Systematic Observations Financing Facility

19th May 2023

GBON National Gap Analysis

Bhutan

Systematic Observations Financing Facility

Weather and climate data for resilience

WEATHER CLIMATE WATER

Screening of the National Gap Analysis (NGA) of Bhutan

WMO Technical Authority screens the GBON National Gap Analysis to ensure consistency with the GBON regulations and provides feedback for revisions as needed. *The screening of the NGA is conducted according to the SOFF Operational Guidance Handbook, version: 04.07.2023 and the provisions in Decision 5.7 of the SOFF Steering Committee.*

Following iterations with the peer advisor and beneficiary country, WMO Technical Authority confirms that the National Gap Analysis is consistent with GBON regulations.

Date: 25th Sep 2023

Signature:

Albert Fischer

Director, WIGOS Branch, Infrastructure Department, WMO

GBON Gap Analysis Report
Bhutan

Beneficiary Country Focal Point	Ugyen Chopel, NCHM
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WMO Technical Authority	

1 Country information from the GBON Global Gap Analysis

Bhutan is small landlocked country at middle of Himalayas. Currently there is only one surface station, called Tsampa which is sending observations to GTS-network. It was also only station which was recognized by WDQMS earlier.

GBON requirement of horizontal resolution of 200 km can somehow be covered by existing station in Bhutan and neighbouring countries, but according to WDQMS they are not operating well enough.

Bhutan does not operate any sounding stations currently. NCHM has made upper air soundings in 2016 but operation was halted due to lack of the funding and availability of hydrogen gas. Nearest sounding stations are located at Siliguri and Guwahati, in India. Both are located under 100 km from border of Bhutan but they both are lacking data. In north the nearest station is about 200 km from Bhutan, in Lhasa, China, but it has lack in variables and temporal resolution of the data.

NCHM owns and manages all operational weather and hydrological observation networks in Bhutan. There are few research stations with limited parameters and operation time, owned by other institutes, but NCHM supports them in installation and operations. Therefore, there are no relevant 3rd party networks to consider.

Table 1. WMO Global Gap Analysis (June 2023). Illustration of the information that the WMO Secretariat provides to each country.

GBON horizontal resolution requirements	GBON target	Reporting	Gap improve	Gap new	Gap total
Surface stations Horizontal resolution: 200km	1	1	0	0	0
Upper-air stations Horizontal resolution: 500km	1	0	0	1	1

WMO Global Gap Analysis (June 2023) considers Tsampa station (WIGOS ID: 0-20000-0-44517) as reporting GBON station. The station is not affiliated with GBON, but it is currently only station in Bhutan sending observations to GTS. As described later in this document, the actual GBON station to be proposed for SOFF is Tsirang Dampchu.

2 Analysis of existing GBON stations and their status against GBON requirements

Currently only GBON - eligible station in Bhutan would be Tsampa (WIGOS-ID 0-20000-0-44517). Tsampa was included in WDQMS-pages on Q1/2023, but it has been recently removed from the listings. Tsampa is also only station which reports data to the GTS network. WDQMS pages showed average 20 times per day of received observation, although official reporting period to GTS is 24 observations for day.

Tsampa is automatic weather station provided by JICA-project, measuring all necessary weather parameters except snow depth required in GBON (tables 2 and 3). Due to its location at high altitude (3700 m), Tsampa has snow cover all year-round so regarding GBON requirements, adding snow depth measurement is recommended.

Although Tsampa has connection to GTS network (reporting observations in SYNOP-format), it differs technologically from majority of Bhutanese AWS stations. Location at high altitude provides valuable information, but also makes maintenance difficult. Station is accessible only for few times per year and it has challenges with data communications.

Therefore, Tsampa will not be recommended to be main GBON station.

Recommended surface station for GBON network would be Tsirang Damphu in central Bhutan. Station is existing station, which has had an old AWS and manual station. Currently only manual station is operating and station will require full upgrade to AWS to bring it to same level as the rest of AWS network. Same location will be also proposed for the new upper air station, so Tsirang AWS will support GBON surface and upper air observations.

NCHM does not operate any upper air sounding station. As a pilot program, NCHM installed a sounding station in Paro international airport in 2016. The main objective of the program was to collect the sounding data for the pre-monsoon season (April, May and June) for three years. The sounding accessories were acquired with the assistance of an external project (SAARC STORM). However, NCHM had to arrange the hydrogen gas supply. With limited capacity, funding and regulations of importing hydrogen gas, the upper air observations were carried out less than 1 year.

The sounding station has been disassembled, and a new station is proposed to be installed in the Tsirang Damphu area in central Bhutan.

Table 2. Assessment of existent GBON stations per their operational status and network ownership

GBON Requirements	Existing observation stations (# of stations)			
	NMHS network		Third-party network	
	Reporting	Improve	Reporting	Improve
Surface stations Horizontal resolution: 200km Variables: SLP, T, H, W, P, SD	**0**	**0**	**0**	**0**
Upper-air stations Horizontal resolution: 500km Vertical resolution: 100m, up to 30 hPa Variables: T, H, W	**0**	**0**	**0**	**0**

Tsampa station has been excluded from the table, as it is not included in the official GBON-network and does not have WIS-connection.

Table 3. Assessment of existing GBON stations per station characteristics. Station type: S: Surface, US: Upper-Air; Owner of the station: NMHS or name of third-party; GBON variables: SLP: Sea-level pressure; T: Temperature; H: Humidity; W: wind; P: Precipitation; SD: Snow depth; Reporting cycle: Number of observation reports exchanged internationally per day (0-24); GBON compliance: weather the station is GBON compliant or not (see GBON guide on compliance criteria).

Station name	Station type (S/UA)	Owner (NMHS/third-party)	Funding source	GBON variable measured						Reporting cycle	GBON Compliance (Y/N)
				SLP	T	H	W	P	SD		
Tsampa	S	NMHS	NMHS	x	x	x	x	x		24	N

Tsampa station has been included in this table, although it is not an official GBON station, it is sending observations to GTS network.

3 Results of the GBON National Gap Analysis

3.1 GBON surface stations

Requirement of the basic horizontal resolution of the GBON surface stations (200 km) would be fulfilled more or less with Tsampa-station. However, Tsampa is not recommended to be the main GBON station due to reasons mentioned in earlier chapters.

Main gap for the surface observation stations is the data delivery process to GTS/WIS -networks. The Tsampa station is sending data to GTS but its time series is not complete. Its data collection works separately from the majority of NCHM AWS network and is not easily utilizable.

Recommended surface station for GBON network is existing station **Tsirang Damphu** in central Bhutan. Technologically upgraded station would be same as the majority of other AWS which would bring synergy in the maintenance and operations.

Basic parameters needed for the station are temperature, pressure, humidity, wind and precipitation. Tsirang area does not have snowfall, so snow depth sensor is not required. Current station needs upgrades and spare parts for the operation.

Same location is also proposed for the new upper air station and this station can serve as a source for surface information for the soundings.

Main component which needs to be developed or acquired, is interface to WIS 2.0 network. Implementing the dataflow to WIS 2.0 for selected station, would enable also data flow from other AWS stations. This would increase the number of observations from Himalayan region and higher altitudes with small effort (quick wins and request by WMO in general).

From data collection point, NCHM has acquired central observation database CDMS to which observations are collected. It can serve as centralized surface observation data storage and source of data for the WIS and other services.

Reliability and real-time availability of the observations from proposed station and from existing network in general can be increased by addressing challenges in data communication methods, lack of spare parts and lack of resources for maintenance and operation.

Also, lack of full calibration laboratory facilities and human capacity with NCHM to operate these facilities is a challenge for station maintenance and data quality. NCHM has capacity to calibrate temperature and partially relative humidity and pressure. However, equipment in calibration laboratory needs maintenance and for other parameters, additional equipment. For routine calibration, also decent spare part pool is needed, currently NCHM does not enough sensors or resources to maintain operational calibration routines.

Only the stations which form a part of the early warning network (have satellite-based communications as back up) have stable connections. Other AWS rely on mobile data connections which are not duplicated.

Table 4. Proposed AWS station to be upgraded to GBON

Station name	Station type (S/UA)	Owner (NMHS/third-party)	Funding source	GBON variable measured						Reporting cycle	GBON Compliance (Y/N)	
				SLP	T	H	W	P	SD			
Tsirang Damphu	S	NMHS	NMHS	x	x	x	x	x	NA	24	N	

3.2 GBON upper-air station

Bhutan does not operate any upper-air soundings. Nearest sounding stations in neighboring countries (Guwahati (ca 250 km) in India, Lhasa (ca 280 km, not recognized by WDQMS) in China, Dhaka (ca 400 km) and Kathmandu (ca 420 km, not recognized by WDQMS)) are lacking data in variables and temporal resolution. Thus, one new manual sounding station is proposed to be installed to Bhutan under SOFF.

Bhutan has operated soundings in 2016 for relatively brief period. The main challenges are operation costs and availability of hydrogen. The pilot station at Paro has been disassembled, and a new station is proposed to Tsirang Damphu (central Bhutan).

From other evaluated places, Paro valley has an international airport which affects to operation of regular soundings and therefore it is not a feasible location. NCHM will get new headquarters in Thimphu area in future, but its schedules have still uncertainty and currently there is no good location for the sounding station. This may change with the new headquarters.

Due to restriction of international supply of hydrogen and difficulties in transportation, sounding station with integrated hydrogen supply is necessary.

Table 5. Results of the GBON national gap analysis

SLP: Sea-level pressure; T: Temperature; H: Humidity; W: wind; P: Precipitation; SD: Snow depth

GBON requirements	Target (# of stations)	GBON Compliant stations (#)	Stations gap	
			New	Improved
Surface stations • **Horizontal resolution**: 200km • **Variables**: SLP, T, H, W, SD • Observation cycle: 1h	1	0	**0**	**1 (Tsirang Damphu)**
Upper-air stations • **Horizontal resolution**: 500km • **Vertical** resolution: 100m, up to 30 hpa **Variables**: T, H, W • **Reporting cycle**: twice a day	1	0	**1 (Tsirang Damphu)**	0

Proposed surface station

Name	Lat	Lon	Altitude (m)	Variables	Reporting cycle
Tsirang Dampchu	27.0094	90.122	1450	SLP,T,H,P,W	24

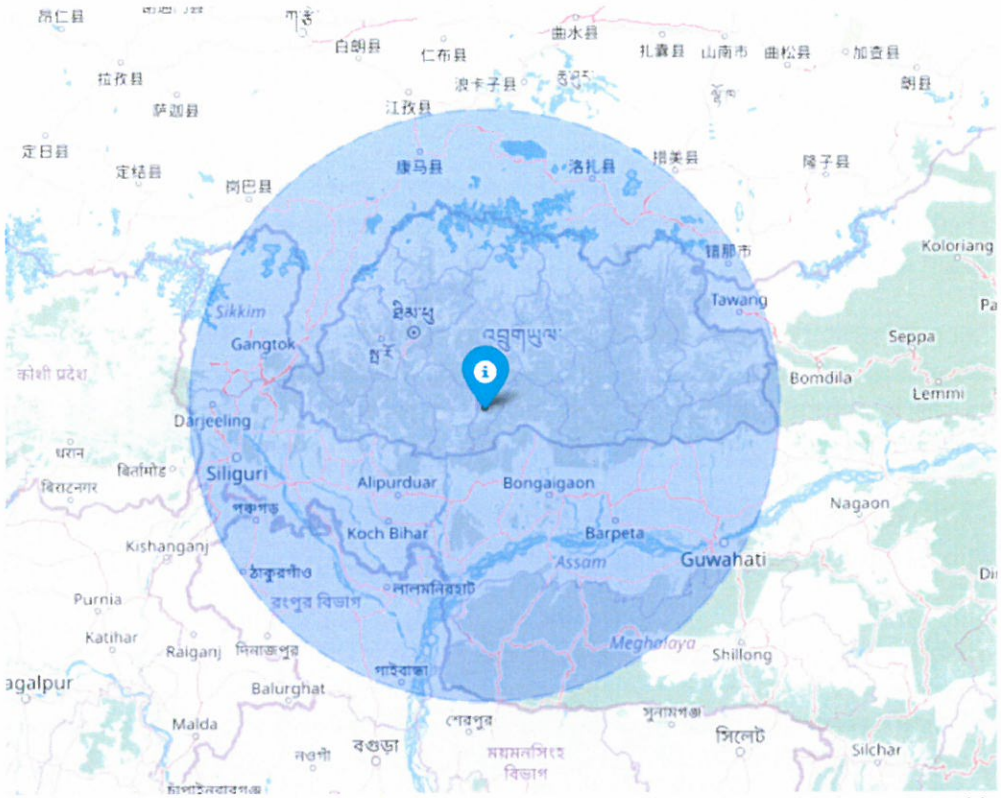

Figure 1: Geographical visualization of the proposed GBON surface station to be supported by SOFF, with 200 km radius

Proposed Upper air station

Name	Lat	Lon
Tsirang Damphu	27.0094	90.122

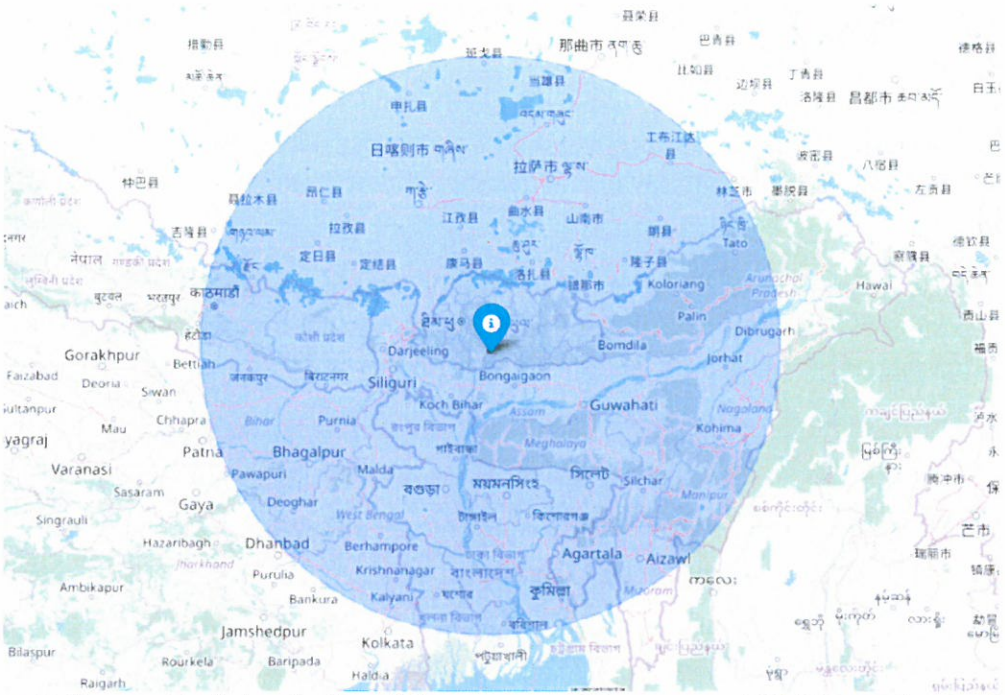

Figure 2: Geographical visualization of the coverage of the proposed GBON sounding station to be supported by SOFF, with 500 km radius

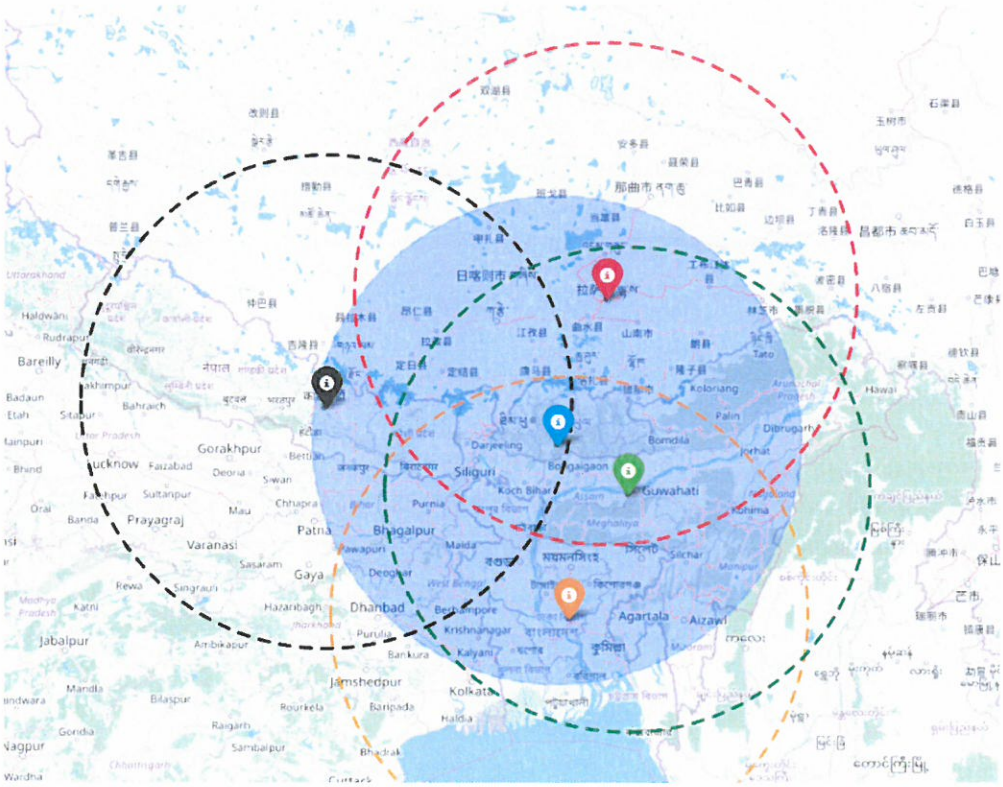

Figure 3: Geographical visualization of the distribution of proposed GBON sounding station and stations in neighbouring countries

3.3 Easy fixes

Supporting the development of the proposed surface station will enable several easy fixes with similar stations. There is strong synergy in maintenance and operations with a common spare part pool.

Developing the dataflow to WIS 2.0, would enable direct dataflow to WIS 2.0 from the other similar stations (and stations collected to CDMS in general). This would improve available observations from the Himalayan region and high altitudes.

Depending on the station, most GBON parameters are observed, with the exception of snow depth at locations which do not have snowfall. There are also additional parameters on some stations such as agro-meteorological parameters.

The actual data sharing policy will be decided separately.

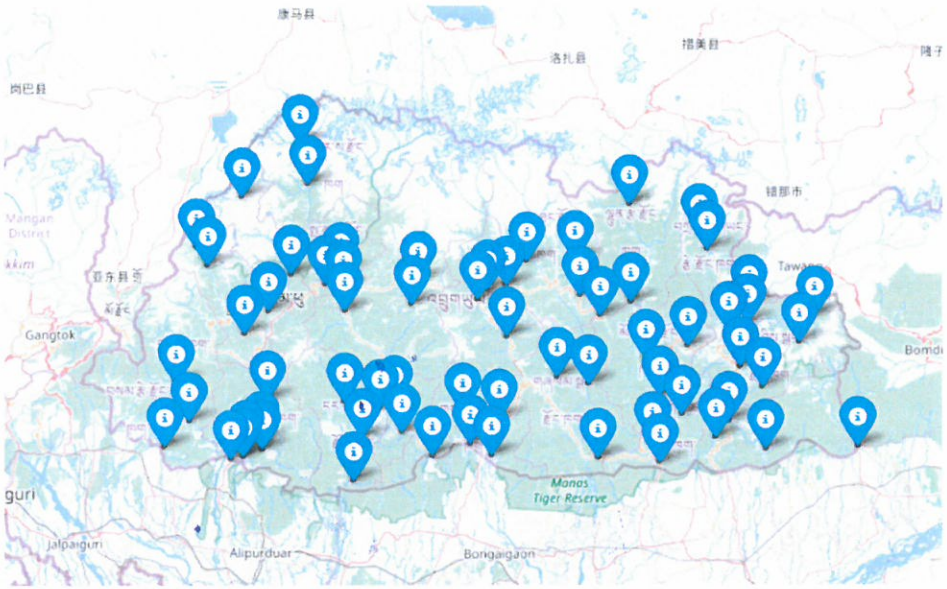

Figure 4: Preliminary map of stations which could be shared via WIS 2.0 using same solutions as proposed GBON station Tsirang Damphu. Possible delivery requires separate decisions and additional support for data communications and station maintenance & operation.

4. Report completion signatures

Peer Advisor signature

Sami Kiesiläinen
Project Manager
Finnish Meteorological Institute

WMO Technical Authority screening remarks and signature

Beneficiary Country remarks and signature

Director
PR of Bhutan with WMO
National Center for Hydrology & Meteorology
Royal Government of Bhutan
Thimphu : Bhutan

ANNEX 1: COVERAGE OF EXISTING GBON STATION

Following figure shows coverage of existing Tsampa station, which is not actual GBON station although it is sending data to GTS network. From GBON point of view, there is not much difference to proposed GBON station Tsirang Damphu

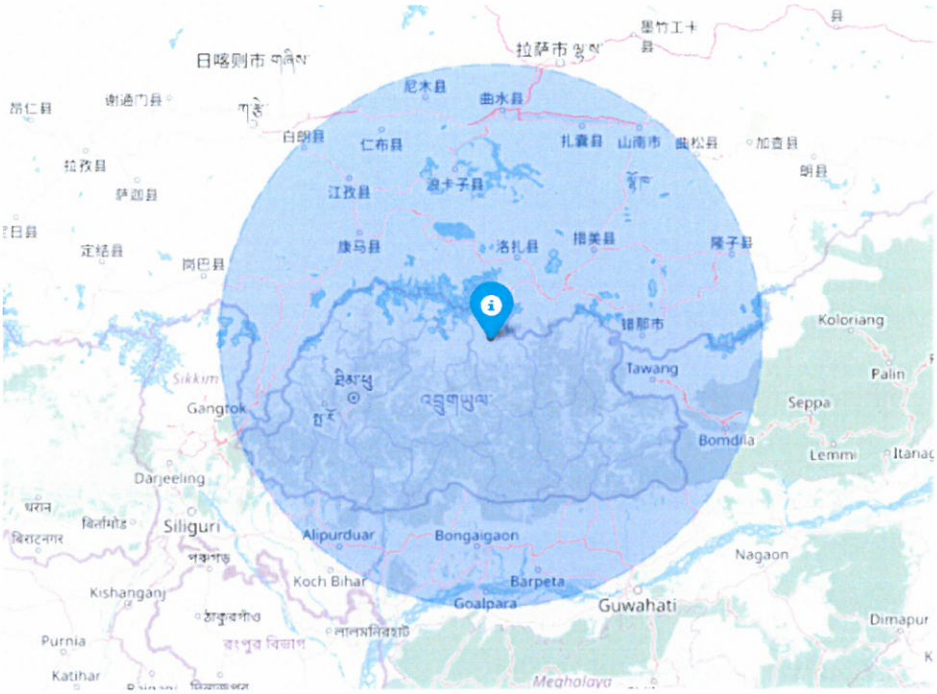

Figure 1: GBON eligible station Tsampa with 200 km radius.