorthomi lake GLOF event

After the 30th October 2023 GLOF incident from Thorthormi glacial lake, a team from the Centre was deputed from 31st October, 2023 to carry out rapid assessment on post GLOF event. The rapid assessment team observed that the whole ablation part of Thorthormi glacier has been disintegrated into ice blocks. The periphery of Thorthormi lake has almost reached the bed rock (rock cliff) at the base of Table Mountain in the extreme upstream. Currently Thorthormi lake measures 4.33 km in length (max), 1.3 km in width (max) with a surface area of 4.33 km^2. Due to the partial breaching of Thorthormi lake on 30th October 2023, the lake level got lowered by 46 cm resulting in release of flood volume of 1.98 million cubic metres (estimated) of water. The detailed findings are compiled and submitted to the Centre in the "Report on Rapid Assessment of GLOF event from Thorthormi lake on 30th October 2023".

Technical Team Assessment outcomes and findings were presented to to the Secretaries of MoENR, MoHA and OGZ (HMS) on 6 Nov 2023 and the same was presented to the Interim Government (IG) Advisor at PMO Office on 7th November 2023

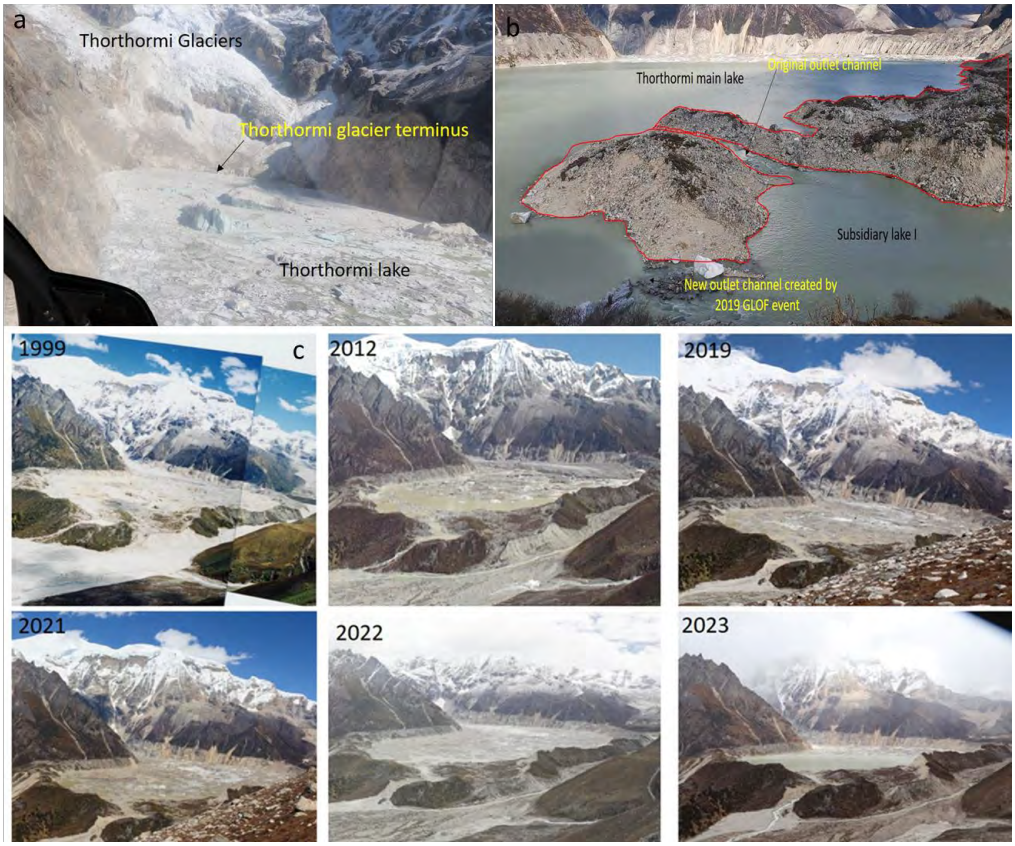


Figure Figure 43: a) Extreme upper part of Thorthormi Tsho .b)Condition at the outlet of main Thorthormi tsho. c)Time series changes on the surface of Thorthormi glacier from 1999 to 2023.

10.6 GLOF EDUCATION AND AWARENESS WORKSHOP

Due to the increasing threats of GLOF from Thorthormi lake, NCHM in collaboration with conducted GLOF awareness workshop for Local Government of Gasa, Punakha, Wangdiphodrang, hydropower projects (PHPA-I & II) and Basochhu Power Plant, DGPC along the Punatsangchhu basin from 6-10 May 2024 before the monsoon. During the workshops NCHM shared about the status of glacier lakes and associated GLOF hazards and risks and status of GLOF early warning systems and sought feedback.

Figure 44:GLOF Awareness workshop in a)Gasa,b) Punakha,c)Wangdue and d)hydro-power plants in the Puna Tsang Chhu Basin.

10.7 Capacity Building in Cryosphere Monitoring and Assessment

Under the World bank funded project for Strengthening Cryosphere Monitoring and Risk Assessment support four officials from the Centre, attended a two-week long training program on the “Applications of Remote Sensing in Cryosphere Monitoring'' at the Geoinformatics Centre, Asian Institute of Technology from 15 to 16 January,2024. The training was conducted to enhance the knowledge and skills of NCHM to effectively use GIS and remote sensing tools for development of cryosphere monitoring and development of hydro-met services and products. The program covered a range of topics, including the principles of remote sensing, satellite data acquisition and processing using google earth engine, python programming and specific applications in cryosphere monitoring.

Figure 45: Participants at Geoinformatics Centre, AIT, Thailand

11 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 necessary standards in line with regulatory requirements of WMO and ICAO for operation of national hydrology, meteorological, aviation and cryosphere services. The division is also responsible for coordinating research works with technical divisions pertaining to hydrology, water resources, weather, climate, snow and glaciers and its applications.

11.1 HYDRO-MET STANDARD MANUALS

The TSRD is responsible for developing and implementing standardized procedures, guidelines, and protocols to facilitate consistent and reliable data collection, analysis, and dissemination. By adhering to the quality control checklist provided by the World Meteorological Organization (WMO), the division ensures that the data and services provided by the National Meteorological and Hydrological Services (NMHS) meet international quality standards. This quality control checklist for national hydrological services, as defined by the WMO, can be accessed at the following site: https://community.wmo.int/en/checklist-developing-quality-management-system-national-hydrological-service

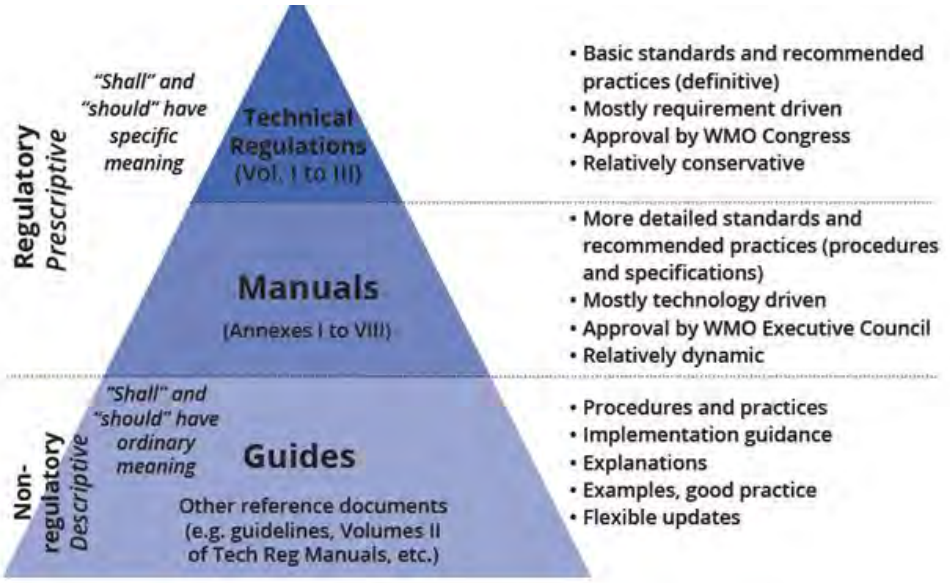


Figure 46: WMO Technical Regulations and other guidance material (Source WMO)

In the FY 2023-24, the division developed the following manuals:

a. Operational Manual for Meteorological Observation (MSD-PR-01): This manual provides comprehensive guidelines for conducting accurate and standardized meteorological observations. It covers various aspects, including measurement techniques, data collection and recording by field staff.

b. Operational Manual for Meteorological Instrumentation (MSD-PR-02). This manual outlines the site selection, network design and other instrumentation aspects related to weather and climate observation.

To identify competencies of hydro-met technicians and enhance the processional capacity, the division also drafting the following manuals:

a. Competency-Based Framework (CBF) for Hydrology/Meteorology Technicians and
b. Standard Training Manuals for the regular capacity building of Hydrology/Meteorology Technicians.

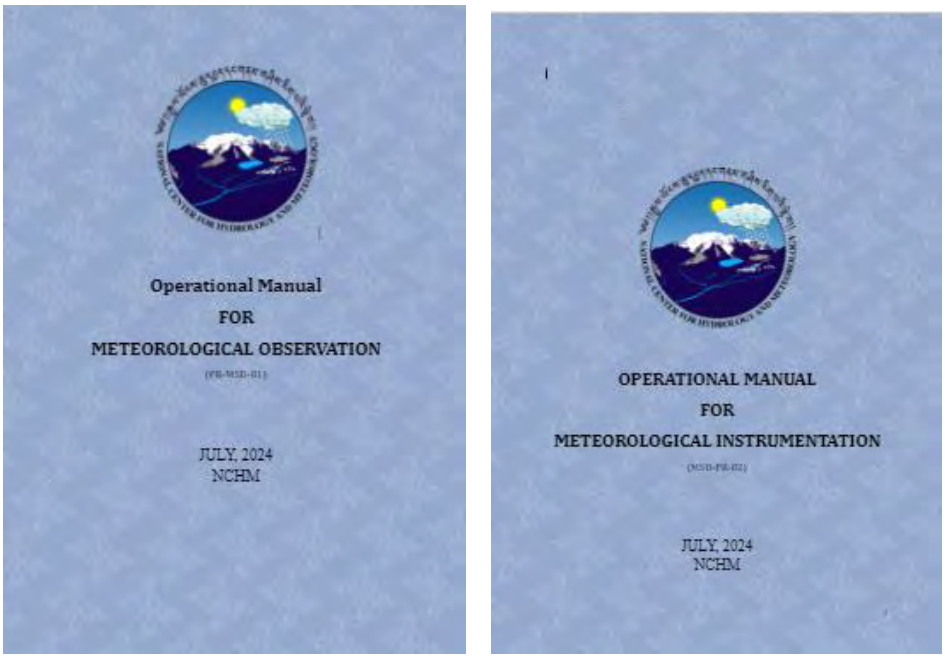


Figure 47: Operational Manuals

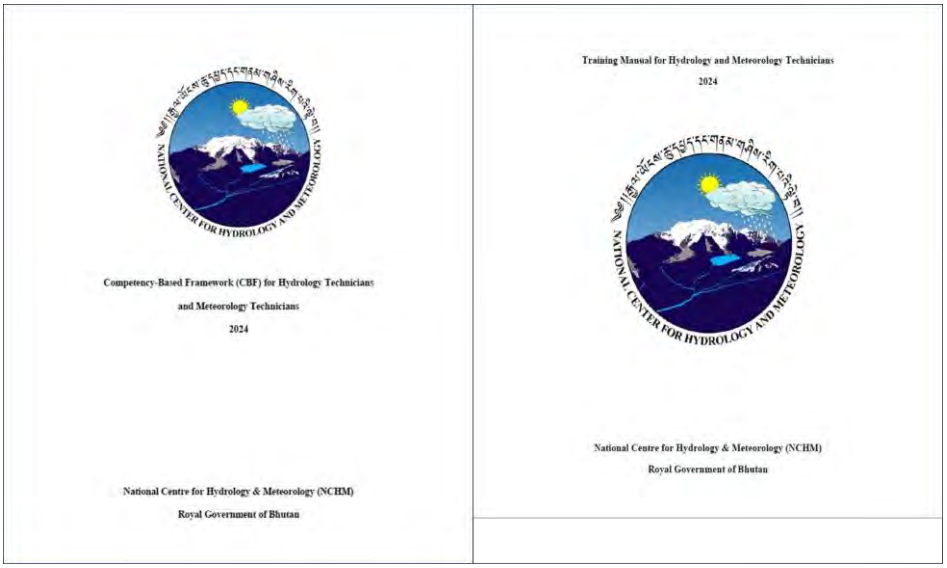


Figure 48: Draft Competency Based Framework (left) and Training Manual (right) for Hydrology/Meteorology Technicians

11.2 CALIBRATION OF FIELD INSTRUMENTS

Calibration is the process of adjusting the accuracy of instruments and sensors used in hydro-meteorological data collection to meet international standards, ensuring reliable and precise data. Proper hydro-meteorological calibration is essential because it helps maintain measurement accuracy, enabling more precise and reliable assessments of water resources, weather conditions, and climate patterns. This accuracy is crucial for various sectors such as agriculture, water management, and climate research.

In FY 2023-24, the TSRD carried out the instrument calibration and inspection of the instrument/sensors in 20 Class A Weather Stations across Bhutan.

Figure 49:Calibration at the field station

12 PUBLICATIONS

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.

Figure 50: NCHM Publications 2023-2024

13 CURRENT PROJECTS

13.1 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 project period was further extended to December 2024 due to additional work for installation of flood EWS that is expected to be completed by September 2024.

The following activities were conducted by JICA experts in coordination with NCHM counters parts;

a. Developed flood runoff models and flood hazard maps of Thimchu and Parochhu. JICA Experts together with the NCHM team also run the Breach Model in Parochhu and Chamkahrchhu for GLOF risk assessment.

Figure 51: Flood Hazard map of Parochhu

Figure 52: Flood hazard map of Thimchhu

b. Established calibration lab and conducted training of calibration of weather observation instruments by JICA Experts.

Figure 53: Instrument calibration training by JICA Expert

c. GTS to transmit data from more local stations to the RTH upgraded and 5 SYNOPTIC stations identified to connect GTS

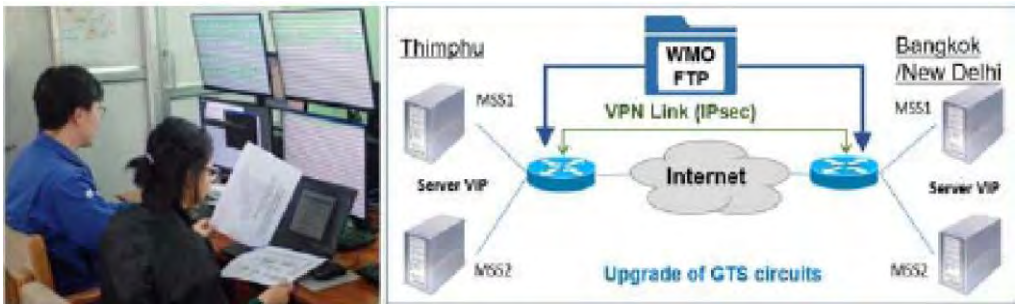


Figure 54: GTS Upgradation

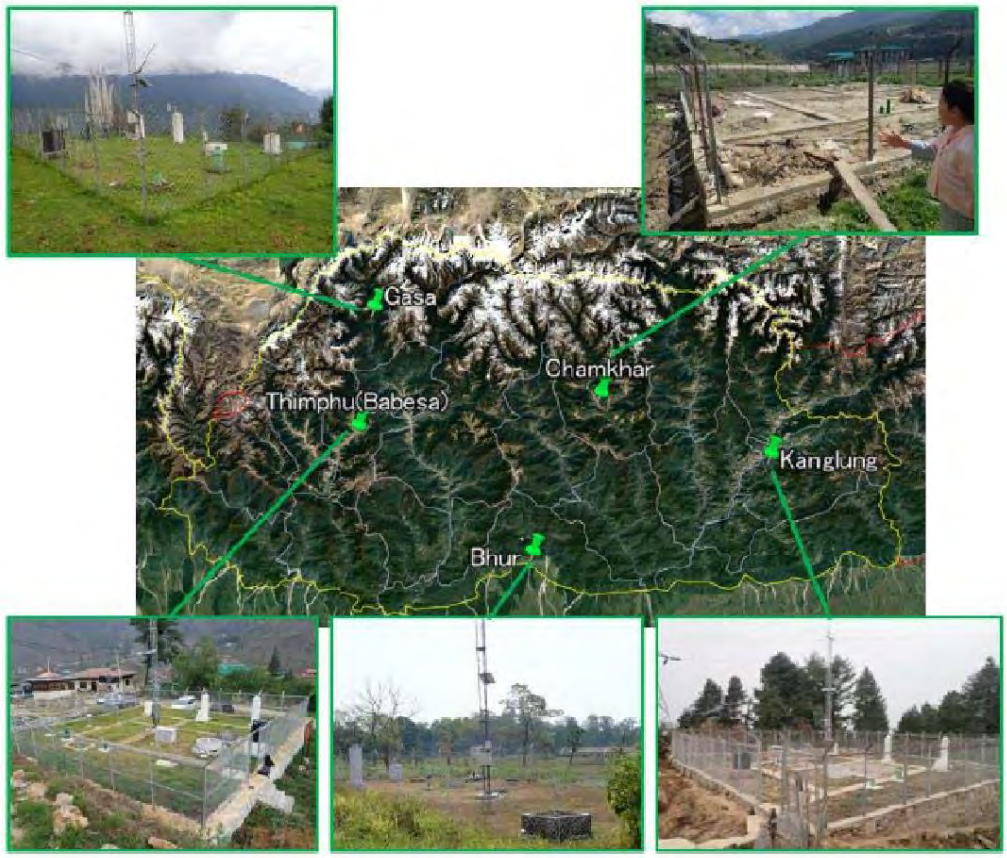


Figure 55: SYNOP candidate stations identified

d. For effective utilization of satellite data in order to improve accuracy of weather forecast, JICA experts conducted verification of the utilization of GSMaP (Global Satellite Mapping of Precipitation) data.

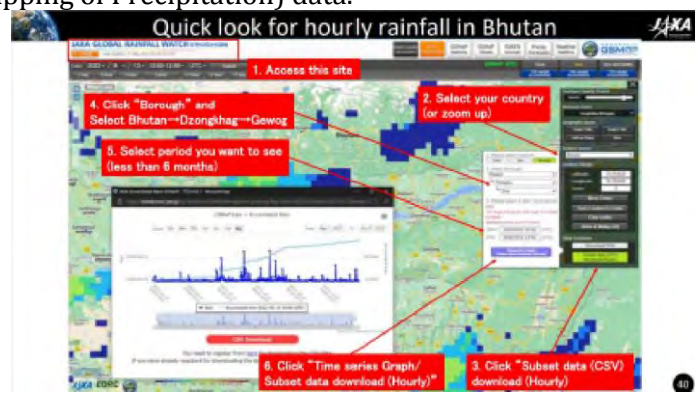


Figure 56: Sample of GSMaP training material, example of extracting hourly estimated rainfall by selecting country and city name

e. JICA experts conducted training to develop forecast guidance for temperature and for quantitative precipitation forecast using available forecast products from NWFWC to improve weather forecasting.

Figure 57: Photos of Guidance presentation and Kalman filter exercises

Figure 58: Training on the use and operation of precipitation guidance

f. JICA project set up a weather studio and conducted training to develop weather forecast broadcasting programs through installation of weather forecasting broadcasting studios within NWFWC.

Figure 59: JICA expert conducting training for use of weather studio and development of program

g. JICA project provided "Training on Flood Disaster Preparedness and Response of Disaster Prevention Organizations" 15-29 November 2023 in Japan. Participants from the National Centre for Hydrology and Meteorology (NCHM), Department of Local Governance and Disaster Management (DLGDM), Department of Human Settlement (DHS), Ministry of Infrastructure and Transport and LGs of Thimphu Dzongkhag, Paro Dzongkhag and Thimphu Thromde attended the training.

Figure 60: Awarding of Certificates to participates at JICA

13.2 GCF PROJECT

The Center 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.

Number of institutional and capacity development programs to improve the capacity of NCHM, Agriculture sectors and farmers and media were conducted as reported under the Agrometeorological Services section above.

13.3 WORLD BANK PROJECT

The World Bank 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 to implement the following activities.

a. Hydro-met Policy of Kingdom of Bhutan (2023) was formulated and was approved by the Cabinet (*Lhengye Zhungtshog)* on 18 September 2023. The Policy was translated to Dzongkha. Policy would provide the strategic direction for systematic development of hydromet sectors in Bhutan.
b. Developed NCHM Road Map for Institutional Strengthening Hydromet and Multi-hazard Early Warning Services in Bhutan (2024)
c. Developed Technical Guidance for the Construction of NCHM HQ and Scientific Facilities at Yusipang, Thimphu. The construction is planned to start in the 13 FYP.
d. NCHM is carrying out national flood hazard assessment and mapping of all the vulnerable river basins and settlement areas.
e. NCHM is working on medium range weather forecast (Agro-met) in collaboration with Agriculture sectors.
f. NCHM is strengthening capacity for cryosphere monitoring and risk assessment. GLOF hazard and risk assessment using the Dam BREACH Modeling tools were conducted for Parochhu and Chamkharchhu basins.

Updates of project activities are reported under the different sections of the report.

13.4 AMOCHHU FLOOD EWS

An interim Flood EWS on Ammochhu basin was installed and operation from May 2020. A Hydrological Flood Forecasting Early Warning System (FFEWS) was developed under the GCF supported NAP project implemented by UNDP. The system was developed with the objectives of initiating web-based flood forecasting to provide early warning services. The system was developed by M/s Campbell Scientific and is piloting for the Ammochu basin from July- September 2023. NCHM will expand the forecasting system to other basins.

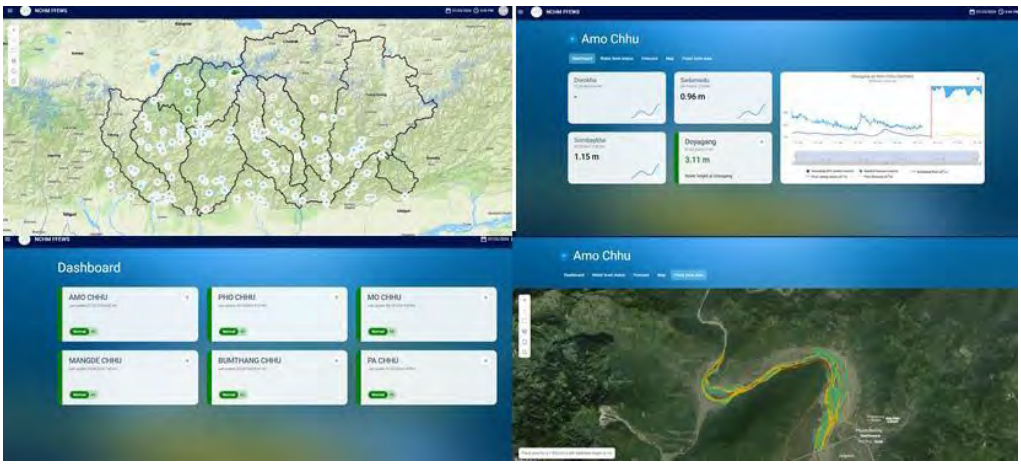


Figure 61:NCHM FFEWS

13.5 BHUTAN FOR LIFE

NCHM is one of the Implementing Agencies for the Bhutan for Life (BFL) Project. Under the Project, NCHM has completed the construction of Flood Warning and Cryosphere Research Office at Lunana. Out of Nu 19.980 million allocated for the FY 2022-23 only Nu. 13.257 million has been utilised as the supply and installation of solar panel and accessories activity could not be completed due transportation issue to from the manufacturer to Bhutan.

Two NCHM staff are stationed in Lunana responsible for monitoring of GLOF EWS and lakes 365 days. New office was constructed at a strategic view point for visual monitoring of rivers and floods. The new office has additional room to set up lab and facilities for research works.

Figure 62: New Flood Monitoring and Cryosphere Research Office, Lunana

13.6 SYSTEMATIC OBSERVATION FINANCING FACILITIES

The Systematic Observations Financing Facility (SOFF) was created by WMO, UNDP and UNEP in 2021 at the 26th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26). SOFF is a United Nations Multi-Partner Trust Fund and the Secretariat is with WMO in

Geneva, Switzerland the an objective to provide grant financing and technical assistance to the Small Island Developing States (SIDS), Least Developed Countries (LDCs) to sustain collection and exchange of essential surface-based weather and climate observations to strengthen the provision of high-quality weather forecasts, early warning systems, and climate services that are essential for effective, resilient development and climate adaptation action that results in saved lives, improved livelihoods, and protected property.

United Nations Environment Programme UNEP as the Implementing Entity (IE) and the Finnish Meteorological Institute (FMI) as the Peer Advisor (PA) to support Bhutan for the implementation of SOFF. NCHM worked together with UNEP and FMI on the SOFF Readiness Phase of the project and submitted Bhutan SOFF Investment Funding request to the SOFF Secretariat on 22 February 2024. Bhutan SOFF Investment Funding amounting USD 4.59 million was approved by SOFF Secretariat on 21 March 2024 for establishment of the upper observation, WMO certified Automatic Weather Stations (AWS), calibration facilities, upgradation of ICT facilities and capacity building. The project is expected to strengthen NCHM capacity for sustained collection and international exchange of essential surface-based weather and climate observations according to the internationally agreed GBON regulations and strengthen the provision of high-quality weather forecasts, early warning systems, and climate services.

The project funds will be routed through IE (UNEP) and an Implementation Agreement will be signed between the Ministry of Finance and UNEP. NCHM is coordinating with MoF and UNEP and plans to sign the Project Agreement during the project inception workshop in September, 2024.

Figure 63: SOFF consultation workshop with stakeholders, 17th August 2023, Paro

14 INSTITUTIONAL STRENGTHENING OF HYDRO-MET SECTOR

14.1 HYDRO-MET POLICY OF KINGDOM OF BHUTAN

After completing all the Protocol for Policy Formulation, the draft Hydro-met Policy was submitted to the Cabinet Secretariat for review and comments. The draft Final Hydro-met Policy of the Kingdom of Bhutan was submitted by the Ministry of Energy and Natural Resources to the Cabinet for approval on 18 May 2023.

The Policy was approved by the Cabinet during the 152nd Session of Third Lhengye Zhungtshog held on September 13, 2023. This policy shall be the guiding document for the development, enhancement, and provision of services on meteorology, hydrology, and cryosphere in the Kingdom of Bhutan.

14.2 HYDROMET ROAD MAP

Institutional Strengthening and Modernisation of Hydro-met and related Early Warning Services in Bhutan- A Hydromet Roadmap (2024-2034) was developed under the support of the World Bank project. A Roadmap document was approved by the Scientific and Technical Advisory Council (STAC) during the 1st Council meeting held on 20th June 2024. Road map was developed to guide the systematic development of the hydro-met sector in Bhutan based on changing needs. It was aimed at providing a direction based on the current status of NCHM and the evolving future service needs for the next 10 years.

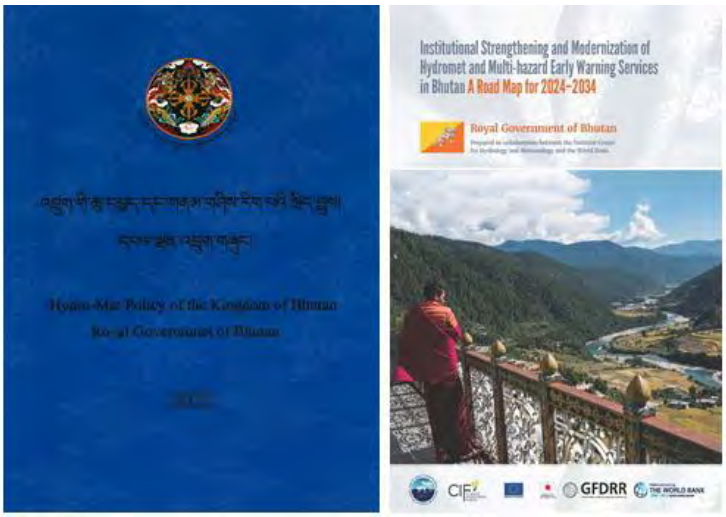


Figure 64: Hydromet Policy of the Kingdom of Bhutan (2023) and Hydromet Road Map (2024)

14.3 CONSTRUCTION OF ACCESS ROAD TO NCHM NEW CAMPUS

To establish a permanent campus and scientific facilities of NCHM, the Centre has acquired 5.0 acres of land in Yusipang, under Chang Gewog, Thimphu Dzongkhag in 2022-23FY. Accordingly, an access road to the above site was constructed under the FWS-GOI program during the 2023-24 fiscal year. The road construction was completed on May 15, 2024, at an estimated cost of approximately Nu. 4.9 million.

Figure 65: Constructed Access Road of NCHM HQ and NWFWC facilities

15 SCIENTIFIC AND TECHNICAL ADVISORY COUNCIL

15.1 1ST SCIENTIFIC AND TECHNICAL ADVISORY COUNCIL MEETING

1st Scientific and Technical Advisory Council (STAC) meeting of NCHM held on 20 June, 2024, Thimphu. During the 1st STAC meeting Mr. Karma P Dorji, Director, Department of Energy, MoENR was elected as the Chairperson of Council. The following are the members of council.

a. Mr. Tashi Penjor, Director, Department of Human Settlement, MoIT
b. Mr. Kado Zangpo, Director, Department of Local Governance and Disaster Management, MoHA.
c. Mr. Karma Jamtsho, Director, Department of Public Health, MoH
d. Dr. Cheki Dorji, President, College of Science and Technology (CST), Royal University of Bhutan

e. Mr. Karma Dupchu, Director,NCHM

The STAC also reviewed and endorsed the following documents.

a. Terms of Reference of STAC of NCHM
b. NCHM Road Map: Institutional Strengthening and Modernisation of Hydromet and related Early Warning Services in Bhutan (2024-2034)
c. Climate Change Projection Report of Bhutan (Insights from CMIP6, 2024).

Figure 66: 1st STAC Meeting, Thimphu and STAC members

16 WMO, IPCC, ICAO AND COP MEETINGS

16.1 WMO SERCOM-3 AND GENDER CONFERENCE

The National Center for Hydrology and Meteorology (NCHM) as the designated National Focal of Bhutan with WMO attended the following meetings during the FY 2023-2024 with funding from the WMO Trust fund

The Third Session of the Commission for Weather, Climate, Hydrological, Marine and Related Environmental Services and Applications (SERCOM-3) and the Gender Conference was held at the Bali International Convention Center (BICC), Bali (Indonesia) from 4 to 9 March 2024, Ms Dechen L Gyeltshen, Met Officer, Meteorology Services Division, National Centre for Hydrology and Meteorology attended the session.

SERCOM-3 was held with the objective of bringing together technical experts from all around the world and facilitating their collaboration in developing standards for methods, procedures, techniques and practices, and ensuring that their recommendations are provided to the WMO Congress and Executive Council. The Gender Conference, held on 7 March 2024, aimed to share knowledge and facilitate

exchanges on promoting Gender Equality and Women's Empowerment and Leadership through the Early Warnings for All initiative.

Figure 67: Ms. Dechen L Gyeltshen at WMO SERCOM-3 Conference, Bali, Indonesia

16.2 WMO LEADERSHIP AND MANAGEMENT PROGRAM

WMO Fourth Leadership and Management Program for Senior Management of National Meteorological and Hydrological Services (NMHS) for RA-II and RA-V was held at Singapore, 4-8 September 2024. The programme was jointly organised by Meteorological Service Singapore (MSS) and World Meteorological Organization (WMO).

Mr. Karma, Specialist, NCHM attended the Fourth Leadership and Management Program for Senior Management at Singapore. The programme was aimed at developing critical management skills in the leadership of NHMS in developing and least developed countries in Asia and South-West Pacific. The programme focused on organizational transformation & change management, organizational development, public communication, future thinking & policy development, performance management, competency management and resource mobilization. The programme was facilitated by reputed resource persons from renowned consulting firms and institutes in Singapore, WMO and related agencies from around the world. 20 senior officials from NMHS from RA II and RA V region attended the program.

Figure 68: Mr. Karma, Specialist at Leadership Program, Singapore

16.3 INTERGOVERNMENTAL PANEL FOR CLIMATE CHANGE (IPCC)

The National Center for Hydrology and Meteorology (NCHM) designated the National Focal of Bhutan with IPCC attended the following meetings during the FY 2023-2024 with funding from the IPCC Trust.

Table 17: List of IPCC meeting

Sl. #	IPCC Meeting	Date
1	Mr. Karma Dupchu, Director attended the Fifty-Ninth Session of the Intergovernmental Panel on Climate Change (IPCC-59) held from 25-28 July 2023 at the headquarters of the United Nations Environment Programme (UNEP), United Nations Avenue, Gigiri, Nairobi, Kenya.	25-28 July 2024
2	Dr. Singay Dorji, Specialist, Meteorology Services Division, NCHM attended the Sixtieth Session of the Intergovernmental Panel on Climate Change (IPCC-60) held from 16-19 January 2024 at Istanbul, Türkiye.	16-19 January 2024

Figure 69: Mr. Karma Dupchu, NCHM attended the Fifty-Ninth Session *of the IPCC (IPCC-59)*

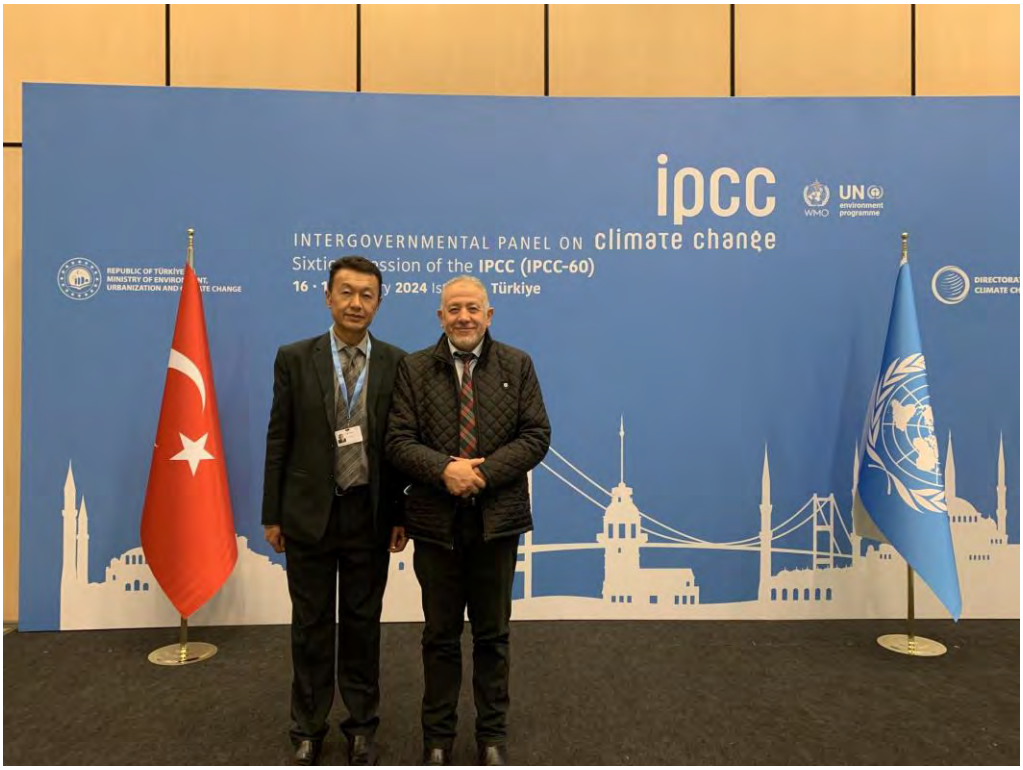


Figure 70: Dr. Singay Dorji, NCHM attended the Sixtieth Session of the IPCC (IPCC-60)

16.4 ICAO REGIONAL MEETING

NCHM is the Aviation Meteorological Services Provider designated by Bhutan Civil Aviation Authority (BCCA) to attend the 34th Asia/Pacific Air Navigation Planning and Implementation Regional Work Group (APANPIRG) meeting held in Hong Kong, China from 11-13 December, 2023. Ms. Ugyen Lhamo Met/Hyd Officer, Aviation Met Section (AMS), Meteorological Services Division, NCHM attended the meeting along with the RGoB team.

Figure 71: Ms. Ugyen Lham, AMS at ICAO APANPIRG) meeting

16.5 28TH CONFERENCE OF PARTIES (COP28), DUBAI, UAE

Mr. Karma, Specialist (ES IIA), Cryosphere services Division, NCHM attended the 28th Conference of Parties, COP28, in Dubai, United Arab Emirates along with a RGoB delegation from Nov 30, 2023 – Dec 13, 2023. He also attended a number of side events organised at Bhutan Pavilion and other international regional organisations pavilions at the panellist at COP 28.

a. Panellist for session 2 on "Rapid Glacier Melting and Impact on Mountain communities and Disappearing Ice Worlds: Witness to Warming" at Bhutan Pavilion, 4 December 2023
b. Panellist for the session "Roadmap Towards the International Year of Glaciers' Preservation and Glacier Day, 2025 and beyond" organised by WMO and UNESCO IHP on 5 December 2023.
c. Panellist for the session "Loss and Damage: Addressing Soft Limits to Adaptation to Avert and Minimizing loss and damage" event organized by UNEP at UNEP Pavilion on 8 December 2023.
d. Panellist for the Session 2: "Summiting Challenges: Climate Change Impact on the Mountain Economy" Bhutan Pavilion on 9 December 2023. Mr. Karma presented "Status of glaciers in Bhutan".

e. Participated in HI-LEVEL REGIONAL DIALOGUE on “The call of the cryosphere: Disappearing snow and ice in the Hindu Kush Himalaya” at Cryosphere Pavilion, #COP28 organized by ICIMOD.
f. Participated in the United Nations Development Programme -ICIMOD event: Tipping Point for Third Pole Communities” at #Nepal Pavilion on 11 December 2023
g. ICIMOD - UNDP Event" Experience of GLOF Risk Reduction and EWS in the higher Himalayas and way forward".
h. Advancing Scientific Tools and Synergies for Climate Change Risk Assessment in the Asia-Pacific organized by UN ESCAP and NIES at Japan Pavilion.

Figure 72: Mr. Karma, Specialist at COP28, Dubai, UAE

17 HUMAN RESOURCES DEVELOPMENT

17.1 SHORT TERM TRAINING (STT)

During the financial year 2023-2024, the Centre has facilitated and processed STTs for 78 employees to attend various trainings, meetings, seminars, workshops and conferences including any other ex-country travels. The STTs were all implemented to enhance technical and professional capacity of the existing employees and to keep abreast with emerging science and technologies in the field of meteorology, hydrology and cryosphere with the funding support from international, bilateral, regional partners and projects. The Centre during the span of one year has implemented 113 STTs as detailed in figures below;

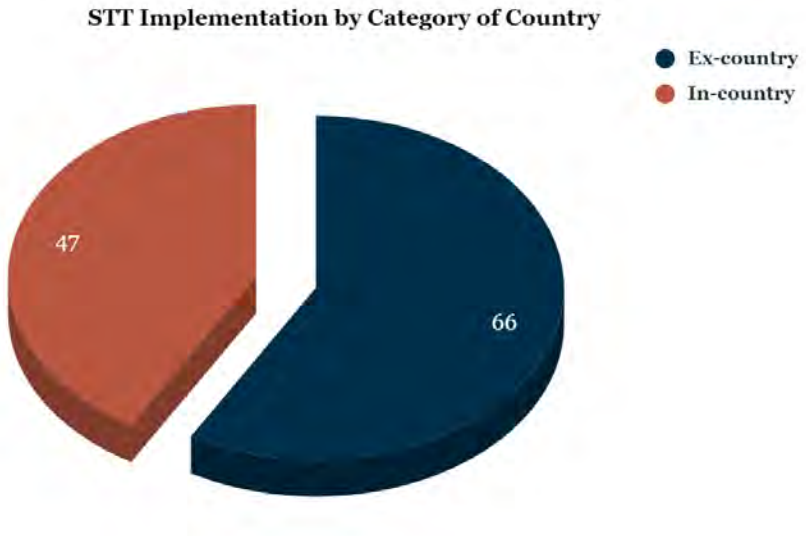


Figure 73: STT Implementation by Country Category for FY 2023-2024

Out of 113 STT implemented for FY 2023-2024, majority of the STT were facilitated and implemented ex-country accounting to 66 in numbers. Remaining around 41.59 % were implemented within the country. The Centre was able to implement the majority of capacity building programmes outside the country primarily due to funding support received from the external partners.

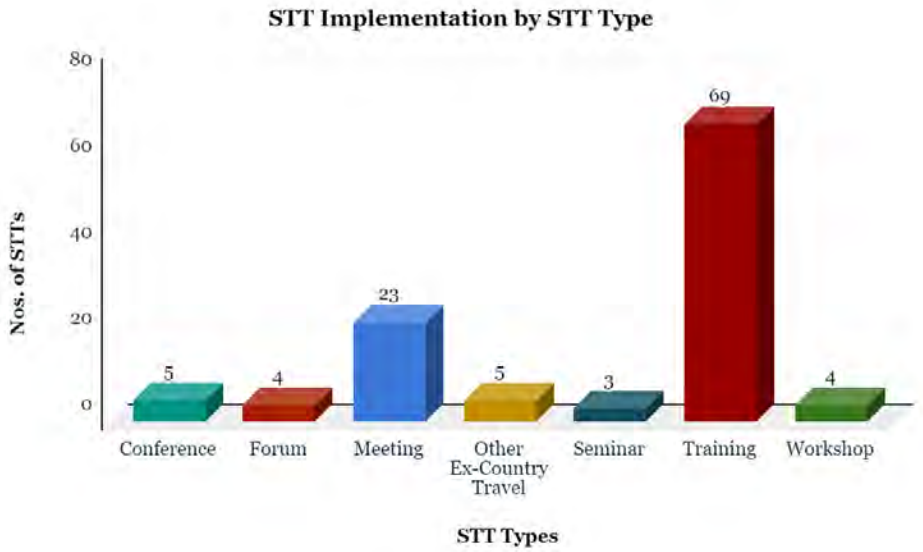


Figure 74: STT Implementation by STT Type for FY 2023-2024

For this particular reporting year, the Centre by STT type has implemented a maximum of training accounting to 61.06% and least being seminar, forum and workshop.

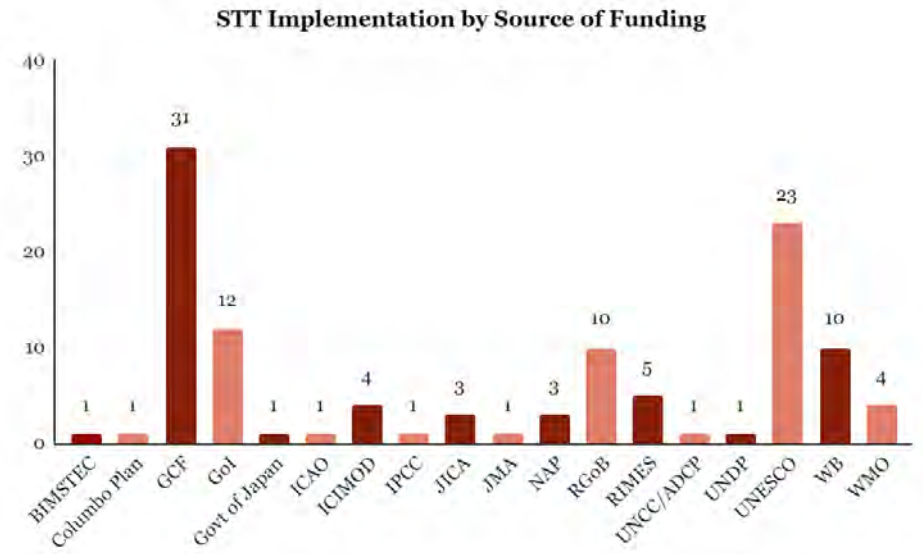


Figure 75: STT Implementation by Source of Funding for FY 2023-2024

For Financial Year 2023-2024, the majority of the STT has been implemented under the funding support of Green Climate Fund (GCF) Projects followed by UNESCO and GoI. The Centre has also implemented mandatory meetings as a national focal point for WMO, IPCC, ICAO and BIMSTEC under funding support from the Royal Government of Bhutan (RGoB).

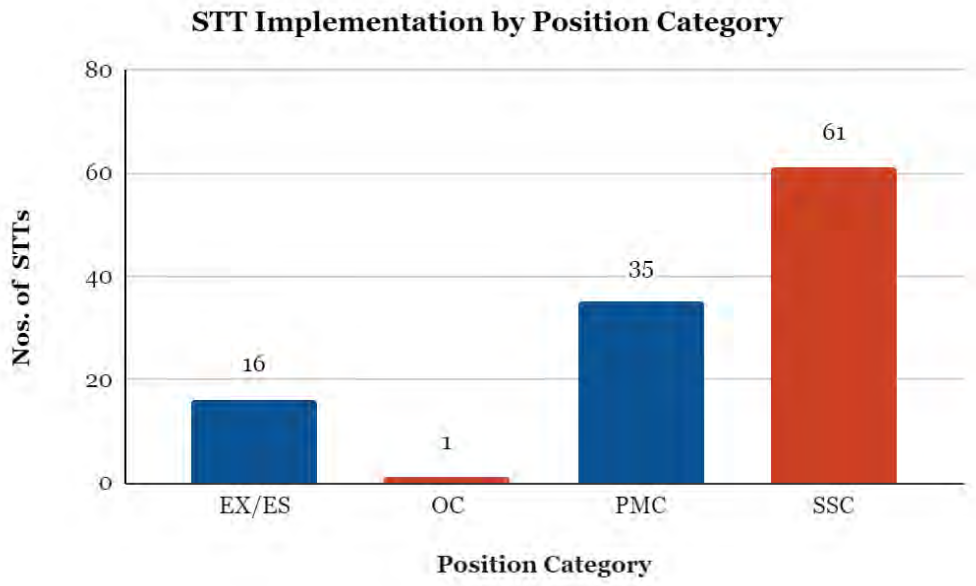


Figure 76: STT Implementation by Position Category for FY 2023-2024

For the reporting year 2023-2024, the Centre has focused capacity building programmes for core working groups at SCC and PMC level to enhance technical competencies, skills and knowledge. Moreover, the staffing strength of Centre comprised the maximum of employees at SSC level followed by PMC and simultaneously, the SSC category employees attended the highest STTs for this reporting year as indicated in figure above. The lowest is in the OC category that is any other ex-country travel and it is also defined as one of the STT types as per Chapter 7 of the BCSR 2023.

17.2 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, ICAO and other regional organisational and bilateral organisations for financial year 2022-2023 as detailed in the table below.

Table 18: List of mandatory meetings/seminars/conference attended for FY 2023-2024

Sl #	Title of Meeting/Conference/Seminar	Head of Delegation	Date	Institute/ Country
1	ICAO Asia and Pacific (APAC) Twenty Seventh Meeting of the Meteorological Sub-Group (Met SG/27)	Ms. Ugyen Lhamo, Met/Hyd Officer	4-8 September 2023	ICAO, Bangkok, Thailand
2	Joint Group of Experts (JGE) Meeting on flood Management between Bhutan and India	Mr. Karma Dupchu, Director	28 – 29 February 2024.	New Delhi, India
3	Thirty-Fourth Meeting of the Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG/34)	Ms. Ugyen Lhamo, Met/Hyd Officer	11-13 December 2023	ICAO, Hongkong, China
4	Third Meeting of the Governing Board of BIMSTEC Centre for Weather & Climate and Third Meeting of the Scientific Advisory Council	Mr. Karma Dupchu, Director	13-14 December 2023	BCWC, Noida, India
5	Twelfth Meeting of the Meteorological Requirements Working Group (MET/R WG/12) and Seminar on Meteorology and Air Traffic Management (MET/ATM Seminar)	Ms. Ugyen Lhamo, Met/Hyd Officer	1-5 May 2023	ICAO, Bangkok, Thailand
6	Sixteenth Session of the Intergovernmental Panel for Climate Change (IPCC-16)	Dr. Singay Dorji, Specialist III	16-19 January 2024	Istanbul, Turkey
7	ICAO Asia and Pacific (APAC), Twenty-second Meeting of the Meteorological Information Exchange Working Group (MET/IE WG/22)	Ms. Ugyen Lhamo, Met/Hyd Officer	18-21 March 2024	ICAO, Bangkok,Thailand
8	Seminar on ICAO Asia and Pacific (APAC), Thirteenth Meeting of the Meteorological Requirements Working Group (MET/R WG/13)	Ms. Ugyen Lhamo, Met/Hyd Officer	22-26 April 2024	ICAO, Bangkok, Thailand

17.3 OPERATION HYDROLOGY TRAINING FOR OBSERVERS

NCHM conducted a 8 days refresher course on "Training on Ambient Water Quality Monitoring and Refresher Course on Basic Hydrological Observation and

Operations" for the field technicians from 23-30 October 2023 with funding support from UNESCO.

Figure 77: Refresher Course on Basic Hydrological Observation and Operations

17.4 SMARTMET AND WRF MODELLING TRAINING

With the support from the GCF/UNDP supported Project "Supporting Climate Resilience and Transformational Change in the Agriculture Sector in Bhutan, WFCR conducted advanced training on updated SmartMet (Common Operating Platform for weather forecasts) and Weather Research and Forecasting Model with auto verification system by the Finnish Meteorological Institute from May 6 to 17, 2024.

Figure 78: FMI Experts with NCHM team

With the support from the GCF/UNDP supported Project "Supporting Climate

Resilience and Transformational Change in the Agriculture Sector in Bhutan inhouse training on SmartMet (Common Operating Platform for weather forecasts) and Weather Research and Forecasting Model was conducted by experts from the Finnish Meteorological Institute in May and June 2024.

17.5 WEATHER OBSERVATION AND SHORT RANGE FORECASTING TRAINING

NCHM conducted training on "Operational Weather Observation and Short-range Forecasting" in Thimphu. Training was conducted by Dr Habibur Rahaman Biswas, Scientist from the India Meteorological Department (IMD) from 22-26 April 2024. The 5 days training covered observation and forecasting techniques for various scales of weather systems. The training was supported through the GCF/UNDP funded Project "Supporting Climate Resilience and Transformational Change in the Agriculture Sector in Bhutan" component implemented by NCHM.

Figure 79: NCHM Participants with IMD Expert

17.6 REFRESHER TRAINING COURSE ON OPERATION METEOROLOGY

A "Refresher Training Course on Operation Meteorology" for the Hydromet Technicians working in Agro-meteorological Stations (Class A) in all 20 Dzongkhags was held from 18-25 December 2023 at College of Natural Resources, Lobesa, Punakha. Training was organized with the objectives to enhance knowledge and skills with emerging needs to cope with the advancement of science and technology in the field of weather and climate observation and data management. The course covered the theoretical and practical sessions on hydrological and meteorological observation

methods, instrumentation, maintenance and calibration, data recording and transmission, and experience sharing from the site observers including challenges and issues.

Figure 80: Refresher Training Course Participants with Chief.

The training was funded by the Green Climate Fund (GCF) funded Project "Supporting Climate Resilience and Transformational Change in the Agriculture Sector in Bhutan".

17.7 KNOWLEDGE SHARING WORKSHOP UPON COMPLETION OF STUDIES

Mr. Trashi Namgyal, Dy. Chief Meteorology/Hydrology Officer successfully completed a 2 years course in Masters of Technology (Water Resources and Development) from the Indian Institute of Technology (IIT) Roorkee, India under the prestigious Nehru Wangchuck Scholarship and joined the Centre on 2 July 2023.

As a part of knowledge sharing and learning, Mr. Trashi shared his learning experiences, knowledge, skills and the lessons learnt from his long-term studies with the Centre Management and cohorts. Mr. Tashi also presented his Master Dissertation papers published in International Journals and presented in the international conference.

"Are open-source hydrodynamic models efficient in quantifying flood risks over mountainous terrains? An exhaustive analysis of the Hindu-Kush-Himalayan region" (Manuscript published in Science of the Total Environment, Elsevier; Impact Factor: 9.8

"Decoding connections between interdependent infrastructure systems to flood risk over data-scarce flood-prone regions (Manuscript under preparation for submission to Journal of Hydrology, Elsevier; Impact Factor: 6.708).

Mr. Trashi also received Recognition for Academic Excellence (CGPA>8.5) among International Students.

Figure 81: Knowledge sharing workshop

18 INSTITUTIONAL PARTNERSHIP AND TECHNICAL BACKSTOPPING SERVICES

18.1 ADJUNCT LECTURER TO CNR

Based on the special request made by the President, CNR, RUB, Mr. Trashi Namgyal, Dy. Chief Met/Hyd Officer and Mr. Jamyang Zangpo, Sr. Met/Hyd Officer were sent as the adjunct lecturers to teach a module "Applied Hydrology" to the second-year students pursuing the BSc in Environment and Climate Change Studies. To avoid the performance of their job, the teaching sessions were done on the weekends.

Figure 82:NCHM Adjunct lecturers with CNR Students

18.2 CNR STUDENT STUDY VISIT TO NCHM

College of Natural Resources (CNR) first year students pursuing BSc Environment and Climate Studies visited the National Centre for Hydrology and Meteorology (NCHM) on study visits on 29th May, 2024. NCHM made presentations about Center mandates, structure and functions, important hydromet data collection for weather and flood forecasting and climate change studies.

Students visited 24/7 National Weather and Flood Warning Center (NWFWC) to learn about weather prediction and flood monitoring and Babesa Class A Meteorological Station to learn meteorological instruments used for climate data collection and analysis processes.

Figure 83: CNR Student visits to NCHM HQ and Site

18.3 JNEC STUDENT STUDY VISIT TO NCHM

As a part of industrial tour, the final year students pursuing BE Survey and Geoinformatics along with the faculty of the Jigme Namgyel Engineering College (JNEC) under the Royal University of Bhutan visited the National Centre for Hydrology and Meteorology (NCHM) on 11th October, 2023.

The Centre shared NCHM mandates, observations network, research, forecasting and hydro-met services delivered by the Center. The JNEC team also presented the research outcome of a “Study on Glacier Dynamics of Bechung Glacier Using Feature Tracking Method '' carried out by the students. Since NCHM has MoU signed with College of Natural Resources (CNR), College of Science and Technology (CST) and Sherubtse College for joint research collaboration, the NCHM and the JNEC team also discussed possible collaboration in joint research, weather observation and data exchange in the areas of hydrology, meteorology, cryosphere, climate change studies and on the job training opportunities for the students to fulfill their academic requirements

The students and faculty also visited the 24/7 Weather and Flood Warning Centre (NWFWC).

Figure 84: JNEC Students at NCHM

18.4 TECHNICAL BACKSTOPPING SERVICES TO DGPC

Druk Green Power Corporation (DGPC) installed an automatic water level station (AWLS) in 2023 in the Nika Chhu stream to monitor the real-time changes in the water level for dam reservoir monitoring with technical backstopping from NCHM. The technical backstopping included developing the technical specifications for the AWLS, site feasibility study and facilitated in tendering the work. The installed AWLS has been finally integrated to the AWLS network of Bhutan in NCHM and uninterrupted operation of the station is maintained.

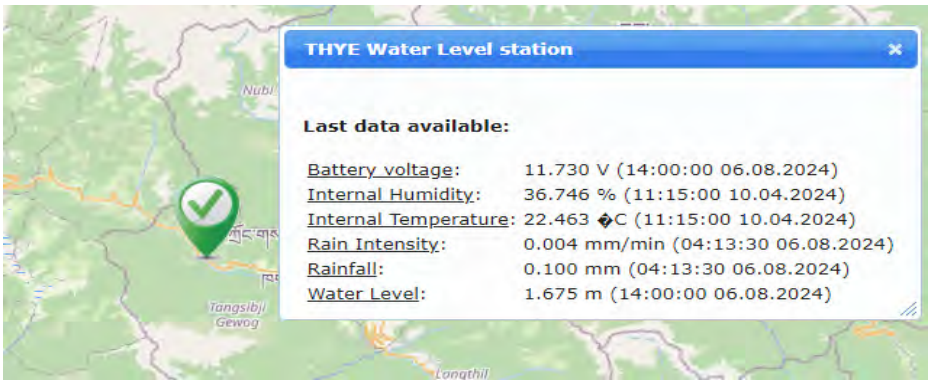


Figure 85: Dashboard showing the DGPC installed AWLS in Nika Chhu sub-basin

19 IMPORTANT EVENTS

19.1 7TH JOINT TECHNICAL TEAM (JTT) MEETING

The 7th Reconstituted Joint Technical Team (JTT) meeting on Flood Management between the Government of India (GoI) and the Royal Government of Bhutan (RGoB), was held during 5-6 October, 2023 at Phuentsholing, Bhutan. The Indian delegation was led by Shri G.L. Bansal, Chief Engineer, Brahmaputra Basin Organisation, Central Water Commission, GoI and the Bhutanese delegation was led by Dr. Singay Dorji, Specialist of Meteorological Services Division (MSD), National Centre for Hydrology and Meteorology, RGoB.

The meeting was held in a cordial and friendly atmosphere.

Figure 86: 7th JTT meeting of flood management, Phuentsholing 5-6 October 2023

19.2 10TH JOINT GROUP OF EXPERTS (JGE) MEETING

The 10th Meeting of the Joint Group of Experts (JGE) of Flood Management between Bhutan and India was held in New Delhi, India on 28 – 29 February 2024. The RGoB delegation was led by Mr. Karma Dupchu, Director, National Centre for Hydrology and Meteorology (NCHM). The Government of India (GoI) delegation was led by Mr. S.K Sinha, Team Leader, Commissioner (B&B), Department of Water Resources, River Development & Ganga Rejuvenation (GR), Ministry of Jal Shakti.

The meeting discussed common issues of flooding, reviewed remedial measures implemented to mitigate flooding in vulnerable areas in southern hills and adjoining plains and modernising flood monitoring systems to enhance data sharing.

The Joint Group of Experts (JGE) of Flood Management between Bhutan and India was constituted in 2004 and meetings are held alternatively in Bhutan and India.

Figure 87: 10th JGE meeting, New Delhi, India 28-29 February 2024

19.3 12TH NDMA MEETING

NCHM hosted the 12th meeting of the National Disaster Management Authority (NDMA) of Bhutan on 28 May 2024. The meeting was chaired by the Hon'ble Prime Minster of Bhutan and endorsed the establishment of the National Emergency Operation Centre at Lungtenphu and the National Weather and Flood Warning Center, along with Scientific Facilities at Yusipang, Thimphu.

Following the meeting, the *Lyonchen* and NDMA members visited the 24/7 National Weather and Flood Warning Centre (NWFWC).

Figure 88: 12th NDMA Meeting
(Photo Source: Official Facebook Page of the Prime Minister's Office of Bhutan)

19.4 3RD JCC MEETING OF JICA TCP PROJECT

The 3rd 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 26 April 2024 in 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), Ministry of Home Affairs.

The meeting was jointly chaired by Director, NCHM and Mr. Taichi Minamitani, Director, Disaster Risk Reduction Division, Global Environment Department, JICA HQ. The meeting was attended by officials from JICA HQ, Tokyo, JICA Bhutan Office and JICA Expert Team from the JICA side. JCC reviewed the progress of the project activities and approved revised Project Design Matrix (PDM) and time extension of the project by three months from September 2024 to December 2024.

Figure 89: 3rd JCC meeting for JICA TCP project, 26 April 2024

19.5 GEF CEO VISITS TO GLOF EWS CONTROL ROOM, WANGDUE

Mr. Carlos Manuel Rodríguez, CEO and Chairman of the Global Environment Facility (GEF) paid a visit to the Punatsangchhu Glacier Lake Outburst Flood (GLOF) Early Warning System (EWS) Control Room, Wangduephodrang on 25 April 2024. He was accompanied by officials from GCF, WWF, UNDP and WWF Bhutan and the Ministry of Finance.

Director NCHM welcomed and presented an overview of NCHM, GLOF EWS in Bhutan and importance of hydro-met data and EWS for climate adaptation. He also shared the status of glaciers and glaciers lakes in Lunana, existing GLOF EWS and its challenges. He also thanked GCF, UNDP and WWF for their continued assistance for modernization of hydro-met sectors and development of EWS in vulnerable river basins.

GEF CEO, WWF and UNDP officials expressed their gratitude to the National Centre for Hydrology and Meteorology (NCHM) for showcasing and operating the Early Warning System.

GEF through LDCF supported NAPA-I project for establishment of GLOF EWS along the Puna-Wangdue Valley (2008 and 2013) and NAPA- II project "Addressing the Risk of Climate-Induced Disaster through Enhanced National and Local Capacity for Effective Actions" for modernization hydro-met network in Bhutan (2014-2018).

Figure 90*: GEF CEO and other delegates at GLOF EWS Control room, Wangdue*

19.6 MINISTER OF MOENR VISITED NCHM

Lyonpo Gem Tshering, Minister, Ministry of Energy and Natural Resources (MoENR) visited National Centre for Hydrology and Meteorology (NCHM) on 12 April 2024 to have an introductory session with the employees of the Centre. During the session, His Excellency emphasised on the importance of the national language and code of conduct while discharging the official duties. He shared that it is a responsibility of the government to motivate and retain civil servants in the agencies. He encouraged

staff to work hard with utmost dedication and sincerity in delivering efficient public services, serve TSA-WA-SUM and fulfil the Royal Vision of His Majesty the King.

He highlighted the importance of teamwork and collaborations and informed that governments and sectors have to work hand in hand to improve overall public service deliveries.

His Excellency also visited 24/7 National Weather and Flood Warning Center (NWFWC) and familiarized on GLOF/Flood Early Warning Systems, Weather Forecasting systems, ICT infrastructures and the weather studio for monitoring of weather and flood warning services.

Figure 91: Lyonpo meeting with NCHM employees and visit to NWFWC

19.7 SPECIAL ASSISTANT TO THE PRESIDENT OF JICA VISITED NCHM

Mr. Toshiyuki NAKAMURA, Special Assistant to the President of JICA made a courtesy visit to the National Center for Hydrology and Meteorology (NCHM) on 27th October 2023. He was accompanied by Mr. Ryuichi UEDA, Program Officer, JOCV Secretariat, JICA Headquarters, and Official from the JICA Bhutan Office. Mr. Nakamura was in the country to attend the 35th Anniversary of JOCV in Bhutan.
Mr. Nakamura also visited the National Weather and Flood Warning Center (NWFWC) and inspected ICT, satellite facilities, and the weather studio established under the JICA supported projects for monitoring weather delivery of weather and flood warning services.

Figure 92: Mr. Toshiyuki NAKAMURA visited to NWFWC

19.8 UN Resident Coordinator Visits to NCHM

Ms. Karla Robin Hershey, UN Resident Coordinator of Bhutan made a courtesy call to the Director, National Center for Hydrology and Meteorology (NCHM) on October 11, 2023. Director welcomed and shared about NCHM roles and responsibilities and importance of climate data and information to build a climate and disaster resilience society. He also thanked UN agencies for their continued support and assistance rendered for institutional and professional capacity development of hydro-met sectors in Bhutan. The meeting also discussed United Nations Early Warning For all initiatives. The UN Resident Coordinator also visited the 27/4 National Weather and Flood Warning Centre (NWFWC).

Figure 93: UN Resident Coordinator, Bhutan visit to NWFWC

19.9 MINISTER, EMBASSY OF JAPAN VISIT TO NCHM

A team led by Ms. Kyoko HOKUGO, Minister for Economic and Development Cooperation, Embassy of Japan in New Delhi, India, made a country visit to NCHM on 1 August 2023. The Centre briefed the delegation 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. team also visited 27/4 National Weather and Flood Warning Centre (NWFWC) established with support of JICA in 2013, newly established Weather Studio and Calibration Lab facilities under the JICA current TCP project for the "Capacity Enhancement of Meteorological Observation, Forecasting and Flood Warning for Disaster Preparedness and Response in Thimphu and Paro River Basins" (2020-2024)

Figure 94: Embassy of Japan, India Minster visit to NCHM

19.10 GLOF FROM THORTHOMI LAKE, 30 OCTOBER 2024

GOLF from Thorthormi Lake occurred on 30 October 2023 at 19:20 Hrs. The GLOF EWS system detected a sudden decrease in water level from 5.51 m at 19:15 hrs to 4.72 m at 19:20 hrs indicating breach of lakes. The warnings were issued to downstream communities through the Local Government of Gasa, Punakha and Wangdiphodrang and the incident was reported to DLGDDM and other higher authorities and media. NCHM Control rooms in Wangdi and Thimphu have intensified monitoring. To understand the ground situation, NCHM Team in Lunana was immediately deputed to Thorthomri lake for field verification.

Figure 95: 30 October 2023 Thorthormi GLOF

A three-member expert team from NCHM led by Mr. Karma, Specialist/Glaciologist, Mr. Phuntsho Tshering, Glaciologist and Mr. Sangay Tenzin, EWS Engineer was deputed to Lunana on 31 October 2-24 at 08:30 AM from Lungtenphug helipad for assessment of risks of Thorthormi lake after the 30 October 2023 GLOF incident.

Thorthormi Automatic Water Level Water Sensors (AWLS) was completely damaged by GLOF incident.

19.11 CIVIL SERVICE AWARD CEREMONY 2023

The Civil Service Award Ceremony for the National Centre for Hydrology and Meteorology (NCHM) for the year 2023 was held on 09 December 2023. The ceremony was graced by the Director and the Management. Along with the Dedicated Civil Service Award for 7 employees, the Centre also awarded:

a. An appreciation certificate for 11 Outstanding Employees for the appraisal period 2022-2023

b. Promotion orders for 19 employees promoted with effect from 1 January 2024

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.

Figure 96:Recipients of Awards, Appreciations and Promotions Orders for the Year 2023

19.12 OBSERVING ZERO WASTE HOUR

Pursuant to the launch of the Zero Waste Hour on 2 June 2019 by Her Majesty the Gyaltsuen, 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 Centre has made it mandatory for the HQ and all the Site/Region offices to observe the Zero Waste Hour every month by cleaning the office surroundings and hydro-met stations throughout Bhutan.

Figure 97: Selected photos from NCHM Zero Waste Hours

20 WELLBEING OF EMPLOYEES

20.1 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.

20.2 FAREWELL FOR OUTGOING STAFF, FY 2023-24

The NCHM family bids farewell to 13 employees on voluntary resignations and transfers for the FY 2022-2023. The Centre has organised farewell events to honor and recognize their contributions, dedications and positive impacts that they have made during their tenure in the Centre. It is to facilitate knowledge and experience sharing with the remaining team and also to ensure smooth transition by officially marking their departure.

Figure 98: Some of the photos taken from the farewell session of outgoing employees

21 CHALLENGES AND ISSUES

Being a technical and scientific agency, the following are some of the challenges and issues faced by the Centre.

a. Lack of office space and scientific facilities
b. Limited skilled and experienced technical professional due to ad-hoc separations and long-term leave and
c. No ICT Officer to take charge of overall ICT infrastructure of the Centre.

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