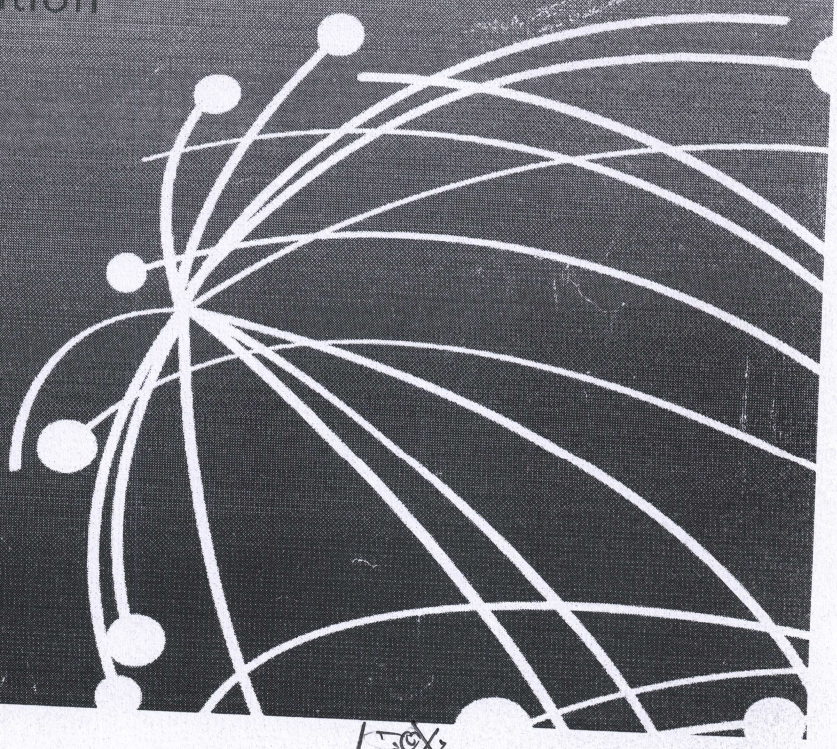
20th Jun 2025

GBON National Contribution Plan of Nepal

Systematic Observation Financing Facility



Weather and climate data for resilience

GBON National Contribution Plan
Nepal

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SOFF
Systematic Observations Financing Facility

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Module 1. National target toward GBON compliance

1.1 National GBON Gap Analysis

The number of stations to be improved has increased from WMO GBON Global Gap Analysis based on easy-fix solution of existing network (Table 1)[1].

Table 1. GBON National Contribution Target.

Type of station	WMO GBON Global Gap Analysis, June 2023				GBON National Contribution Target	
	Target	Reporting	Gap		To improve	New
			To improve	New		
	[# of stations]				[# of stations]	
Surface	4	0	4	0	5	0
Upper-air	1	0	0	1	1	1
Marine	*when applicable					

1.2 Establishment of the National target toward GBON compliance

Currently Department of Hydrology and Meteorology (DHM) is disseminating surface weather observations to the GTS from 17 synop/aero-synop stations but there is lack in GBON temporal resolution due to use of manual observation systems and data transfer[2]. GBON compliance requires upgrading of four manual stations to automatic ones and improvement of one AWS, data transmission system and management, and operation. Geographical coverage of stations is shown in Figure 1.

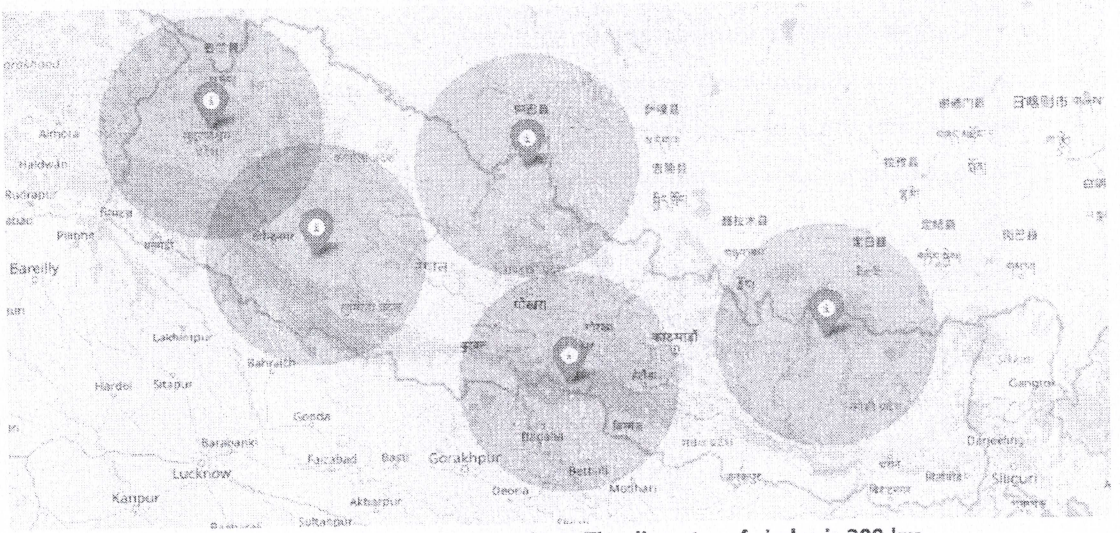

Figure 1. Coverage of proposed GBON surface stations. The diameter of circles is 200 km.

[1] Personal communication between Dr. Ana Heureux (SOFF Secretariat) and Dr. Jagadishwor Karmacharya (DHM) via email on 19th Dec 2023.

[2] https://wdqms.wmo.int/gbon/land_surface/daily/availability/temperature/all/2023-09-10

Due to challenging topography and already existing AWS network (total 133 AWSs) denser GBON network (100 km) should be considered as an easy fix opportunity. Denser network resolution could be reached by adding 15 stations. To ensure data quality from denser network additional investments would be needed, e.g. upgrading of some sensors, spare parts and sustained funding for O&M.

Horizontal coverage of national and regional upper-air sounding network (Figure 2) could be improved by installing one new sounding station in western Nepal and enhancing existing station as an easy fix solution. The existing sounding station is operating maximum once per day due to budgetary reasons, however data has not been disseminated to GTS/WIS due to communication related technical reasons.

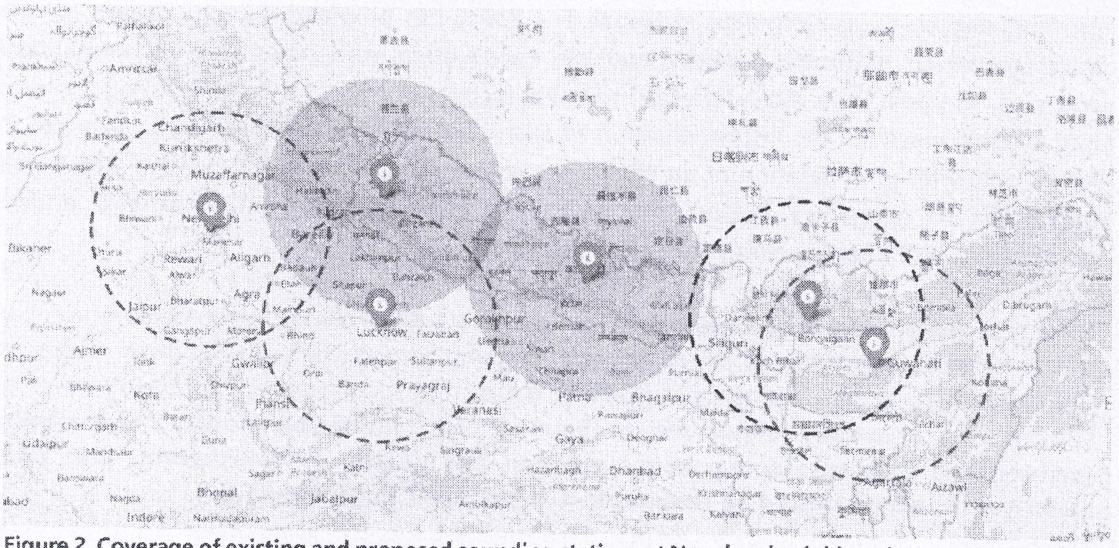

Figure 2. Coverage of existing and proposed sounding stations at Nepal and neighbouring countries. Existing Kirtipur station and proposed station are in shaded blue circle. Diameter of circles is 500 km.

Table 2. Summary of GBON National Contribution target and requirement.

GBON requirements	Target (# of stations)	GBON Compliant stations (#)	Stations gap	
			New	Improved
Surface stations	**4**	**0**	**0**	**5:** Upgrading and ensuring sustain operation of existing stations to fulfill GBON time resolution.
Upper-air stations	**1**	**0**	**1:** New sounding station in western Nepal would improve spatial coverage of soundings regionally.	**1:** Enhancing availability of supplies and data transfer of existing Kiritpur station

Module 2. GBON business model and institutional development

2.1 Assessment of national governmental and private organizations of relevance for the operation and maintenance of GBON

DHM is a governmental institute under the Ministry of Energy, Water Resources and Irrigation (MoEWRI). The MoEWRI has assigned meteorology and hydrology related activities to the DHM and operation of the DHM is highly steered by the line ministry. Financing of the DHM is allocated by the Ministry of Finance (MoF) via MoEWRI. Recently, Hydromet Policy has been promulgated by the government of Nepal. The Policy has provided clear guidelines for the development of Hydromet services and the cooperation with national and international agencies. The policy has also addressed the cost recovery system for the specialized services e.g. Aviation weather. The implementation of cost recovery mechanism would be possible in future only after promulgation of the hydromet act/regulation, which is lacking in Nepal. **It's important to entry the Policy and act/regulation into the legal force and ensure continuous, sufficient funding for DHM's operation.**

DHM is operating the national weather observation network in Nepal. Maintenance and repair of the network is outsourced to the private company because of lack of human resources. Currently, there is one maintenance contract for current fiscal year but it doesn't cover all stations. **It's especially important to have a valid multi-year contract on station maintenance to ensure sustainable operation and quality of observations and thus, multi-year contract should be ensured also in the SOFF implementation.**

Few other governmental institutes have installed weather stations for their own purposes. Civil Aviation Authority of Nepal (CAAN) is operating AWOS (Automatic Weather Observation System) at all three international airports. AWOS observations are available for airport met office and are planned to be integrated into the centralized database. The CAAN is also operating AWSs at domestic airports where DHM has no AWS installed. The possibility to utilize permanent staff of CAAN at the airports in maintenance work could be explored. Nepal Agricultural Research Council (NARC) and DHM are co-operating in operation of some stations. Province and local level governments have installed meteorological and hydrological stations for disaster risk management purposes. DHM provides technical support for installation, data quality management and data integration to DHM's systems.

Nepal is a mountainous country with large seasonal variability in rainfall threating the communities, especially rural, agriculture-based communities are vulnerable for weather-related hazards, like heavy rain, storms, floods and landslides. Some NGO's (e.g. Red Cross, Group of Helping Hands - Sahas) have installed community-level or riverbasin-level meteorological and hydrological stations for early warning purposes with technical support of DHM. See more in chapter 4.4 Gender and CSOs considerations.

In future, co-operation with private sector (tourism, hydro power, agriculture) could be enhanced. E.g. currently the DHM is installing new weather stations next to few trekking routes with its' own funding for tourism purpose (not GBON compliant). In addition to stations tailored for the operation of specific sectors, there are some temporary stations installed for research

purposes. International Center for Integrated Mountain Development (ICIMOD) is currently operating some stations at Himalaya[3]. National Geographic Society installed total five high altitude stations[4] in 2019 in co-operation with the DHM and Tribhuvan University. Also, the Central Department of Hydrology and Meteorology under Tribhuvan University is maintaining stations for research purposes and private hydro power companies have temporary stations for hydro power planning and operation purposes. Research co-operation between different institutions should be continued and improved by partnerships. Awareness and engagement of different stakeholders (governmental, research, private sector, NGO's) on SOFF is recommended to be enhanced by organizing a stakeholder workshop during implementation phase.

DHM has a MoU with the Nepal Telecommunication (NTC) and Ncell for data communication which allows free data transfer from stations to DHM's server. NTC is also providing the toll free number for public dissemination of forecast and warning. The most ICT infrastructure are centralized to the Governmental Integrated Data Center (GIDC), like the server for the Data Management System (DMS). Back-up servers are usually located at the DHM. The technical maintenance of the DMS was outsourced to the private company but currently there is no long-term service contract in effect. GIDC has sometimes challenges to provide the service level as required by the DHM. **It's recommended to continue the existing service model on centralized ICT services to avoid duplication and save human resources. The services and service level provided by the GIDC to DHM should be clarified. Long-term contract on maintenance of the DMS should be implemented to ensure continuous operation of the DMS.** DMS server located in the GIDC crashed at the end 2023 and reestablishing of normal service level took a long time. **It is crucial to enhance reliability and robustness of the DHM critical infrastructure, including backups and duplicated services.**

2.2 Assessment of potential GBON sub-regional collaboration

DHM is sharing daily real-time data to South Asia Flood Forecasting Guidance System (SAsiaFFGS) and non-GTS data to Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) for the improvement of ECMWF forecast products. Also, bilateral co-operation on sharing of surface observations and radar data with Bangladesh is in process. Previously, DHM shared rainfall data to India for total 16 surface stations under regional SAARC STORM[5] project, but this activity is discontinued.

Data sharing between neighboring countries is important for severe weather and flood forecasting but it's also recommended to share knowledge and experience on common technical systems. Capacity building development by Regional WIGOS Centre RA II could be explored. Potential collaboration under SOFF with other beneficiary countries has been identified. E.g. Nepal, Bhutan and Maldives are all using Microstep stations and informal technical group could be organized under SOFF. Also, SOFF funding has been optimized between neighboring countries (Nepal, Indian, Bhutan, China, Bangladesh) by taking in account spatial resolution of existing and planned GBON stations. It's recommended to organize common refreshing training for Microstep users in one of the countries to optimize the budget

[3] https://rds.icimod.org/Home/Data?group=11&&themekey=Nepal&&page=1
[4] https://everest-pwa.nationalgeographic.org/
[5] https://saarc-sdmc.org/implementation-saarc-storm-project

and enhance information exchange, organize regional benchmarking visit to Finland and enhance regional data sharing.

2.3 Assessment of the most effective business model to support network operations

The most urgent needs to ensure current service level and GBON compliance in future are sufficient funding and successful procurements, in addition to improved human resources. Without successful financing, procurements and staffing the service level of DHM might drop in coming years. Following matters should be acknowledge during SOFF Investment and Compliance phases:

1) Funding of the DHM is allocated by the MoF via MoEWRI. **The approval from the MoF is required before investment phase application to SOFF.** The national procurement act of Nepal shall be followed in SOFF while procuring the service and goods. Fiscal year of Nepal changes in mid-July. Annual procurement process can be started after the change of fiscal year and approval of procurement plan. In case of failed tendering, retendering is possible according to the procurement act and regulations of Nepal. **It's recommended to establish an office within DHM for the implementation of the SOFF project. Development of lifecycle plans for AWS, soundings, ICT and long contracts for outsourced services are necessary to avoid shortages in the operation.**
2) Total costs of DHM's services were NRP 270,305 000 (capital expenses due to BRCH[6] 50 % meaning total costs of NRP 540,479 000) in fiscal year 2021–2022: The salaries covered 37 %, O&M only around 4 % due to outsourced observation and 47 % for station maintenance and ICT support including investment to equipment and consulting services[7]
3) If excluding capital expenditure, the governmental budget for operation and development has increased in 2022-2023. In reality, there have been budget cuts during fiscal year 2022-23 and 2023-24, and the allocated budget has not been at sufficient level for sustainable operational service. E.g. weather radar have generators for power shortages but not sufficient budget for diesel, daily filed allowance is very limited and does not cover necessary costs during station visits, and travel expenses are not in suitable level to implement several station repairing visits. **It's recommended to purchase vehicle for GBON station inspection and monitoring purposes.**
4) In addition to the available budget, the main challenge has been usage of the budget in last years. Only around 50–60 % of the planned budget has been used. This is because of budget cut downs later in the fiscal year and unused budget left especially from consultancy and capital expenses:
   a) Insufficient budget, national procurement rules or availability of service providers have limited implementation of outsourced services and procurement of properties. **It's recommended to make long-term (minimum 5 years) contracts related to procurement of goods and operational consultancy services, such as O&M of stations, procurement of spare parts, balloons & sensors.**
   b) DHM has a critical shortage of staff to run 24/7 service even for public weather services and thus, a relative high share of DHM's operation is outsourced. High modernization

[6] BRCH = Building Resilience to Climate-Related Hazards project funded by WB
[7] World Bank, 2023. Strengthening Hydromet and multi-hazard early warning service in Nepal. An Hydromet Master Plan. Draft 26.9.2023.

of value chain would require variety of human skills, especially ICT and technical know-how. Currently 277 persons excluding manual observers are working at the DHM where proposed number of staff was over 300 in the BRCH[8]. Permanent staff (meteorologists, hydrologists, electronic engineers and assistants) are selected by the Public Service Commission. Contract based employees (e.g. ICT) or consulting services could be proposed from DHM budget. **To ensure sufficient operation of GBON stations, allowances of necessary personnel should be included to the SOFF. The salaries of the permanent staff is paid from centralized budget system.**

5) Development funding is highly competitive in Nepal and thus long-term partnerships with operational support are recommended to ensure sustainable development of the DHM.
6) Cost-recovery of services is not currently implemented. The Hydromet Act and regulations would guide the enable implementation of cost-recovery in future. Based on MoEWRI decision, the DHM charges on data, and revenue will be directly collected to centralized budget system.

DHM has implemented public-private partnership[9,10], where NMHS owns the infrastructure but it's operated and maintained by private company, for years. **It's recommended to continue public-private partnership as existing due to lack of human resources i.e. O&M (including calibration) of GBON surface and upper air stations will be outsourced for a private company and DHM will supervise the service and monitor observations, DMS is maintained by a private company.** In addition, implementation of the SOFF would support WMO principles of public-private engagement[11] by providing more accurate weather observations for numerical weather prediction models and thus, base information for forecasting and warning services to enhance public safety and sustainable economic growth of weather-depend sectors., Sharing observations freely nationally and internationally provides opportunities to further research and development of the services by academic institutions and private sectors.

2.4 Assessment of existing national strategies and projects for developing and improving observing networks

The Sixteenth Plan[12] (Fiscal Year 2024/25–2028/29) of the National Planning Commission (NPC) states development objectives related to hydrology and meteorology in line with national strategies, including:

- Upgradation of manual stations to automatic stations;
- Development of effective and real time-based early warning system (EWS);
- Undertaking reliable forecasting by the utilization of modern technology such as radar, wind profiler, sounding observations etc.;

[8] Project report. BRCH Phase 1, Tehcnical Summary report, appendix 4a: PLAN FOR TRAINING AND PROFESSIONAL DEVELOPMENT OF THE STAFF OF DEPARTMENT OF HYDROLOGY AND METEOROLOGY OF NEPAL
[9] SOFF Operation manual https://www.un-soff.org/document/soff-operations-manual/
[10] World Bank. Recommendations for the Design of Sustainable Meteorological Observation Networks and Systems in Developing Countries, https://www.worldbank.org/en/news/feature/2022/10/11/charting-a-course-for-sustainable-hydrological-and-meteorological-networks
[11] Guidelines for Public-Private Engagement (WMO-No. 1258) https://library.wmo.int/viewer/57344/?offset=#page=18&viewer=picture&o=bookmark&n=0&q=
[12] Government of Nepal, National Planning Commission. The Sixteenth Plan (Fiscal Year 2024/25–2028/29). https://npc.gov.np/images/category/24060707174 3%E0%A4%B8%E0%A5%8B%E0%A4%B9%E0%A5%8D%E0%A4%B0%E0%A5%8C%E0%A4%82%20%E0%A4%AF%E0%A5%8B%E0%A4%9C%E0%A4%A8%E0%A4%BE.pdf

- Development of Impact based forecast service and
- Specialized service for various sectors (public, health, aviation, energy and water resources)

NPC is preparing budget and development plans for the government. The DHM is highly steered by the line ministry. The MoEWRI has developed a draft plan for the whole Ministry, which includes near (upcoming year) and mid-term (3 years) development plans, if approved. Based on these, DHM has planned to implement following improvements for observations networks (official documents not available):

- Calibration service for aero-synop stations. Later calibration service will be expanded to other stations
- In 5 the year plan: all manual rainfall stations will be upgraded to automatic ones
- Install high altitude stations (over 3000 m) if project funding is available. Currently only 2 AWSs and 9 manual stations are at high altitudes and include snow measurements. Upgrading of snow stations as fully automatic is ongoing and additional stations are under installation for trekking routes

In addition, multiple DHM-specific plans have been drafted as part of development projects; e.g. the World Bank (WB) is drafting a "Hydromet Master Plan", a development plan and a roadmap of the full value chain. One objective of the Master Plan is GBON compliance in future[13].

Recently completed projects related to the GBON:

- FNEP3 Exit (Finnish-Nepalese Project for Improved capability of the Government of Nepal to respond to the increased risks related to the weather-related natural disasters caused by climate change, Exit phase) funded by Ministry of Foreign Affairs Finland. FNEP3 Exit includes development of new QC check to the DMS and benchmarking of calibration practices.
- JICS (Japanese grant): upgrading on manual observation stations to automatic one and few new AWS covering total 13 stations. Data will be integrated into the DMS.

Existing development plans and projects at the DHM are supporting development toward GBON compliance but are not overlapping with the SOFF. **It's recommended that all technical systems to be installed as per the specifications of existing AWS networks to ensure sustainability of the networks, and data is collected to centralized DMS for further use.**

2.5 Review of the national legislation of relevance for GBON

DHM's operation is based on cabinet and line ministry decisions but there is lack of legal and regulatory documentation on hydro-met service provision. Preparation of the Hydromet Policy is ongoing with support of the WB. The subsequent act based on the policy would be a guiding document for the hydromet sector. **However, it's important to get the Policy in legal force.** The policy would also address the cost recovery system for the specialized services e.g. aviation

[13] World Bank, 2023. Strengthening Hydromet and multi-hazard early warning service in Nepal. An Hydromet Master Plan. Draft 26.9.2023.

weather. The implementation of cost recovery mechanism would be possible in future only with the hydromet act/regulation, which is lacking in Nepal. Implementation of cost recovery would enhance DHM's budgetary situation e.g. related to the GBON operation. Currently, funding of the DHM is allocated by the MoF via MoEWRI. **Governmental budget is crucial for sustained operation of DHM and it would be important to ensure long-term funding.** The SOFF is an important funding instrument to ensure sustainable operation of GBON stations. The MoF should approve the SOFF grant and/or commitment of governmental contribution to SOFF implementation.

Weather, climate and hydrology-related activities are recognized in several regulations but only a few states DHM as the responsible authority. E.g. Work Division Regulation of Government of Nepal (in Nepali)[14] states MoEWRI as meteorological and hydrological service provider but MoEWRI has delegated responsibilities to the DHM. According to the Disaster Risk Reduction National Strategic Action Plan (2018-2030), DHM is responsible for providing real-time weather observations[15].

Civil Aviation Requirements for Meteorological Services for International Air Navigation, CAR-3[16], states that the Civil Aviation Authority of Nepal (CAAN) shall designate DHM to provide or to arrange for the provision of meteorological services for international air navigation on its behalf.

It's crucial to pay attention to national procurement rules when planning SOFF investments. It's recommended to establish Project Management Unit to ensure efficient implementation of the SOFF project.

- All procurements have to follow public procurement rules and regulations[17]. Procurement has to be implemented via centralized E-GP system (online system for procurements). Public procurement monitoring office under Office of the Prime Minister & Council of Ministers is responsible for online system and monitoring of all procurement activities and provide templates for procurements.
- Bidding should be based on the annual procurement plan. The bidding process can begin only after the budget of the ongoing fiscal year is approved. International bidding should be done when costs of the service is more or there are no national venders available (e.g. sounding system)
- Bidding process takes usually several months
- All bidding process is based on 1. legal and quality compliance, 2 Least cost basis
- In international procurements, suppliers must pay 13 % VAT (value added tax), 5 % custom clearance tax, 5% TDS (Tax deduction at source) and additional charges if applicable (such as storage charges) as per Nepal government rule and regulation.

[14] GoN, Working division Regulation
[15] GoN, 2018. National DRR Strategic Plan of Action 2018–2030. https://dpnet.org.np/resource-detail/26
[16] Civil Aviation Authority of Nepal, 2017. Civil Aviation Requirements for Meteorological Service for International Air Navigation, CAR-3, https://caanepal.gov.np/storage/app/media/CAR-3.pdf
[17] GoN, 2007. Public Procurement Act 2063 (2007) https://ppmo.gov.np/detail/post/7404 and Public Procurement Rule 2064 (2007) https://ppmo.gov.np/detail/post/7396

Module 3. GBON Infrastructure development

3.1 Design the surface and upper-air observing network and observational practices

Aim of the SOFF initial investments is to strengthen the network so it provides the largest impact on NWP skill through:

i) installation or rehabilitation of upper air stations,
ii) installation of surface stations in significantly under-observed regions,
iii) sub-regional optimization of the network design.

Based on the National Gap Analysis, following initial investments are required to archive the GBON compliance in future:

- upgrade of four manual stations as automatic and support for existing one AWS, regular maintenance of stations (more info in 3.1.1)
- establish operation of the existing calibration laboratory (more info in 3.1.3)
- install one new manual sounding system and enhance operation of existing station as easy-fix solution (more info in 3.1.2)
- improve existing DMS and ICT infrastructure (more info in 3.2)
- capacity building and additional human resources to operate the GBON network (more info in 4.2 & 4.3)

DHM has implemented full modernization in 2013–2021 under BRCH funded by the WB. The project included GBON related activities like installation of 88 AWS and one sounding station (Figure 3), calibration laboratory and upgrading of DMS with necessary ICT infrastructure. Unfortunately, maintenance contract of the AWS ended in 2022 and DHM has not been able to fully renew it due to procurement and budgetary reasons, budget for sounding consumable is not enough for daily operation and DMS has technical issues preventing full utilization of the system and ICT infrastructure are in the end of lifetime, operation of the calibration laboratory has not been established due to limited training and limited man-power. **To improve sustainability of the DHM, all SOFF investments should be integrated with the existing system. Utilizing the existing system would enable easy fix solutions, like the suggested denser (100 km) GBON network with 15 AWS.** This would provide more accurate information for global models from Himalaya region in cost-effective manner. Improvement of GBON standard density network (enhanced DMS and data transfer from DMS to GTS/WIS, establishment of calibration laboratory) would also reduce regional data gaps. Limited number of stations in Nepal are located near / above 3000 msl providing only limited real-time information on weather conditions from high-altitude Himalaya region for global models as recommended by WMO.

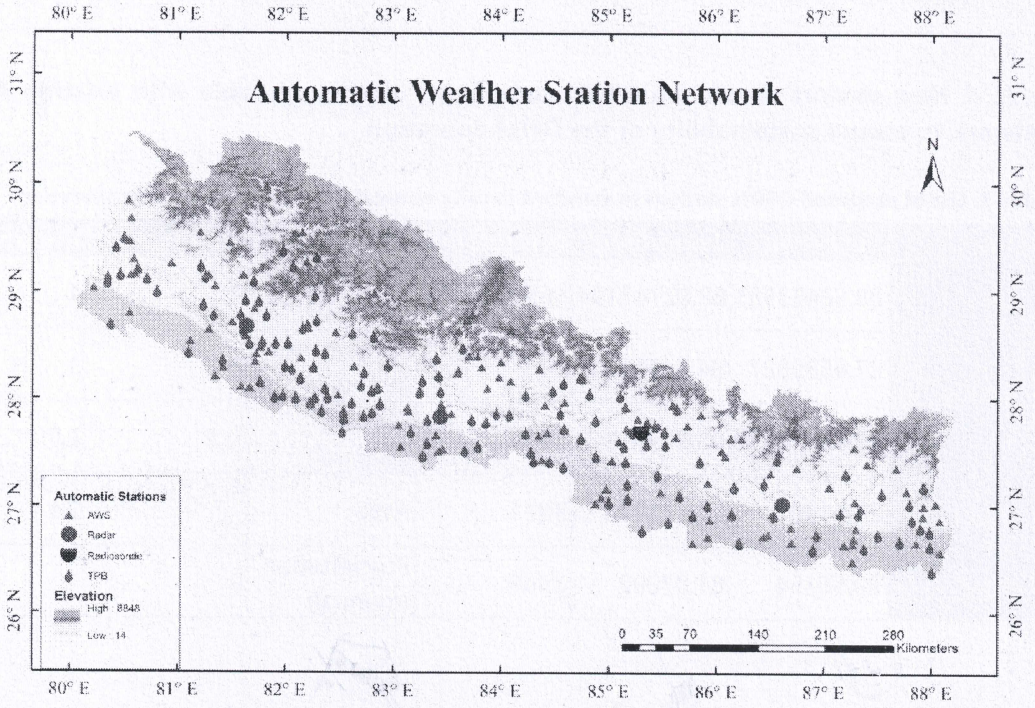

Figure 3. Existing AWS network in Nepal

3.1.1 Design of the GBON surface network

List of proposed GBON stations in standard density network (horizontal resolution 200 km) are shown in Table 3 and Figure 1. Four of the stations are manual and requires upgrading to automatic ones. One station is automatic and requires renewal of sensors. Detailed list of required investments are shown in

Table 4. **New sensors should be GBON compliant[18] and compatible with existing AWS network to ensure sustainability of the DHM operation.**

Table 3. List of proposed GBON stations in standard density network (200 km) and current operation

Name	Lat (deg)	Long (deg)	Altitude(m)	Station type	Variables	Reporting
Rakam	28.52453583	82.02147194	565	Precipitation (manual)	P	1
Madi Kalyanpur	27.4589827	84.3431641	240	Precipitation (manual)	P	1
Chhoser	29.22713194	83.979815	3886	Climate (manual)	T, P	2
Syangboche	27.8149	86.713376	3821	AWS	SLP,T,H,P,W, SD	24
Thalara	29.56154	81.07092	2360	Precipitation (manual)	P	1

[18] WMO TT-GBON, 2022. Deliverable 6.1 – GBON Tender Specifications for AWS.

Table 4. List of investments per station

Name	Altitude (m)	Station type	Required investments
Syangboche	3821	AWS	- upgrade of power system (solar+battery) + electricity and fencing - upgrading of all sensors and duplication of sensors (T, RH) - upgrade of data logger + transmission (satellite)
Rakam	565	Precipitation (manual)	- power system (solar+battery), fencing expand & upgrade - sensors: T, RH, p, rain, wind - data logger + transmission - wind mast
Madi Kalyanpur	240	Precipitation (manual)	- power system (solar+battery), fencing expand & upgrade - soil lifting + walking ways - sensors: T, RH, p, rain, wind - data logger + transmission - wind mast
Chhoser	3886	Climate (manual)	- power system (solar+battery), fencing expand & upgrade - duplicate sensors: T, RH, p, rain, wind, Snow Depth - data logger + transmission (satellite) - wind mast
Thalara	2360	Precipitation (manual)	- power system (solar+battery), fencing expand & upgrade - sensors: T, RH, p, rain, wind - data logger + transmission - wind mast
Spare sensors			- 30 % spares in general (total 4 sets of sensors+logger, 2 sets of batteries, solar panels)
Other			- Installation and maintenance of stations by consultant - Operational costs (allowance for observer, data transmission) - Salary and travel costs (including vehicle) of the DHM

Existing AWS network is reporting to the DMS in 10-minute interval fulfilling the GBON temporal resolution, but quality assurance is missing[19]. **Maintenance of AWS network is partly outsourced due to limited human resources.** Maintenance has included only repairing of malfunctioning instruments and data connection. Thus, **maintenance plan should be updated** considering recommendations by sensor manufacturer. Initially the maintenance plan should include regular visit (2 times per year) at stations in addition to problem solving/repair when needed. Response time for problem solving is recommended to be 3-days in maximum to meet the GBON temporal resolution. Improve monitoring tools and draft SOP for near-real time data monitoring (3–12 h) to identify problems at stations in time, and mechanism should be established between DHM and consultant to inform about issues and near real-time updated on efforts to resolve those issues.

Sensors should be calibrated regularly. For temperature and humidity annual calibration is recommended and for pressure every second year. Validity of wind sensor, rain gauge and snow depth sensors should be check during maintenance.

The spare part pool should contain extra equipment to ensure operation during calibration and maintenance. Recommended value is 30 % of total. For temperature and humidity spares are needed so that they can be rotated and calibrated on an annual basis, and for the pressure sensors for calibration every other year. A higher number of spares is also recommended for the acoustic wind sensors, which are vulnerable to damage caused by birds. In addition, **duplicated spare sensors are recommended to high altitude stations to ensure operation during damages.**

Lifecycle plan of instruments (+data logger) should be drafted based on manufacturer recommendations. Initially sensors should sustain two calibration cycles meaning spares for temperature and humidity is recommended to update every second year, pressure sensors every 4 years. Lifetime of the wind sensor, rain gauge and snow depth is around 4-6 years.

Station security has been included in the risk table (Module 5: Risk Management Framework). Natural disasters cause high risk to the infrastructure and thus, stations should be located to sites where probability of landslides and flooding is smaller, and attention will be given to civil works to reduce impacts of those hazards in addition to lightning (lightning protection system) and earthquakes. To ensure siting, the site evaluation is recommended to be included in the SOFF activities before procurements. The possibility for vandalism or damages by wild animals are small but stations will be surrounded by fences. Technical operation of stations will be ensured by back-up batteries and dual SIM or satellite communication system, and solutions proposed by the supplier to ensure data transfer. In most stations there is a manual observer who can monitor the station condition and take care of minor issues. However, the key for success is regular maintenance, timely repair when needed and availability of spare parts (AWS, sounding, hardware, DMS). Thus, training, development of processes and outsourced services are highly recommended to be included into the SOFF.

[19] WIGOS Manual (WMO-No.1160)

3.1.2 Design of the sounding system

Horizontal coverage of national and regional upper-air sounding could be improved by installing one new sounding station to western Nepal and supporting operation of existing station as easy fix solution. Stations are shown in Table 5 and Figure 2.

Table 5. Lis of proposed GBON sounding stations

Name	Lat (deg)	Long (deg)
Dipayal (new)	29.26209694	80.93690083
Kirtipur (existing)	27.70382	85.35625

The new sounding station will be installed next to existing AWS which will provide necessary surface weather information to the sounding. There are observers at the station and DHM owns the land.

The station should be GBON compliance[20] and compatible with the existing sounding station to ensure sustainability of the DHM. Labor costs related to manual sounding are relatively low in Nepal and annual maintenance of the automatic sounding system by system provider might be quite high. Thus, it's recommended to continue sounding operation manually. Also, dedicated hydrogen generator should be installed at site due to safety and logistic reasons.

Exact specifications for sounding stations will be defined in the bidding phase but necessary investments are:

- Required civil infrastructure including storage house for sensors and spare parts
- Manual sounding system with installation
- Hydrogen generator with de-ionized water converter, required shelter (ATEX requirements apply)
- Consumable parts and operational costs (balloons, sondes, electricity, data communication, water supply)
- Annual maintenance of the system
- Labor costs of the sounding operators (4 persons, outsourced service)

Easy fix opportunity: DHM launches upper-air soundings at Kirtipur, Kathmandu. Sounding observations contain temperature, humidity, pressure, and wind measurements at different pressure levels with minimum of 100 m vertical resolution up to 30 hPa level. This complies with the GBON requirements. Soundings are made maximum once a day due to budgetary reasons. DHM does not disseminate sounding data to the GTS/WIS system due to problems in registering station to OSCAR and transmission problems in suitable format to the GTS/WIS. These problems could be solved as an easy fix solution (data communication, consumable parts and operational costs, support for annual maintenance and labor costs of operators). New sounding system procured in 2024 and is now in operation.

[20] WMO TT-GBON, 2022. Deliverable 6.2 – Requirement document to be used as input to tender specifications for radiosonde-related procurements.

3.1.3 Needs related to calibration service

The lab calibration facilities for temperature, humidity and pressure was installed during BRCH in 2019. Due to lack of human resources and training the calibration service has not been established yet.

For establishing calibration laboratory, the investment below are required:

- Maintenance of calibration facilities during establishment of operation
- Labor costs of 1 engineer & meteorologist (outsourced service)
- Calibration of the reference sensors at the WMO Regional Center (e.g. China/Japan)
- Calibration training and development of SOP for full value chain

3.2 Design of the data management system and ICT infrastructure

Development of ICT infrastructure for a value chain of automatic observation network is recommended by building required human capacity and resources. Due to challenges in recruiting new staff, private partner is recommended to provide skills and knowledge relevant to IT in meteorological observation. The DHM is recommended to gain knowledge and skills in meteorological data, data processing principles and tools, data formats (e.g., NetCDFv4 and BUFR), system architecting, software developing, database, API, network management, as well as web developing. These will be important topics to master, even through the actual work would be procured outside.

Current ICT infrastructure and its reliability should be strengthened while planning the SOFF/GBON related improvements. Many of the required components do exists, although they may not be fully utilized yet.

DHM has been harmonising its station network in BRCH project and in addition to stations, they acquired data management system (DMS) developed by a private company. Data collection system allows real time data flow from AWS to database but there are still operational challenges in the system. However, this system can be considered as operational system from GBON surface observation point of view. **DMS can serve a real time database and it is recommended to be used also as data source for the WIS2.0 interface**. With this approach, there is **no need for separate short-term storage**. As back-up DHM has governmental cloud-based database with limited data storage due to slow response time of the DMS.

Dataflow via database allows centralized real-time monitoring of the system, real time quality control and centralized source for metadata. Currently the automatic quality control (QC) is not fully utilized. Automatic real time QC can be performed in DMS preventing delivery of the clearly erroneous values. Developing and adjusting the QC-routines to Nepalese environment is not scope of this project. There are also technical issues in applying the QC. Manual quality control will be performed with delay and therefore it is excluded from these plans.

While considering data management in general at DHM, dataflow via database simplifies overall data management remarkably. Users, including delivery to WIS, do not need to worry about how the data is collected or which station has produced it, as they can acquire all observations from DMS.

This approach is used by peer advisor (although with different technical solutions which cannot be copied feasibly). Dataflow through the database and real time quality control does not cause problems for the real-time needs (at peer advisor system, delay is < 1 minute in general). However, it is expected that at the beginning there are some delays in DHM database.

On the perspective of metadata management, DMS would be used as main storage. If dataflow bypasses DMS, it would require metadata to be maintained in several locations separately.

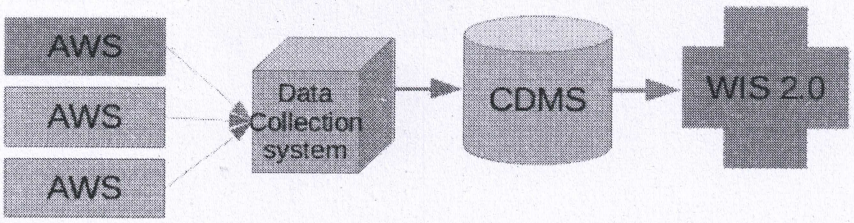

Figure 4. Simplified dataflow for NCHM setup. Blue components are existing, and red components are proposed to be implemented with SOFF support.

Simplified dataflow is shown in Figure 4. **Dataflow from AWS to DMS exists**, but WIS 2.0 interface is missing. With **implementation of WIS-module, it interchange the data from existing stations as well (easy fix).** DHM is disseminating data to the GTS but there is significant lack of fetching international observations. Data flow from GTS hubs should be evaluated in co-operation with WMO Regional Hubs.

Sometime proposed approach is to deliver data directly from stations to international delivery (GTS/WIS 2.0). This approach is not allowed according to data policy in Nepal and would avoid duplication of DMS. As mentioned earlier, centralized data collection and storage allows real-time quality control, centralized source for metadata and centralized real-time monitoring system. It also simplifies dataflow in DHM in general.

DMS is and will be crucial component in the DHM infrastructure, so its operations need to be ensured (Figure 5). Adjusting and improving the dataflow to optimal level is expected to be performed gradually and it will take some time. However, peer advisor sees this approach most feasible to Nepal as well.

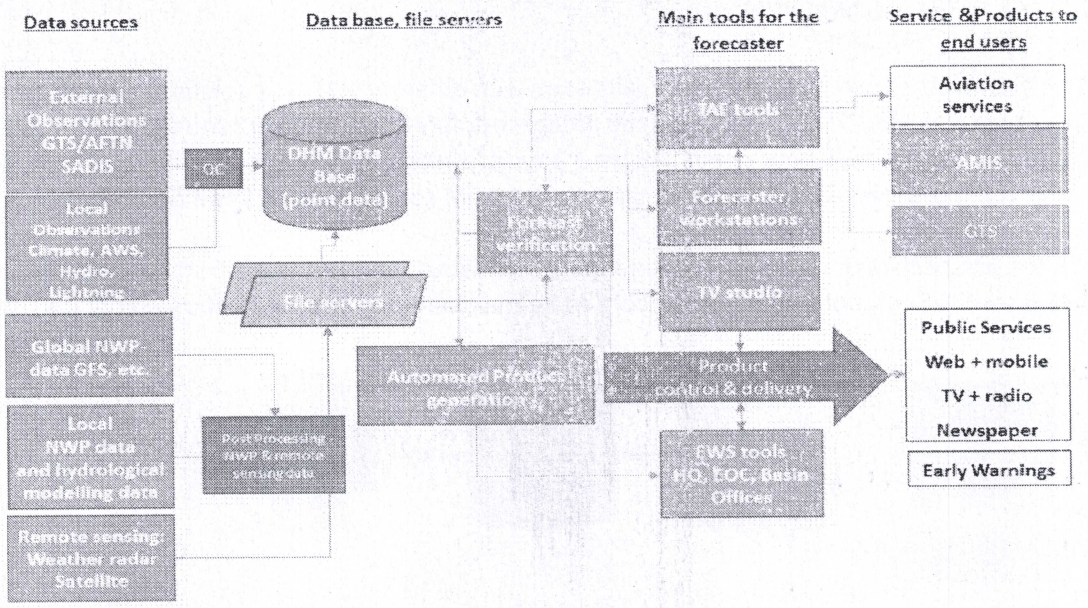

Figure 5. Design of the DHM's production process planned in the BRCH. The WIS2.0 would be parallel with the GTS

Technical specifications

Technical specifications for database (which existing DMS fills at least to some extent): In addition to automatic and/or manual meteorological observations, a modern, functional DMS is a key element in the value chain of observation from measurement station to end user interface. The following specifies general key elements to consider in technical and budgetary perspectives.

Ability to ingest and store multiple types of weather observation data formats. Including, but not limited to, the following:

- Surface weather observations
- Upper-air radio sounding observations
- Aviation weather observations
- Lightning observations

Nepal has three weather radars. However, their data have such a big volume and requires much more from storage capacity than a single point/profile data and is thus beyond the considerations of this document. Data ingestion to the data warehouse (database) should be made with a modular approach so that new data feeds may be added with minimal effort and modification to the already existing components and database structures.

A data quality control (QC) module should be an independent and/or modular part of the system. Additionally, the quality control module must be able to perform real-time quality control and should enable non-real-time manual quality control.

The database system should support queries of timeseries with adequate performance. System must be able to serve as real-time and long-term (climatological) data storage. Modules to

calculate added value parameters and use of data from the archive should be made possible. These may include aggregate parameters like daily means, minimums, and maximums.

The data management system must be made capable of offering data to a standard API for a retrieval of the database contents. The API could include the following but not limited to

- WFS
- EDR
- WMS
- Export to SYNOP & BUFR message format and delivery to GTS network
- WIS 2.0 (GBON compliance)

Some of these API's or modules can be provided by external programs.

System must be able to store relevant metadata regarding stations, station networks and observations. Automatic updates to the WMO/OSCAR -system are preferred.

Management of Metadata in general is on basic level at time of the writing this document. In general, all metadata should be stored and maintained in specific location, which would be DMS. Extent of the available metadata and updates to and from WMO/OSCAR needs to be clarified on implementation phase of the WIS 2.0 interface.

Hosting of the infrastructure

Most of the DHM servers are hosted by governmental IT-center GIDC. Although there has been some challenges with GIDC to provide service level required by DHM during last few years, this approach is recommended.

Data delivery & main gaps

DHM will be the sole hosting authority of WIS 2.0 in Nepal. The delivery of GBON hourly observations will be reported by following WMO guidance (no. 306[21]) and GBON practices where applicable. However, although GBON defines certain protocols which should be used in the data collection from weather stations, given the existing infrastructure and software, GBON protocols should be considered as recommendations, not mandatory requirements.

The delivery of GBON hourly observations should be reported by following WMO guidance (no. 306) and GBON practices. Main GAP of proposed existing system is the lack of **WIS 2.0 interface, which needs to be provided either by existing DMS or more likely by external software, such as WIS2Box**. The delivery of GBON hourly observations should be reported by following WMO guidance (no. 306) and GBON practices.

First step is to get dataflow from proposed GBON stations via WIS 2.0. On the next phase, existing stations can be added to international delivery utilizing these solutions.

Observations coming from abroad via GTS or WIS 2.0 will be utilized in the forecasting process. Storing of international observations to the same database and data policy needs to be

[21] WMO-No.306

developed in the next step. First step is to get dataflow from Nepalese stations to work efficiently.

Recommendation
It is highly recommended that the new station and dataflow to WIS2.0 are integrated into the existing system via DMS, and efforts are made to improve robustness and efficiency of the current system.

Resilience and continuity of the full data processing chain requires reliable equipment, adequate human resources, and full-time monitoring. On the technical side, it also means redundant environments with backup and recovery plans, starting from AWS to data communications and servers.

Utilize GIDC services where feasible and improve co-operation between DHM and GIDC to reach required service level.

Budget considerations; Resilience and the continuity of the full data processing chain: Budget must consider the infrastructure needed to run a DMS and store the data. Also, a solution for a backup of essential data needs to be considered when making investments. A valid support contract with a hardware vendor is advisable during the lifetime of the hardware. The lifespan of such hardware may be estimated to be between 5-8 years before the need of renewal of the systems.

Resilience will be supported by two main resource factors: skilled staff and IT hardware including sufficient lifecycle plan and budget. DHM will be solely responsible for taking care of the complete data pipeline. Thus, development of ICT infrastructure for a value chain of automatic observation network is recommended to begin with building required human capacity and resources. Adequate staff to ensure resilience should be addressed and trained in skills and knowledge relevant to IT in meteorological observation. The organization is recommended to gain knowledge and skills in meteorological data, data processing principles and tools, data formats (e.g., NetCDFv4 and BUFR), system architecting, software developing, database, API, network management, WIS2.0 as well as web developing. Please find further considerations on human capacity resilience in Module 4.

3.3 Environmental and sustainability considerations

The key success factor of sustainable investment and day-to-day operation of GBON stations relay on highly competent and motivated management and staff in SOFF implementation. **Sustainability and ecological solutions should be acknowledged in all SOFF activities from procurements to operational processes** including:

- High quality equipment with long expected lifetime
- Reusing of existing infrastructure and recycling possibilities
- Saving and use of eco-friendly materials
- Encouraging use of local production and services
- Energy efficiency and use of renewable energy

Procurements: in the scoring system of tenders the quality of equipment and services, and environmental efforts of the company should be emphasized. These could include, but not limited to, the company's efforts toward energy efficiency in production, of equipment and using of materials, share of renewable energy in production process, and saving and using of eco-friendly materials (equipment and packing). E.g. energy efficiency of equipment (AWS, sounding + hydrogen generator, back-up battery) and use of renewable energy are easily measurable parameters, like composition of biodegradable materials in material selection (balloons, radiosondes, packing). If applicable, cargo with a low carbon footprint should be encouraged.

Installation and operation of GBON stations: Sustainability aspects of GBON stations and DHM's operation have been taken into account in SOFF readiness phase. Proposed GBON stations are utilizing the existing stations, all investments are recommended to be consistent with existing AWS and sounding networks, and to be integrated to the existing DMS to enhance sustainability and further benefits of the SOFF investments. Likewise, establishing of the calibration laboratory, improvements of the DMS and capacity building activities are supporting the whole AWS network.

There is a need to establish only one new station (sounding station). When establishing a new station and enlarging the existing manual stations the harm to the surrounding environment should be minimized and replace/upgrade of civil infrastructure (power system, wind mast etc.) is recommended to be reusable. Use of local services is recommended to minimize travel need. Use of renewable energy is key in power supply. Surface stations are powered by solar panels with batteries. Sounding stations are operated by the national electricity network which is generated mainly from hydropower. Generation of hydrogen locally at the station will make the operation more environmentally sustainable, safety and independent from importing gas by the 3rd party.

All stations are located at sites where permanent staff work daily. This will decrease unnecessary travelling and financial burden. There is a proposal to include double sensors to the high-altitude stations to decrease downtime of the station in case of malfunctioning. Training activities and development of the SOP are supporting sustainability and environmental impacts. By establishment of preventive maintenance and calibration practices the lifecycle of sensors will be lengthened as long as appropriate. E.g. the sounding system investment is made for 20–30 years and needs annual maintenance throughout its lifetime. Environmental impacts of O&M and calibration will be noted in the SOP's e.g. encouraging recycling and minimizing waste when appropriate.

Module 4. GBON Human capacity development module

4.1 Assessment of human capacity gaps

DHM has a serious shortage of staff to operate and demand on 24/7 weather and hydrological service. In the end June 2024 DHM had around 277 employees (Table 6). Among those, most of the staff take care of operational service but also engage in the administrative work, like procurements and reporting responsibilities are stealing the working time. In the

BRCH, the proposed number of staff was 308[22], especially duty forecasters and **(ICT) engineers were missing.** There is a pretty good balance between genders at expert level.

Table 6. Proportion of staff in the end June 2023.

Total Staff number	**277**
Management	5
Senior Divisional meteorologist/Meteorologist (including aviation meteorological service, climate and agromet services)	44
Meteorological Technician (assistant meteorologist)	94
Hydrologist	33
Hydrological Technician	43
Senior Divisional Engineer/ Electronic Engineer	3
Communication Asst.	8
Senior Divisional Chemist/ Chemist	2
Assistant Chemist	1
Other (account, administration)	44

DHM has tackled the shortage of human resources by outsourcing certain tasks such as O&M of observation system, ICT and DMS. **It's important to ensure that DHM is capable of managing, monitoring and controlling the quality of these services on its own in future.**

Posts relevant to the GBON station operation and maintenance at the DHM including data communication are:

- Senior Meteorologist: Coordination, monitoring, follow up SOFF procurements, programme implementation and reporting
- Meteorologist: site inspection, installation, maintenance, calibration of instrument, data monitoring and quality control
- ICT Engineer: installation and maintenance of instruments, data communication and configuration of calibration equipment, DMS operation and maintenance, hardware and network handling
- Assistant Meteorologist: operation of radiosonde station, maintenance and calibration of instruments, site inspection and quality control

A specific education qualification is required for the recruitment of government staff for a special position. A minimum bachelor's degree in meteorology is mandatory to become a meteorologist. Tribhuvan University in Kathmandu offers a master's degree in meteorology which covers the WMO BIP-M competence requirements. For ICT engineers, a bachelor's

[22] Project report. BRCH Phase 1, Technical Summary report, appendix 4a: PLAN FOR TRAINING AND PROFESSIONAL DEVELOPMENT OF THE STAFF OF DEPARTMENT OF HYDROLOGY AND METEOROLOGY OF NEPAL

degree in electronics and telecommunication engineering or equivalent is required. Several campuses under Tribhuvan University, Kathmandu University and Pokhara University offer engineering courses. Public Service Commission of Nepal selects and recommends the personnels as per the request of the concerned ministries.

The challenge is that many employees are assigned to multiple responsibilities/ departments which threatens the achievement of quality work done in time. There is no specific post on Hydromet ICT, but DHM can propose short-term contract-based employees (like ICT) by getting approval of the line ministry. It is much easier to hire a consulting service than a contract base employee from allocated budget.

Development of advanced level expert depends on organizational support for development, interest of individuals, training opportunities but also long-term commitment. Employees participate to project-specific trainings or international trainings organized by the WMO Regional Training Centre, SAHF, BIMSTEC, RIMES, occasionally. Regular refreshing training and continuous development possibilities are recommended to ensure the capacity of DHM to operate 24/7 service. The competence building process with personnel inquiry template was drafted under the BRCH[23] but implementation is missing. **Implementation of competence building process is recommended to support quality of operation and management.**

4.2 Design capacity development activities for technical staff

Due to serious shortages of staff **following labor are recommended to be include in the SOFF investments** to ensure GBON compliance in future:

- Project managements Unit with two (2) project officers to coordinate, monitor, follow up SOFF procurements, programme implementation and reporting , and a driver (outsourced)
- Two (2) ICT Engineer for DMS operations and maintenance, software development + hardware and network handling
- Two (2) meteorologist for monitoring and quality control of data
- Eight (8) Assistant meteorologist for the operation of radiosonde station (outsourced)
- One (1) engineer and one (1) meteorologist to operate calibration laboratory (outsourced)

Maintenance of AWS network, calibration service and radiosonde station operation, and DMS maintenance should be outsourced to external consultant. **Supervising outsourced maintenance service requires basic knowledge to follow quality of the service.** Development of the QMS is in planning phase but several SOP's for instrument level and general processes are drafted under BRCH and FNEP. Enhancing and following of these SOP's is recommended, and responsibilities and communication process between DHM and maintenance service provider should be implemented based on above mentioned practices. In addition, implementation of the competence framework drafted in the BRCH as part of the QMS is recommended.

[23] BRCH, 2015. Phase 1 Report. Appendix 4a. Plan for training and professional development of the staff in Department of Hydrology and Meteorology of Nepal.

Recommendations on training activities within SOFF framework to support work towards gaining minimum competence relative to WMO guiding no. 1083[24]:

Quality management system (QMS): Effective and continuous development of QMS is the basis for the systematic operation and maintenance of observation networks. The organization has basic knowledge about QMS and is planning to develop the QMS for aviation service in the first phase. An effective development of observation process including lifecycle planning requires support through benchmarking mature sub-processes for surface weather stations in other organizations. DHM is recommended to enhance the existing surface station sub-process and have training for internal auditing.

Data quality control and assurance: The relevant staff members need refreshing training to manage scientific background behind different QA/QC methods. Benchmarking QA/QC methods in other organizations would provide substantial benefits. A roadmap for implementing relevant automatic QA/QC methods and whole QA/QC process in general should be developed.

Instrument and station operation and maintenance: Once sufficient technical training for maintaining different sensor types has been received, the technical staff would benefit from regular refreshing training, enhanced SOPs and competence requirement criteria. Both the SOPs and having required competence support self-confidence at any work. Refresher training on lifecycle maintenance is needed to avoid shortages in the operation, and basic training on upper-air system operation for new employees is necessary. This kind of training is important even if the station network maintenance is outsourced to the external company.

Calibration and maintenance at workshop: The calibration laboratory for basic parameters was installed by the BRCH-project and SOP for calibration was drafted. Unfortunately, DHM lacks the standard reference equipment for the calibration of the equipment. DHM should have standard reference equipment to operate calibration laboratory for maintaining the data quality. Furthermore, adequate training was not carried out when the laboratory was established, and DHM has very limited skilled technical employes to make laboratory operational. Training is important even the calibration service would be outsourced to the external company. Calibration operation should be established and SOP for calibration process should be developed with external support. It is critically important that scientists analyze the calibration results to support lifecycle and maintenance planning. SOP's should be enhanced to include calibration to the full value chain of observations. Benchmarking sister organizations would support in developing this area in the beneficiary organization.

Network monitoring and ICT system operations: Two long-term employees with basic web-technologies are proposed to support SOFF implementation (1 for server and DMS administration, 1 for DMS use). These persons should receive sufficient training so that they

[24] WMO, 2032. Guide to the Implementation of Education and Training Standards in Meteorology and Hydrology. Volume I – Meteorology.
https://library.wmo.int/viewer/35676/download?file=1083_en.pdf&type=pdf&navigator=1

can cover each other as needed. Required basic training contains data transfer from station to database and from database to users, such as WMO WIS 2.0, management of OSCAR information and operation of the DMS are required. Benchmarking of other ICT and DMS services are recommended to support development as Hydromet ICT expert and to ensure the 24/7 automatic operation to international distribution. SOP for near-real time network monitoring and procedures between DHM and service provider should be developed and established.

ECMWF data integration and utilization: SOFF is implementing two-way approach, and all beneficiary countries will have access to the ECMWF dataset. The ECMWF dataset is recommended to integrated to the existing forecasting systems to enhance efficient use of the data. In addition, the peer advisor is recommended to provide training for data utilization to strengthen the value of the dataset, as proposed in the ECMWF Train-the-trainer programme.

4.3 Design capacity development activities for senior management

Recommended capacity building activities to encourage status of the DHM and quality of services in future:

Strategic and financial planning: Benchmarking strategic, financial, human resource planning and international co-operation of modern NHMS is important for DHM's further development and sustainability of the SOFF investments. DHM is strongly led by the government and thus, the most important governmental stakeholders should be involved in these activities.

Project management: Training on project management and business development are essential to efficiently plan, execute and oversee projects, like successful implementation of the SOFF. Business development would empower DHM's possibilities to foster partnerships and develop DHM's budgetary framework in future.

4.4 Gender and CSOs considerations

Climate change and extreme weather events are not gender neutral, but they affect women, girls, men, and boys differently[25]. This is due to socioeconomic circumstances, cultural beliefs or traditions that can all contribute to inequality, resulting in women being put in situations of disadvantage when disasters strike. In Nepal this is not only limited to gender but also some castes and ethnical/religious minority. Therefore, it is important that in the pre-disaster context, those who likely will be the most affected by crisis, are also included in the preparedness process[26]. This includes having equal access on political, social, and economic levels as well as being able to participate in decision making. Not only is it fair, that population is equally engaged in climate change adaptation and resilience building, but there is also substantial evidence that shows women are often the most resilient members of society and the powerful agents of change in the event of a disaster. They also have historic coping mechanisms that

[25] UNDP, 2017, Gender adaptation and disaster risk reduction.
[26] GFDRR, 2018, Gender Equality and Women's Empowerment in Disaster Recovery.

can be of use when designing and tailoring local grass-root level early warning systems or other climate change adaptation services and activities. To include women or minority group in designing hydrometeorological and climate services directly leads to saving lives and livelihoods, as the needs of different groups would have been better identified.

The rational for organizations to pursue gender equality in governance, strategy, programmes, and decision making, is highlighted in WMO's recently updated Gender Action Plan[27]. It emphasizes that organizations that respect and value gender equality and diversity attract and retain talented staff and improve overall organizational performance, have more satisfied employees, are more innovative and have better governance. Teams that have gender diversity have better decision-making processes and attract more external partnerships, as well as have better access to local communities. Encouraging women to take up leadership positions has also shown to lead to important achievements in the field of climate change adaptation and disaster preparedness.

Constitutional Law of Nepal includes provisions for gender equality and prohibits discrimination and the government encourages to gender balance. E.g. 1/3 of seats in parliament and local bodies and also in public service are reserved to women. The DHM has not produced a gender assessment but women are relative well presented in all activities. E.g. management level (DDG, senior divisional meteorologist) is well presented by women, and in the FNEP3 30 % of focal persons were female and they were responsible on main stakeholder event organization and chairing. About half of the trainees and 1/3 of study visit participants were women. Relatively high share of meteorologist are women, but field work is more often implemented by males due to family and physically related reasons causing natural gender unbalance in different tasks.

It is recommended that; **a gender assessment should be conducted to fulfill the human capacity assessment. This could be implemented in a Gender Workshop. Based on the findings of the analysis, it is recommended that DHM develops institutional Gender Policy.** The following actions from the WMO Gender Action Plan[17], have been selected as recommendations to include in the Gender Policy and to be discussed during the gender workshops:

- Increase the participation of women by: (i) identifying and nominating female experts from NMHSs or other national institutions to participate in the work of WMO governance bodies and their working structures and (ii) seeking equality in the composition of delegations to sessions (1.1.1(c) in WMO Gender Action Plan).
- Strive for gender balance, including in management and working structures (1.1.2(c) in WMO Gender Action Plan).
- Encourage and support female networks of experts (1.1.3(c) in WMO Gender Action Plan).
- Designate NMHS gender equality focal points (1.3.4(c) in WMO Gender Action Plan).
- Develop monitoring mechanisms at the national level by (i) adapting the WMO gender monitoring indicators or (ii) using an existing national framework (2.4.1 in WMO Gender Action Plan).

[27] WMO, 2023, Gender Action Plan for the Eighteen Financial Period.

- Include gender equality (including the WMO Policy, GAP, link to online trainings and gender webpage, information on key activities) in the induction of new PRs and NMHS staff (3.1.4(c) in WMO Gender Action Plan)
- Develop the capacity of NMHS staff on unconscious bias, inclusive leadership, gender mainstreaming, and gender responsive service delivery through trainings and workshops (3.1.5(c) in WMO Gender Action Plan)
- Offer internships to young professionals, especially female, and secondments of staff from meteorological services on a rotational basis. (3.4.2(c) in WMO Gender Action Plan)
- Engage with international organizations field offices, such as UN Women, UNDP, etc. (5.1.4 (c) in WMO Gender Action Plan)
- Conduct research and provide the Secretariat with case studies, stories and examples of gender mainstreaming, including in service provision, for the development of a compendium of good practices (5.3.3(c) in WMO Gender Action Plan).
- Develop and disseminate communication materials (i) highlighting the role of women in meteorology, hydrology and climatology, (ii) promoting female role models, and (iii) advocating for gender responsive weather, hydrological and climate services (5.1.3(c) in WMO Gender Action Plan).
- (i) Customize weather and climate services to the particular needs and roles of women and men and (ii) Provide education and training to target female users in accessing and using weather and climate information and products (7.3.1(c) in WMO Gender Action Plan).
- Recommendations on activities, consultations, and areas of collaboration for the implementation of the Plan to ensure active CSOs participation and promotion of gender balance and gender opportunities.

During SOFF investment phase, a strong recommendation is to have equal participation of genders in the capacity building activities and consultations with civil society organizations. It must be noted that 50 % women participation is not feasible in training related to O&M of stations or DMS which are mainly operated by male.

Specific gender balance related activities during the SOFF investment phase will include the following:

Activity	Indicator
Gender workshop to assess gaps in gender balance and gender opportunities and provide recommendations	Outline of the gender assessment with recommendations for actions in DHM
Stakeholder engagement workshop /consultation including CSO's promoting gender equality by establishing minimum threshold for female participation and encourage participation of different castes	Equal participants of different genders invited
Promote gender equality by establishing minimum threshold for female participation in SOFF-related training events	At least 20 % women participants

CSO Participation

DHM is co-operating with the NGO's. E.g. with Red Cross DHM has initiated impact-based forecast on weather for selected districts. Cold wave forecast was also carried out as a pilot project in the FNEP. Currently DHM is participating in ECHO project to increase climate-smart disaster preparedness and risk reduction. NGO's and local governments have also installed community-level or river-basins meteorological and hydrological stations for early warning purposes. Data from local stations is connected to the DMS and transferred to the local governmental offices as per need.

To include CSO engagement during and after the SOFF implementation phase will bring mutual benefit and grounds for sustainable operation. The following actions are recommended to ensure that CSO's are regularly consulted during the entire length of the programme cycle:

- Conduct stakeholder engagement workshops on the implementation of the SOFF project deliverables (observational data exchange to support weather/climate and hydrological services and products), bringing together key stakeholders(governmental, research, private sector, CSOs), to involve and collaborate with the DHM and the SOFF project team from the onset, as well as ensure the stakeholders are consulted on operations and maintenance.
- Organize awareness-raising activities for the community by engaging CSOs, i.e. to prevent vandalism.
- Organize high level dialogues on benefits, co-production, and ownership of the new national GBON infrastructure.
- Organize stakeholder engagement workshops/consultations including, where possible, local civil society organizations (CSOs) focused on women's empowerment
- Ensure equal participation of gender from the DHM and stakeholders in consultations with civil society organizations.

Module 5. Risk Management Framework

WMO recommends its members to establish a Quality Management System (QMS) to ensure that customer and end user requirements are met (WMO no. 1100[28]). DHM is planning to implement the QMS for aviation service at the first place, although SOPs exist for the most main functions of the DHM. SOPs need to be updated to include full value chain of observation service.

As stated in the SOFF Operations Manual, the risk mitigation procedures of the Implementing Entity (IE) will be relied upon for SOFF implementation during the Investment phase. The Operational phase is supported by the risk mitigation procedures of the beneficiary.

The following summarizes overarching key risks for investment and operation phase to be carefully considered and handled by IE, beneficiary, and peer adviser.

[28] WMO-No.1100

Potential key risks for investment and operation during SOFF implementation	Mitigation measures and responsibilities	Monitoring and evaluation
Investment phase		
Unstable political situation, Epidemic/Pandemic	Partners cannot control these issues but information sharing between partners on situation is important for implementation	IE, peer advisor, beneficiary country and technical partners jointly monitoring the situation
Slow implementation and delays in procurement, installation and capacity building activities	Seamless collaboration between the IE, peer advisor, beneficiary country and technical partners will help to ensure that the project activities are executed without any delays	IE, peer advisor, beneficiary country and technical partners jointly monitoring regularly as the project progresses
Failure in bidding process, insufficient technical specification of items and other quality criteria in tender process. Price cannot be the only criteria for choosing a vendor and **compatibility with existing infrastructure is crucial**	Seamless collaboration between IE (responsible for tender process), peer adviser (responsible for technical sensor specification), beneficiary (responsible for supporting in setting up quality requirements and technical specifications to best support the needs in the country). Establishing of SOFF project (including Investment and Compliance phase) to outsourced project coordinator could enhance continuous operation of the GBON system.	IE (on request with support from beneficiary and peer adviser) will be responsible for monitoring and evaluating the quality of documents before opening the tender process.
Possibility for tax exemption when importing the goods	MoF may waive custom clearance tax but consent required before investment phase application Before shipment IE will be responsible to ensure that shipper and freight agent are aware of the tax exemption process in Nepal border. Beneficiary is responsible for providing all required	The beneficiary is responsible on the agreement with the MoF on tax exemption. IE will be responsible for following up the shipment process until it has been tax exempted in the Nepalese customs.

	documentation, information, and support for the tax exemption declaration process.	
GBON data are not collected or shared or are shared with insufficient quality	The Investment Phase will include budget operations and maintenance of the equipment to ensure that GBON Infrastructure has been installed and internationally exchanges data. This will also help in smooth transition to the compliance phase. After this the country will receive SOFF support in the compliance phase which will help to ensure that all the equipment is properly functioning and sharing data. In addition, trainings held during the Investment Phase trainings will help to ensure that the beneficiary country has the capacity to manage quality of the data.	The management of beneficiary country is responsible for reviewing and monitoring that work has been conducted as intended

Operation phase		
Decrease in funding support for operations	Sufficient lifecycle planning, and subsequent, annual budget planning combining different funding source (SOFF, governmental budget, other)	IE and DHM are responsible for monitoring and taking required corrective actions.
Insufficient staff competence, changes in staff members	The beneficiary develops an internal training programme including the criteria of competence requirements for technical staff. A duplication of skilled staff members for critical tasks and refreshing trainings.	The management of beneficiary organizations is responsible for monitoring and evaluation.
Stoppage of operation due to power or network shortages	Power supply for AWS is from solar panels with back-up batteries. Sounding system will be connected to	IE and DHM are responsible for monitoring and taking required corrective actions.

	line and equipped with generator. Also the DHM and GIDC has generator for power shortages affecting to the DMS operation. All systems will be equipped with duplicated SIM, satellite transfer or band line to ensure data transfer to network shortages	
The management of observation and data processes is insufficient.	Frequent follow up on how strategic goals and annual targets have been achieved.	The management of beneficiary is responsible for reviewing and monitoring that work has been conducted as expected
Station security is not sufficient	DHM staff will be available most of the time at station, especially around sounding times, and stations have fencing. Equipment is checked regularly according to maintenance plan.	Security of station is monitored by DHM and proper actions taken as necessary.
Natural hazards	The Himalayan area is prone to earthquakes. The possibility of earthquake is addressed in civil works as best practices., Possibility of flooding and landslides might be avoided by careful siting, and damages by lightning with lightning protection system.	IE, peer advisor, beneficiary country and technical partners jointly monitoring the situation

Module 6. Transition to SOFF investment phase

The transition to SOFF investment phase is recommended to carry out by following the Gap Analysis and this National Contribution Plan. The IE will prepare the funding request for SOFF implementation phase in co-operation with the peer advisor and beneficiary. This supports the best coordination in the transition phase.

Summary of GBON National Contribution Plan

Components	Recommended activities	Related outputs and technical details
Module 2. GBON business model and institutional development	1. Formulation and Promulgation of Hydromet act and regulation are important to entry into the legal force and ensure continuous, sufficient funding for DHM's operation.	
	2. It's recommended to continue existing public-private service model on external observation maintenance service. It's especially important to have a valid multi-year contract to ensure continuous, sustainable operation and quality observations.	
	3. It's recommended to continue the existing centralized ICT services to avoid duplication and save human resources. It's recommended to continue public-private service model in DMS maintenance. Long-term contract on maintenance should be implemented to ensure continuous operation of the DMS. It is crucial to enhance reliability and robustness of the DHM critical infrastructure, including backups and duplicated services.	
	4. Co-operation with other governmental institutes, private sector, NGO's and research institutes could be continued and improved by partnerships.	
	5. It's recommended to share knowledge and experience on common technical systems with neighboring countries in addition to data sharing. Capacity building development by Regional WIGOS Centre RA II could be explored.	
	6. It should be noted that in the investment phase planning, MoF should approve the SOFF grant and/or allow using budget of the Government of Nepal in SOFF implementation before Investment phase application. MoF may waive tax but agreement must be prepared and signed before the project (Implementation phase) starts.	
	7. Development of lifecycle plan for AWS, soundings, ICT and outsourced services are necessary to avoid shortages in the operation. Also, allowances of necessary personnel should be included to the SOFF.	

	9. It's recommended that all technical systems to be installed follow specifications of existing AWS networks to ensure sustainability of the networks, and data is collected to centralized DMS for further use.	
	10. It's crucial to pay attention to national procurement rules when planning SOFF investments to ensure more successful procurement process. Establishing of SOFF project (investment + compliance phase) could enhance more continuous operation of GBON stations.	
Module 3. GBON infrastructure development	1. To improve sustainability of the DHM, all SOFF investments should be integrated and compatible with the existing system. Utilizing the existing system would enable easy fix solutions, like denser (100 km) GBON network with 15 AWS.	
	2. Maintenance plan should be updated and the lifecycle plan of instrument should be drafted to ensure continuous operation of GBON system	
	3. The spare part pool should contain extra equipment to ensure operation during calibration and maintenance. Recommended value is 30 % of total. Duplicated sensors are recommended to high altitude stations to ensure operation during damages.	
	4. Sustainability and ecological solutions should be acknowledged in all SOFF activities from procurements to operational processes. e.g in the scoring system of tenders the quality of equipment and services, and environmental efforts of the company should be emphasized	
	5. Existing DMS can serve a real time database and it is recommended to be used also as data source for the WIS2.0 interface. Dataflow via database allows centralized real-time monitoring of the system, real time quality control and centralized source for metadata.	
Module 4. GBON human capacity development	1. DHM has a serious shortage of staff e.g. number of (ICT) engineers are missing. It's important to ensure that DHM has capacity to manage, monitor and control the quality of O&M services also in future. There is no specific post on Hydromet ICT, and the formalities for hiring contract-based employees (like ICT) is challenging and difficult for DHM. It is recommended to seek any alternative options in this SOFF project. Expert pool with duplicated knowledge and refreshing trainings are also recommended.	

	2. Implementation of competence building process is recommended to support quality of operation and management.	
	3. Labor costs related to the GBON implementation are recommended to be included in the SOFF budget to ensure GBON compliance in future	
	4. A gender assessment should be conduct to fulfill the human capacity assessment. This could be implemented in a Gender Workshop. Based on the findings of the analysis, it is recommended that DHM develops institutional Gender Policy.	
Module 5. Risk Management	1. The SOFF Risk Management Framework should be monitored and updated regularly to ensure that it is up to date, and any new risks and mitigation measures should be added to the matrix as soon as they surface.	
Module 6. Transition to SOFF investment phase	1. The transition to SOFF investment phase is recommended to carry out by following the Gap Analysis and this National Contribution plan	

Annexes

None

Report completion signatures

Peer Advisor signature 24.7.2025 Harri Piel ILMATIETEEN LAITOS • FINNISH METEOROLOGICAL INSTITUTE •
Beneficiary Country remarks and signature 30.7.2025. Kamal Ram Joshi Director General Government of Nepal Ministry of Energy, Water Resources and Irrigation DEPARTMENT OF HYDROLOGY & METEOROLOGY Babarmahal, Kathmandu
WMO Technical Authority screening remarks and signature

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