Systematic Observations Financing Facility

17th October 2023

GBON National Gap Analysis

Rwanda

Systematic Observations Financing Facility

Weather and climate data for resilience

Screening of the National Gap Analysis (NGA) of Rwanda

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: 20th Oct 2023

Signature:

Albert Fischer

Director, WIGOS Branch, Infrastructure Department, WMO

Document review process notes:

- Version 21.12.2022 for SOFF peer advisors and Implementing Entities feedback by 10 January 2023
- This revised guidance note will be included into the SOFF Operational Guidance Handbook, which complements the SOFF Operational Manual

GBON Gap Analysis Report
Rwanda

Beneficiary Country Focal Point	Dr. Vedaste Iyakaremye, Rwanda Meteorology Agency
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WMO Technical Authority	Mr. Leonid Kadinski

Version no.	**Date when submitted for comments**	**Other**
Version 1	19.5.2023	Sent for beneficiary. Feedback received 26.5.2023
Version 2	8.6.2023	Sent for beneficiary and implementing entity
Version 3	29.6.2023 for SOFF secreteriat	Gap analysis reviewed together with Meteo Rwanda, UNDP and FMI before submission, including field mission on potential surface station
Version 4	10.8.2023 FINAL VERSION	Document updated based on the review report from SOFF secretariat (Annex 5), reviewed by Meteo Rwanda, and submitted to SOFF secretariat.

1. Country information from the GBON Global Gap Analysis

Meteo Rwanda has registered 4 surface stations in WDQMS database (Fig. 1). However, they do not provide data in the schedule compliant with GBON requirements. Further information about the number and status of surface measurement stations as well as other capacity gaps is described in Annexes 1 and 2. No upper air observations are carried out in Rwanda (Fig. 2). Table 1 summarizes the compliance relative to the WMO Global GBON requirements.

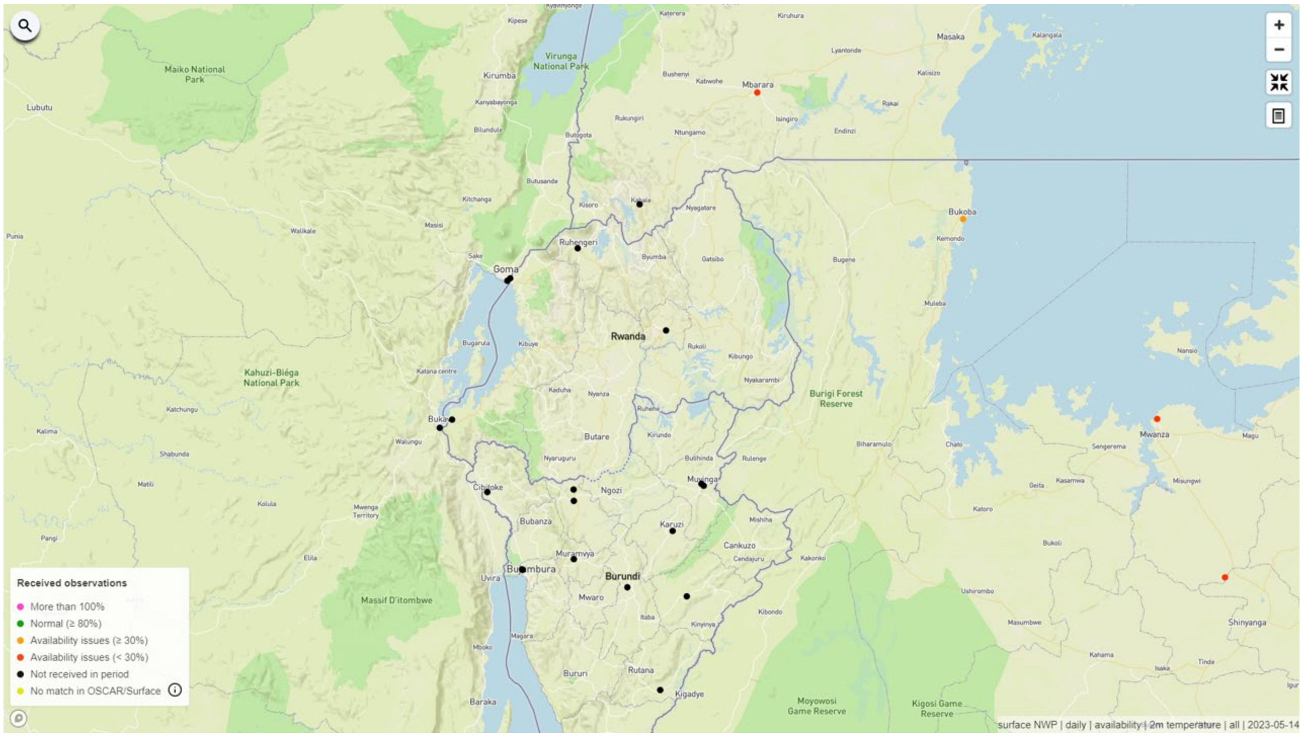

Figure 1. The status of surface weather stations in Rwanda and its neighboring countries based on WDQMS information.

Figure 2. The status of upper air stations in Rwanda and its neighboring countries based on WDQMS information.

Table 1. WMO Global Gap Analysis (June 2023).

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

*GBON global target is based on the following calculations for surface and upper air stations, respectively, target number of stations = surface area of the country km^2/200 km x 200 km (or 500 km x 500 km).

**Based on the geographical dimensions of Rwanda (Fig. 3).

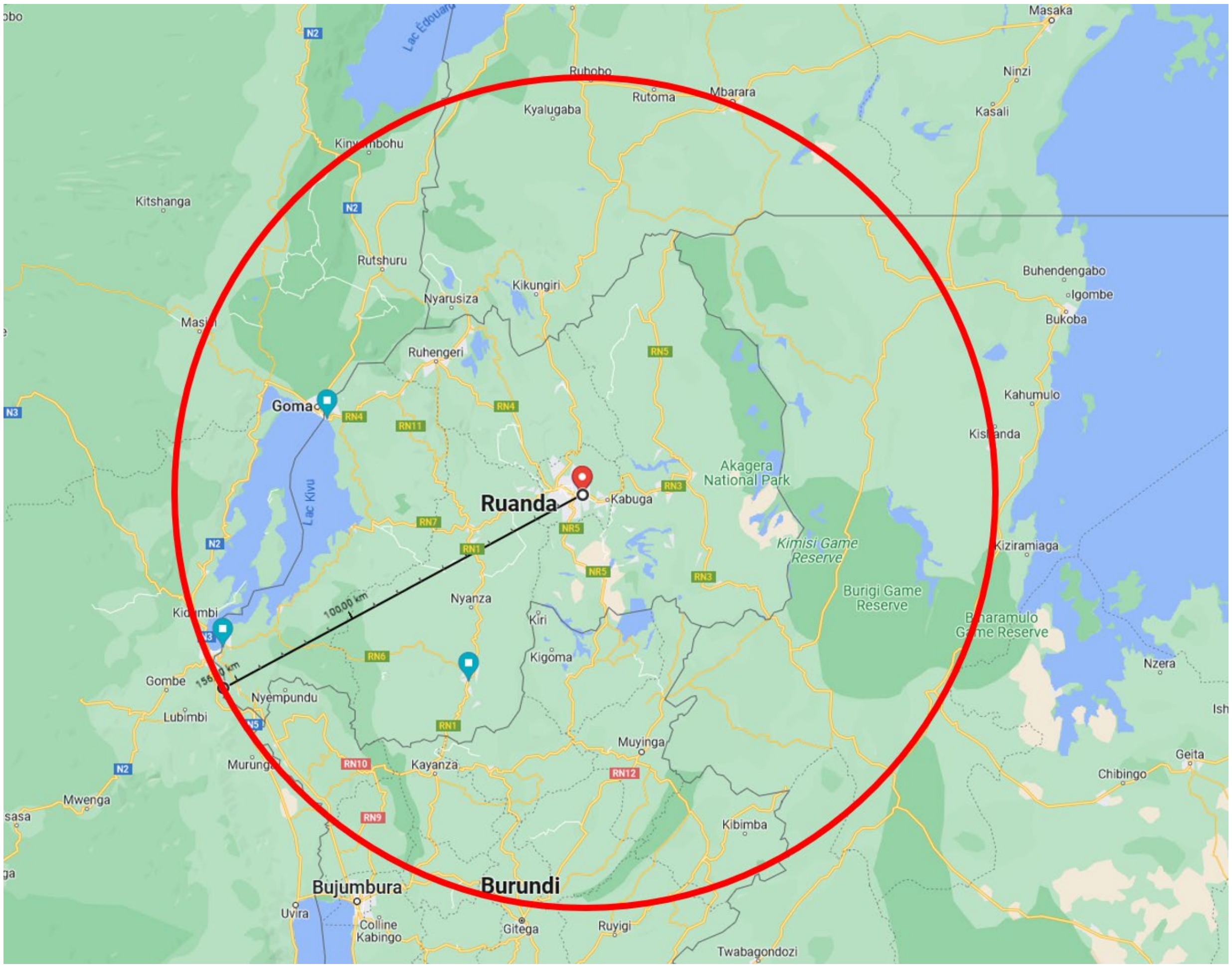

Figure 3. Surface station at Kigali international airport (not exact coordinates). A schematic circle with radius of ca. 156 km covers the whole Rwanda. This means that when looking only Rwandan area; one surface station and one radiosounding station will fulfil minimum GBON global requirement for spatial resolution 200 km and 500 km, respectively. However, due to the complexity of Rwandan terrain, there is a need to add more stations in order to capture microclimate. The map is from Google maps tool.

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

Tables 2 and 3 as well as Fig. 4 summarize existing NHMS and third-party observation networks relevant to GBON. In annexes 1 and 2 more detailed information is provided.

Table 2. Assessment of existent 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**	**1**	**0**	**0**
Upper-air stations Horizontal resolution: 500km Vertical resolution: 100m, up to 30 hPa Variables: T, H, W	**0**	**0**	**0**	**0**

Table 3. Assessment of existing GBON stations per station characteristics.

Station name (number of stations)	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		
Reporting surface stations (4)	s	NHMS	NHMS	x	x	x	x	x	-	12*	N
Agrometeorological surface station (9)	s	NHMS	NHMS	x	x	x	x	x	-	-	N
Climate sations (75)	s	NHMS	NHMS	-	x	-	-	x	-	-	N
Authomatic and manual rain stations (172)	s	NHMS	NHMS	-	-	-	-	x	-	-	N
Community surface stations (18)	s	Communities	Not known	-	x	-	-	x	-	-	N
Full authomat	s	NMHS	NHMS	x	x	x	x	x	-	-	N

ic non-reporting surface stations (59)											

***Notes*: 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).

*Kigali Airport surface station operates 24h and national data delivery cycle is 12. Three other surface stations at airports (Kamembe, Gisenyi, Ruhengeri) operate 12h/day and national data delivery cycle is 12. For more information about stations please see Annex 2.

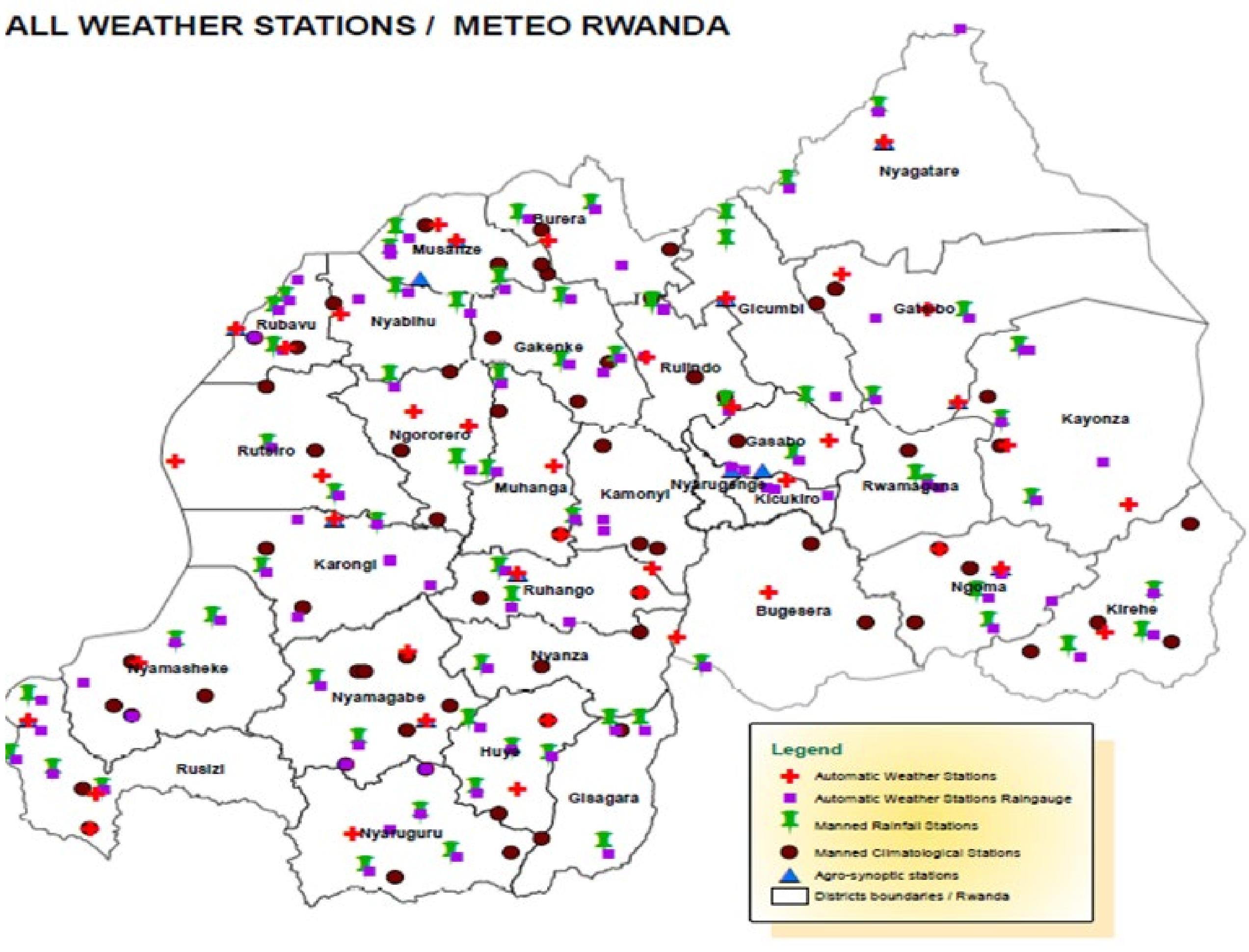

Figure 4. The distribution of surface weather stations in Rwanda.

3. Results of the GBON National Gap Analysis

Based on the presented analysis, one surface station and one upper air sounding station would fulfil the minimum GBON global requirement for spatial coverage in Rwanda. The WMO guide no. 1160, however, states that "Members should operate surface land observing networks/platforms at horizontal resolutions of 100 km or higher". Rwanda owns highly varying topography with different microclimatic environments. Consequently, based on the exercise on map, identified gap in surface observation network is 9 improved surface weather stations (Fig. 5) with the shortest distances between stations being ca. 40-100 km.

Meteo Rwanda has registered 4 stations in WDQMS. Distances between these stations are ca. 84 - 100 km. They are all located at airports, and thus, are strategically important locations for Meteo Rwanda to keep operational and up-to-date. Five yellow dots in Fig. 5 represent potential locations for improved surface weather stations based on areal coverage analysis.

Meteo Rwanda – FMI delegation carried out a field mission to two eastern stations in Nyagatare and Kibungo to investigate the current status of station infrastructure (Figs 6-7). The field mission indicated that civil infrastructure (electricity, access to 4G, tower for wind sensor etc.) is in good condition. The automatic observation sensors, however, are already aged. Additionally, Meteo Rwanda has had insufficient budget for replacing sensors periodically according manufacturers' guiding. Data loggers consists of out-dated technique, and for example, do not allow 4G internet connection for data transfer nor support all required sensors at the station. These findings suggest that upgrading proposed surface stations require only the procurement of new sensors together with data logger. Annex 3 gives further information about the location and age of stations to complement the given description.

The summary of gap analysis is provided in the table 4 with none of the stations being compliant with the GBON requirements (Table 5). **The SOFF programme will support improving one surface weather station and investing in one new upper air station** (Annex 5), **which are requested based on this Gap Analysis**. Additionally, the gap analysis shows that there is a need to upgrade the current climate database management system of Meteo Rwanda. Funds for the database upgrade has been secured in the CREWS East-Africa project. There will be requests for capacity building related to surface weather and upper-air station management and calibration (Annex 1) including the staff members of both Meteo Rwanda and Rwanda Standard Board.

Due to a lack of sensor calibration and insufficient lifecycle planning including required budget, there are no real easy fixes to ensure other needed surface stations to become SOFF compliant including the ability to report 24/7 (Fig. 5 and Table 4). To upgrade sensors and data loggers at stations up-to-date, the Meteo Rwanda is recommended to further look for funding from different sources, such as through annual budget planning with national government or international development collaboration projects. Further considerations will be given in the National Contribution Plan.

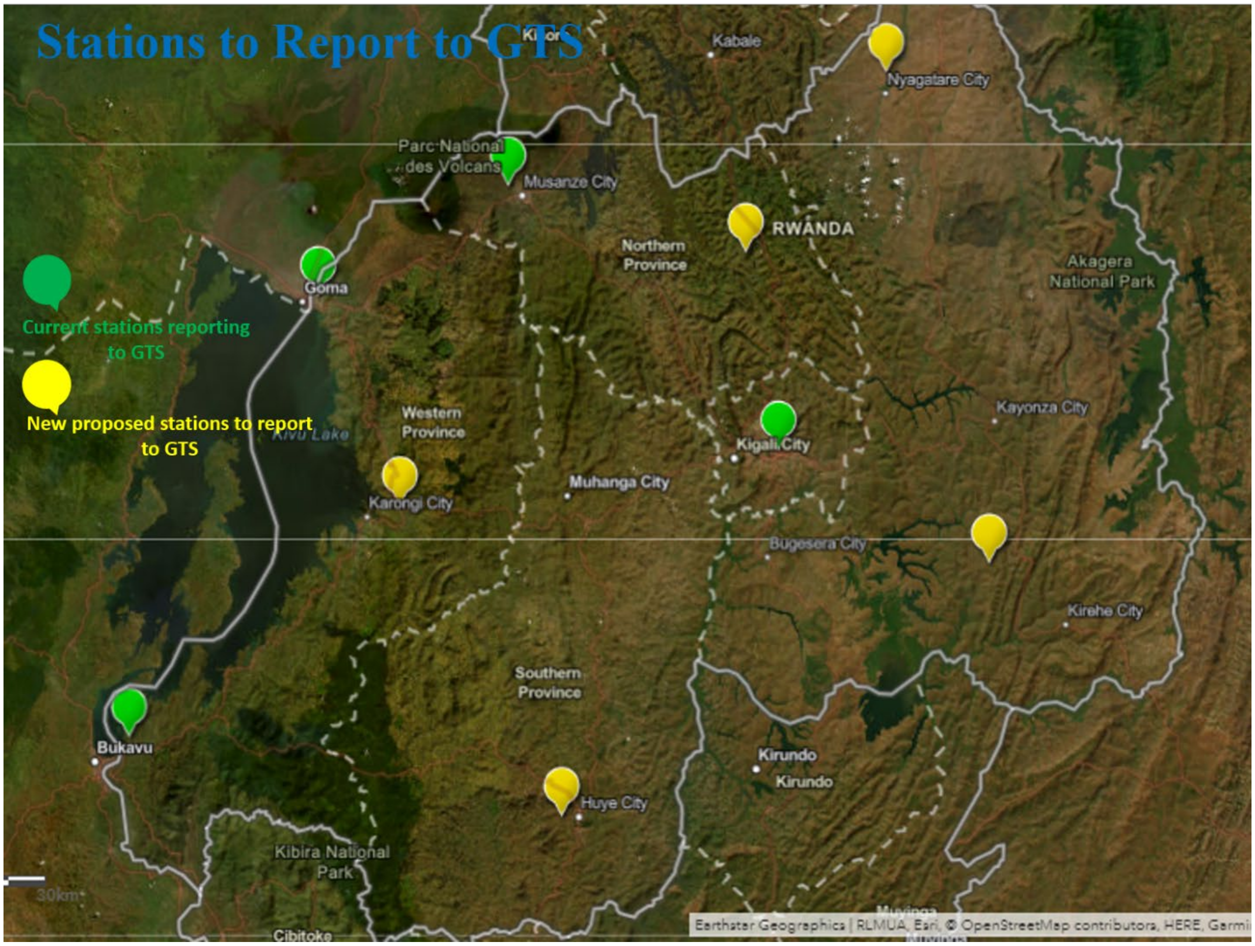

Figure 5. Green markers indicate surface observation stations at airports and are registered in WDQMS. Yellow markers represent the potential locations for improved surface stations.

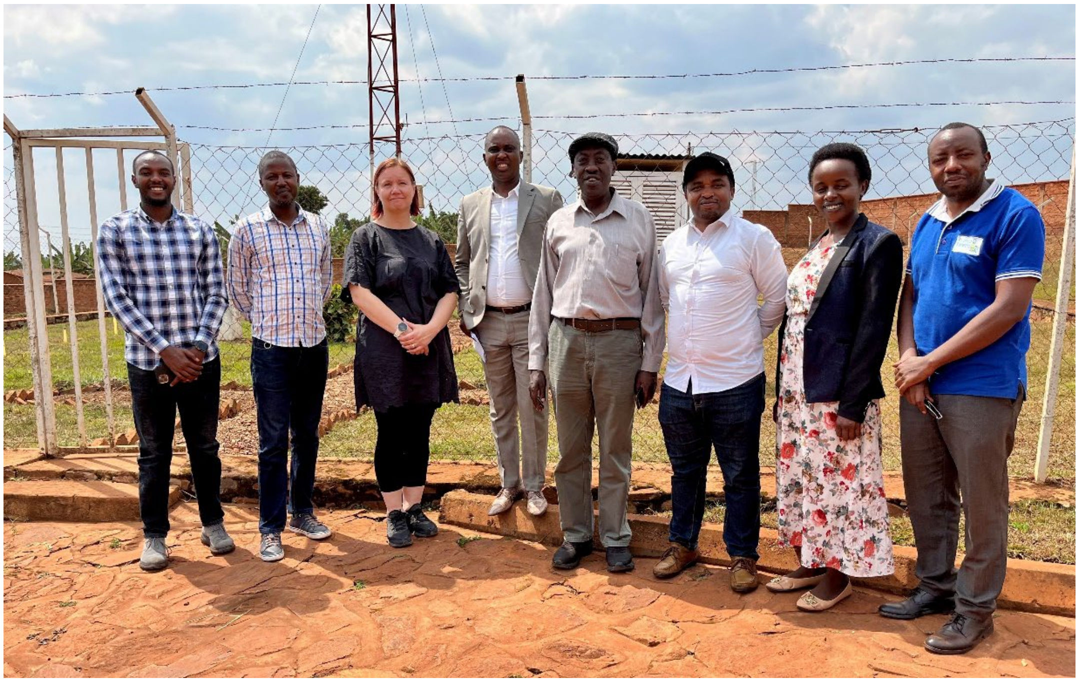

Figure 6. Field mission to identify potential surface stations to improve and include in SOFF programme. From left Herve Murenzi, DG Aimable Gahigi, Anne Hirsikko, Fidele Kamanzi, Didace Musoni, Aminadab Tuyisenge, Constantine Ingeli, and Constantin Ngomanzungu on 26th June 2023.

Figure 7. Surface weather station in Nyagatare.

Table 4. Results of the GBON national gap analysis

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***
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****	**0**

*Minimum to fulfil GBON requirement

**Minimum to fulfil GBON requirement; Location to be determined in the procurement phase based on site surveys and a provision of permissions by the authorities.

Table 5. Recommended existing surface, upper-air and marine stations to be designated to GBON.

Station name	Station type (S/UA/M)
No compliant stations	S
No compliant stations	UA

4. Report completion signatures

Peer Advisor signature
ANNE HIRSIKKO, PROJECT MANAGER HELSINKI, 17.10.2023 ILMATIETEEN LAITOS • FINNISH METEOROLOGICAL INSTITUTE
WMO Technical Authority screening remarks and signature
Beneficiary Country remarks and signature
Meteo Rwanda appreciates the joint effort in the development of the gap analysis document. GAHIGI Aimable Director General 18/10/2023 RWANDA METEOROLOGY AGENCY - METEO RWANDA REPUBULIKA Y'U RWANDA UBUMWE - UMURIMO - GUKUNDA IGIHUGU

Annex 1.

Review of GAPs in capacity

In addition to number of GBON compliant observation stations, the discussions of Gap Analysis included a short review of Quality Management System (QMS) for observation process, the status and capacity gaps in data transfer, database and its management, sensor maintenance and calibration, metadata, and quality control.

QMS

The Meteo Rwanda is certified by ISO9001:2015 until 2025.

Identified gaps

- No sub-process for upper air sounding
- Need for review, and subsequently, potential enhancements for existing surface station sub-process for improvements

Central database

The central database IT hardware is ca. 10 years old. The data base has capacity to store surface observations. However, radar observations are stored in separate hard disks due to the lack of storage space. The current configuration of database requires also upgrading and automating old fashion manual data handling processes. Data management, different monitoring information, improvements in quality control mechanism, capability to communicate with APIs, and flexibility for importing open data are needed. It will be important that data from different sources is stored in one place to simplify the system of data pipeline as a whole. The observational data has back up storage in national data centre.

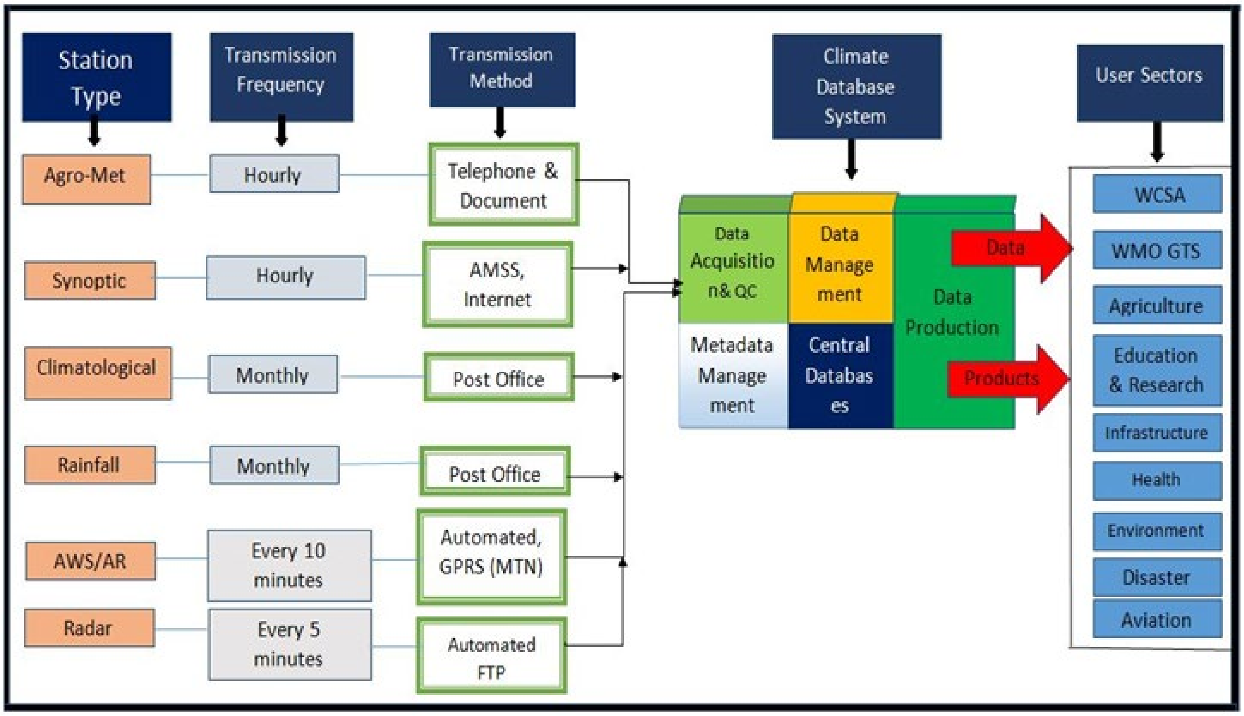

Figure A1. The ideal schematic (not fully operational) diagram of data transfer and database for observational data in Meteo Rwanda.

<u>Identified gaps</u>

- IT support in observation data, transmission, quality control, processing, and archiving. Hardware and robust software for database management.
- Insufficient staff capacity and programming skills
- Benchmarking other organizations

Data transfer

The data reading and transfer processes are largely manual; including synoptic observations (even though stated otherwise in Fig. A1). Especially, Meteo Rwanda has a lack of skills to automate data transfer processes to share data with international data sharing collaborations (GTS etc.).

<u>Identified gaps</u>

- Insufficient staff capacity and programming skills
- Data transfer software
- Benchmarking other organizations
- Lack of training on WIS2.0 which will replace GTS system
- Lack of training on OSCAR surface services
- Lack of clear communication channel with Regional WIGOS center (RWCs) on Incident management system (IMS) when there is an open ticket
- Dependence on regional telecommunication hub (RTH) in data sharing to GTS: data sharing is regularly delayed from RTH.

Metadata

The Meteo Rwanda stores the metadata of observation stations and observations.

Identified gaps

- Lack of enough skills/trainings to operate OSCAR/surface tool for metadata update
- Insufficient skills on new GBON station web tool developed

Data quality control and assurance

Data quality is under the responsibility of Quality Control team. Their aim is to assess data quality by following WMO guidelines. However, the Meteo Rwanda pointed out that there is a strong need to enhance capacity for data quality assurance (QA) and control (QC) throughout the value chain of observation.

Identified gaps

- Insufficient staff capacity
- QC/QA methods and algorithms
- Programming skills
- Benchmarking other organizations

Sensor maintenance and calibration

Meteo Rwanda does not carry out calibration of sensors but it is in a process to pilot the calibration of tilting bucket raingauges and temperature sensors together with Rwanda Standard Board (who is responsible for calibration activities in Rwanda). In order to carry out calibration, sufficient capacity and infrastructure has to be build first. In similar way the Meteo Rwanda staff members lack sufficient knowledge to maintain the observation infrastructure, particularly the Automatic Weather Stations where they are always below 60% efficiency in reporting.

Identified gaps

- Insufficient staff capacity
- Knowledge on sensor maintenance and calibration
- Calibration infrastructure/collaboration with neughboring countries
- Insufficient budget for maintenance (including spare parts)

Data rescue and archival

The recovery of climate records from paper and obsolete electronic media is an ongoing task for Meteo Rwanda.

Identified gaps

- Insufficient funding to carry out this activity
- High number of data available in papers that is not digitized and imaged

- Limited technology to convert data on papers into digital format
- Lack of proper storage facility for data on paper records

Annex 2.

Information about the existing observation stations in Meteo Rwanda. The observational data from third parties are shared with the Meteo Rwanda.

Type of station	**Number of stations**	**Owner of station**	**Measured variables**
Fully automatic surface weather station	42/59 functional*	NHMS	T, H, W, P
Agro-synoptic stations	12/13 functional*	NHMS	T, H, W, P
Climate station	75	NHMS	T, P
Manual rain station	74	NHMS	P
Automatic rain stations	40/97 functional*	NHMS	P
Community stations	16/18 functional	communities	T, P

*Out of 59 full authomatic surface stations only 42 are operationally functional and can provide observations to Meteo Rwanda every 10 minutes time schedule. Out of 97 automatic rain station only 40 are regularly providing data into Meteo Rwanda data server. The poor performance of automatic rain stations is due to aging sensors that need to be upgraded.

Annex 3.

Information about proposed surface stations to be included into SOFF programme.

Station Name	Qualifier	Lon,Lat	Altitude (m)	Installation of manual station	Installation of AWS
RUBENGERA MET	AGROMET	29.41,-2.05	1700	1928	2014
BYUMBA MET	AGROMET	30.05,-1.6	2235	1931	2010
NYAGATARE	AGROMET	30.31,-1.28	1377	1954	2010
KIBUNGO-KAZO	AGROMET	30.5,-2.15	1604	1932	2010
KIGALI AERO	SYNOPTIC	30.138312, -1.965724	1490	1946	2013
BUTARE AERO	SYNOPTIC	29.736497, -2.595532	1760	1967	2010
GISENYI AERO	SYNOPTIC	29.25981, -1.675995	1554	1974	2014
KAMEMBE AERO	SYNOPTIC	28.91,-2.46	1591	1958	2014
RUHENGERI AERO	SYNOPTIC	29.63226, -1.498986	1878	1977	2014

Annex 4.

The Gap analysis was carried out through Teams meetings and exchanging emails. Working group included the following members

- Dr., Mr. Vedaste Iyakaremye, Meteo Rwanda
- Mr. Joseph Hazabintwari, Meteo Rwanda
- Mr. Herve Murenzi, Meteo Rwanda
- Mr. Amos Uwizeye, Meteo Rwanda
- Mr. Didace Musoni, Meteo Rwanda
- Ms. Blandine Mukamana, Meteo Rwanda
- Ms. Anne Hirsikko, FMI

Review and agreeing the content of the Gap analysis in Meteo Rwanda headquarters on 29.6.2023.

- Mr. Bernardin Uzayisaba, UNDP
- Ms. Anne Hirsikko, FMI
- Dr., Mr. Vedaste Iyakaremye, Meteo Rwanda
- Mr. Fidele Kamanzi, Meteo Rwanda
- Mr. Herve Murenzi, Meteo Rwanda
- Mr. Aminadab Tuyisenge, Meteo Rwanda
- Mr. Didace Musoni, Meteo Rwanda
- Mr. Francois Xavier Habineza, Meteo Rwanda
- Mr. Godfrey Habukuri, Meteo Rwanda
- Mr. Aimable Gahigi, Meteo Rwanda