30th June 2025

GBON National Contribution Plan of the Bahamas

Systematic Observations Financing Facility

Weather and climate data for resilience

GBON National Contribution Plan
The Bahamas

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Abbreviations

BDM	The Bahamas Department of Meteorology
CariCOF	Caribbean Climate Outlook Forum
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CHUAS	Cooperative Hurricane Upper Air Station
CIMH	Caribbean Institute for Meteorology and Hydrology
CMO	Caribbean Meteorological Organization
CoCoRaHS	Community Collaborative Rain, Hail and Show Network
DMS	Data management System
FMI	Finnish Meteorological Institute
GBON	Global Basic Observation Network
IDB	Inter-American Development Bank
IE	Implementing Entity
NMHS	National Meteorological and Hydrological Service
NWS	National Weather Service
QC	Quality Control
QMS	Quality Management System
SOP	Standard Operation Procedures
WMO	World Meteorological Organization

Module 1. National Target toward GBON compliance

Table 1 GBON National Contribution Target as per GBON Global Gap Analysis in June 2023

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	3	0	3	-	1	-
Upper-air	1	0	1	-	1	-
Marine	*when applicable					

Table 1 represents the GBON National Contribution Target along with the accepted standard density. If evenly distributed, three GBON surface weather stations would provide sufficient coverage. However, the two GBON stations that are currently operational (at Lynden Pindling International Airport in New Providence and the Grand Bahama Airport in Grand Bahama) are situated 200km apart thus providing adequate coverage for the northern portion of the island chain but exceeding the 500km distance recommendation (the minimum density indicated for SIDS) at national level. The GBON target only allows for one additional surface weather station the station and as per the National Gap Analysis the selected station is in Crooked Island to provide the best coverage for the GBON network. A network with three stations is represented in **Error! Reference source not found.**.

Increasing the GBON network with more surface weather stations in the future is recommended for the BDM to improve the national coverage and to provide redundancy in case of malfunctions or hurricane damages to the site.

The BDM has:

1. Procured several automatic surface weather stations that fulfill the GBON requirements,
2. Produced the concrete soles needed for the stations and
3. Have prepared them for shipping at the central office in Nassau.

SOFF support is required to cover the shipping, installation and site work for one existing AWS station form Nassau to Crooked Island.

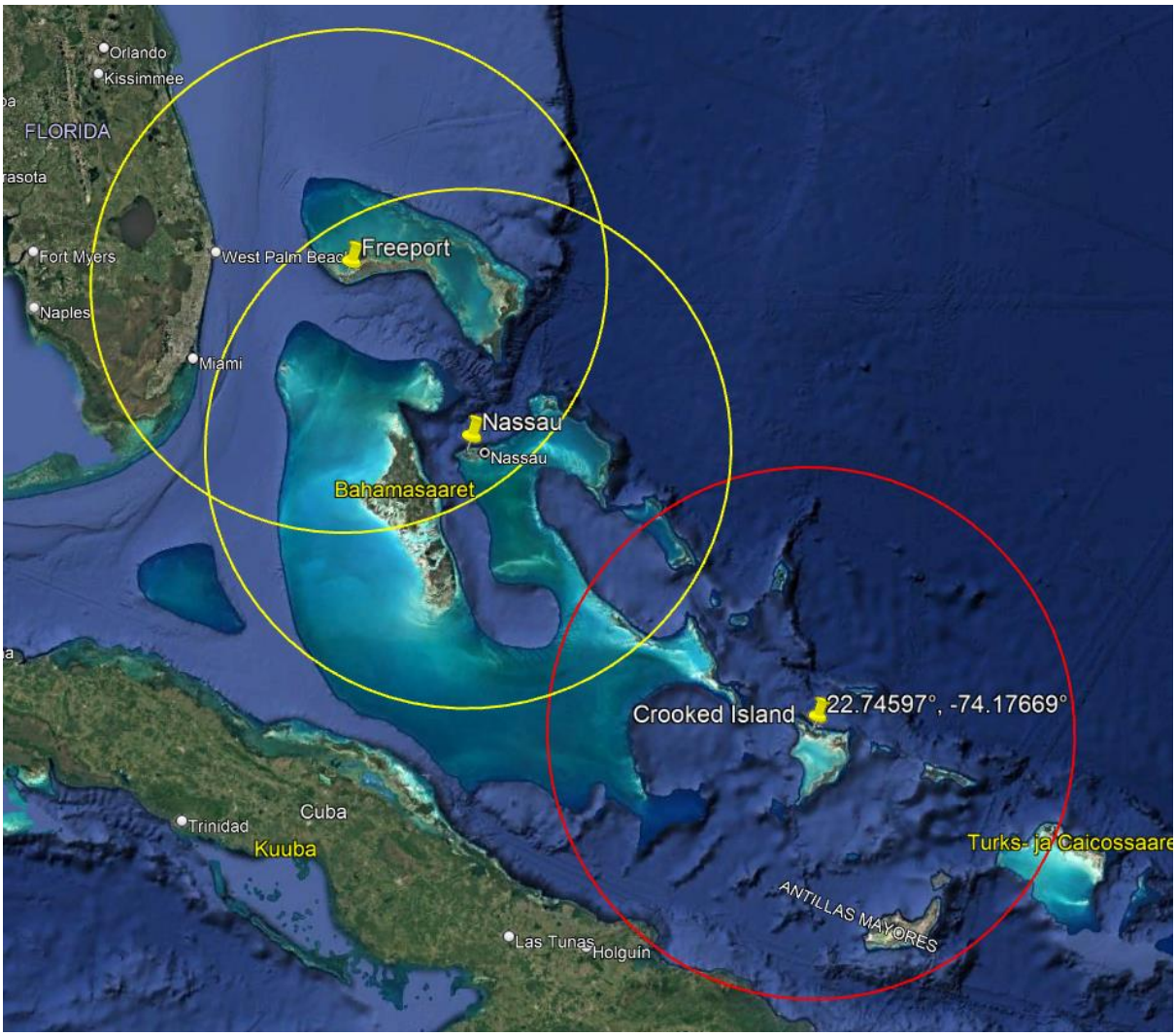

Figure 1 Location of the GBON surface weather station. Circles indicated with 250km radius. Yellow circles for Freeport and Nassau stations that are GBON compliant. Red circle for Crooked Island station that requires SOFF support for functioning.

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

The meteorological network in The Bahamas is basically owned and operated by the BDM. This network includes mostly automatized surface observation network, a weather radar network, and airport weather observation systems. There is also a mix of private observation stations, both marine and weather stations, operated by private companies and homeowners. These stations are not currently part of the national network. The BDM is seeking to collaborate with the private owners to retrieve the data from these stations. Those private stations that meet the requirements for standard exposure and the WMO acceptance of instrumentation will be assigned station identification numbers. **The BDM is recommended to assess the potential partnerships in expanding the network to include privately owned systems.** Additional observations will add value to the BDM's work, but unless the observations are transmitted hourly, the systems are maintained and calibrated according to WMO standards, they will not support the GBON compliance targets.

The BDM has good working experience with private service providers to maintain its observation systems. This was accomplished through extended warranties, service contracts covering annual maintenance and calibrations, and contracts for rapid onsite maintenance and repair work. The support rendered via the aforementioned agreements has been especially beneficial when new technologies were introduced such as: the weather radar network and for remote locations where sending the BDM own staff would cause significant delays in maintenance and repair operations. **It is recommended that the BDM continue to maintain successful partnerships and formalize existing unofficial partnerships, especially those on the remote islands, to support high uptime and quality of GBON-compliant observations.** The outsourced services should be considered in the budget planning.

The upper-air station in the Bahamas is part of the Cooperative Hurricane Upper Air Station (CHUAS) network and is therefore supported by US National Weather Service (NWS) and the National Oceanic and Atmospheric Administration (NOAA). Through CHUAS, NWS provides support that includes consumables, spares, and repairs for the systems, which are carried out based on the estimated annual consumption and budget availability. This support translates into direct support for the implementation of the GBON network. The upper-air station in recent years has not been operational due to severe problems with the hydrogen balloon generator. There have been several attempts to repair the hydrogen generator with the support of NWS. Although some parts of it have been replaced the results have been unsuccessful. NWS has not allocated any near-term budget to replace the generator and unless supporting funding is available it may still take a long period of time before the generator is replaced. The NWS has recommended SOFF to support the key investments for the BDM to reinstate the operation on the upper-air sounding station as the CHUAS budget does not have allocation for the works. **It is recommended that a new hydrogen generator and line-conditioner be purchased for the site. It is also recommended that the existing Memorandum of**

Understanding between the BDM and US NWS as part of the CHUAS initiative be updated to ensure that long-term support is provided sufficiently to maintain the upper-air station as required by GBON standards. Before the generator ceased to function, the BDM did successful soundings twice a day or more during the hurricane season.

The BDM has experience collaborating with civil society which is evident in the collection of rainfall data as part of the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS). This network is a non-profit, community-based network of volunteers working together to measure and map precipitation. The approach is to use low-cost rain gauges and volunteers to fill in the observation network density and engage the public in weather observation. The data from the network is valuable, however it does not support the GBON Target for compliance. There are no plans to increase the observation frequency to an hourly schedule or to have the data transferred automatically.

The national observation network has large gaps in the coverage over the vast marine areas. Most of the Bahamas consists of marine areas with less than 10% of the area covered with land which is spread in the numerous islands and cays. Observing weather in the marine areas is not only imperative for the national transportation, fishing and tourism sector, but also provides valuable information on the approaching regionally important phenomena such as hurricanes. **It is recommended to support the BDM to develop new partnerships with the different marine users and stakeholders for the mutual benefit of marine observations and to support the expansion of the marine observation network with marine stations when SOFF support extends to include marine areas.**

The BDM has recently initiated discussions with the Caribbean Catastrophe Risk Insurance Facility (CCRIF) to receive funding to support the national weather monitoring network. These funds will be targeted at assisting in the installation of the automatic surface weather systems that are in stock and to strengthen the data management system.

2.2. Assessment of potential GBON sub-regional collaboration

Although the BDM is not a member, it actively follows and participates in activities staged by the Caribbean Meteorological Organization (CMO) and the Caribbean Institute of Meteorology and Hydrology (CIMH). These activities are made possible via the WMO Region IV Activities and other Regional Initiatives. CMO is a specialized agency of the Caribbean Community that coordinates the joint scientific and technical activities in weather, climate and water related sciences in sixteen English-speaking Caribbean countries. As agreed in the CMO Resolution 1 -CMC51[1] The Bahamas is responsible for provisional TAFS and Tropical Storm Warnings for the islands and coastal waters of the Turks and Caicos Islands.

CIMH is a training and research organization that assists in improving and developing meteorological and hydrological services and awareness of the benefits of such services for the economic well-being of its member states. CIMH provides training courses, hosts the regional

[1] http://cmo.org.tt/resolutions.html

calibration laboratory, runs a regional numerical model, and hosts the Caribbean Climate Outlook forum.

The BDM has an agreement with the Caribbean Climate Outlook Forum (CariCOF) to provide national observations to the Caribbean Regional Climate Center hosted by Caribbean Institute for Meteorology and Hydrology (CIMH), in exchange, The BDM receives the regional climate outlooks. For the climate outlook, CIMH is centrally collecting observations from a multitude of countries in the region. Most of the observations shared for the climate center are produced by non-GBON stations. Through this collaboration all members can receive observation information as well as the climate outlooks generated.

It is recommended that, when appropriate, regional training activities relating to the installation, operation, and maintenance of GBON stations and network and the implementation of WIS2.0 protocol and WIS2Box be coordinated with CMO, CIMH and the other countries in the region.

The regional capacity to calibrate all required sensors from the GBON station suppliers should be increased. The regional calibration laboratory at CIMH has a very limited capacity to serve the region and The BDM is recommended not to rely solely on their services. The recommended calibration laboratory must be operational and capable of providing high-quality, traceable services for at least temperature, humidity, pressure and precipitation measurements. **Annual sensor calibration provided by the sensor supplier with a service contract is recommended to continue until CIMH can provide these services.** The annual calibration costs, be it via a service contract or the costs of shipping and calibration work, from the regional calibration center, need to be included in the annual budget.

The Bahamas is one of the countries working closely with the US through both the CHUAS program and CoCoRaHS initiative. NWS is directly supporting many of the region's countries in achieving GBON compliance through the CHUAS program.

All-in-all the regional collaboration is very strong, and although the Bahamas is not a direct member in all the regional organizations, the support is highly valued. Collaborations that can directly support the GBON initiative are: improving the regional calibration laboratory capabilities, facilitating region-wide training activities, providing assistance for the wis2.0 support at region level, enhancing observation and the limited area model data sharing through CIMH, continuing the support on national legislative development and facilitating coordination in the region.

2.3. Assessment of a business model to operate and maintain the network

The BDM is currently funded through budget allocation from the government. Two thirds of the annual budget is spent on salaries and allowances. The BDM's budget includes a service agreement with a private service provider to maintain and calibrate recently procured

observation systems. Besides this, there are little funds for system maintenance, spare parts and sensor replacements or any new investments. Development is mainly made through national and international collaboration projects. To ensure the sustainability of observations it is important to systematically justify budget and project funding allocations for maintenance, spare parts and sensor replacements, calibration services and other updates. **The BDM is recommended to develop a lifecycle plan for AWS operation and related IT hardware and to link this to the annual budget planning.** To address the overall financial sustainability, it is recommended to strengthen the BDM national recognition and funding. To provide the needed proof and justification for the government budget allocation, it is recommended that The BDM conduct a Socio-economic Benefit Analysis of its products and services.

In recent years, The BDM had a service agreement with the systems provider for a large modernization project that included the procurement and installation of weather radars, automatic surface observation systems and automatic weather observation systems. The warranty and service contract included the annual maintenance and calibration of the systems. The level of service has been high and response rates fast, overall, the experience of this partnership has been a very good one. Besides this project, the BDM has experience with partnering with private maintenance experts for the maintenance and repair of systems in the remote islands. The projects' deliverables have included maintenance training and refresher opportunities throughout the service contract period. As the service contract comes to an end, the BDM is planning to independently maintain the systems. **It is recommended that The BDM continue GBON station sensor calibration with a service contract.**

In the event such partnerships discontinue, The BDM will need to allocate the resources to form new calibration partnerships or establish calibration facilities and capabilities inhouse (requires a significant initial investment). It will also need to improve the responsiveness of in country travel. Developing the needed capability will require some time and assistance. **Thus, it is recommended to continue with the successful partnerships with the private service providers to ensure calibration of the systems, fast maintenance and repair responses.**

Due to the lack of legislative status, the BDM is currently not allowed to conduct a cost-recovery of the product and services provided. **As a part of the meteorological legislation development, it is recommended to establish cost-recovery mechanisms to ensure financial flexibility for the BDM to independently support its activities.** Cost-recovery is recommended to be targeted on tailored services and products for specific sectors and industries. Public sector forecast and warning services and data sharing should remain free of charge. Based on the BDM service portfolio and initial stakeholder interaction there seem to be very good opportunities for cost-recovery and/or commercial services for the BDM. However, operational activities will require a sustainable budget and thus cannot be fully dependent on cost-recovery.

The existing collaboration and support of the upper-air observations from the CHUAS network will continue to directly support GBON. It is recommended to renew the existing Memorandum

of Understanding with US NWS to ensure that long-term support is provided sufficiently to maintain the station as required by the GBON standards.

As the national surface weather observation networks are fully owned and operated by the BMS and data is shared freely without any cost-recovery or commercial partner involvement, it is recommended for SOFF to fully support the investments needed for the implementation of the surface weather stations (covering the shipping, installation work and needed site work) and the necessary investments for the upper-air sounding station (investment in hydrogen generator and line-conditioner as recommended by NWS) and to support the operation and maintenance of the GBON network.

2.4. Assessment of existing national strategies and projects related to observing networks

The BDM currently has no formal strategy in place, but a draft is being developed as part of the ongoing QMS activities. Regarding the observation networks the strategy will take into consideration the needed SOPs and risks from the quality perspective. **The BDM is recommended to finalize the QMS work and start implementing it.**

In a recent project funded by the Government of the Bahamas, The BDM procured several automatic weather systems for both synoptic and aviation purposes and a network of weather radars. All airport weather observation systems have been installed, but due to unexpected changes in the project implementation not all of the procured AWS systems got installed. As of this, the BDM has several new GBON compliant AWS systems stored in Nassau ready to be installed when funding to cover the costs of shipping and installation is secured. **One of such existing system is recommended to be shipped and installed to Crooked Island as part of the SOFF funding.** For the future strategy for the BDM surface weather network expansion, it is **recommended to secure funds to finalize the installation of the existing stations before procuring any new systems.**

The BDM has also received three new AWS stations from the Enhancing Climate Resilience in CARIFORUM Countries project. Since the data from these systems were not readily decoded for transmission (new type/brand of station), it was agreed to have these stations installed on the main island near to the BDM's headquarters. It must be noted that these stations do not directly contribute to GBON efforts.

The 2024 budget and work plan have funds and time allocated for the repair of the upper-air sounding station building, some work on the hangar has already been completed. An ongoing part of the annual plan is to source funding to cover the shipping and installation costs of the automatic weather stations and to carry out the works when funding is secured.

An ongoing hydrometeorological development project is focusing on the development of a storm surge risk model and sustainable management of coral reefs. This project, however, does not contribute directly to GBON.

A most recent discussion between the BDM and the Caribbean Catastrophe Risk Insurance Facility (CCRIF) has been initiated to receive funding to support the national weather monitoring network. The funds are targeted at the installation of a few of the automatic surface weather systems in stock. This initiative will strengthen the data management system, support the GBON efforts, improve the national coverage and increase the redundancy of the national network. **The BDM is recommended to closely coordinate the efforts of the separate projects and to seek maximum mutual benefit.**

2.5. Review of the national legislation of relevance for GBON

The BDM has developed a national act "The Bahamas Department of Meteorology Bill" that defines the mandate and main tasks of The BDM. The bill was updated in 2019 and is currently at the Attorney General's Office for review. In the unapproved bill there is a defined cost-recovery based on products and services provided by The BDM. After the bill is passed and based on its form, there is a good opportunity to review the strategy and business model of the department. Currently, all budget funding comes from the government and is mainly used for personnel costs and running of the operations. All funding for new investments or new service development comes as project-based funding or through funding from different development and cooperation financing instruments.

It is recommended that the BDM prioritize the approval of the bill to fit the national standards. **Facilitation of a high-level dialogue with the line ministry is recommended as an action point in the implementation phase.**

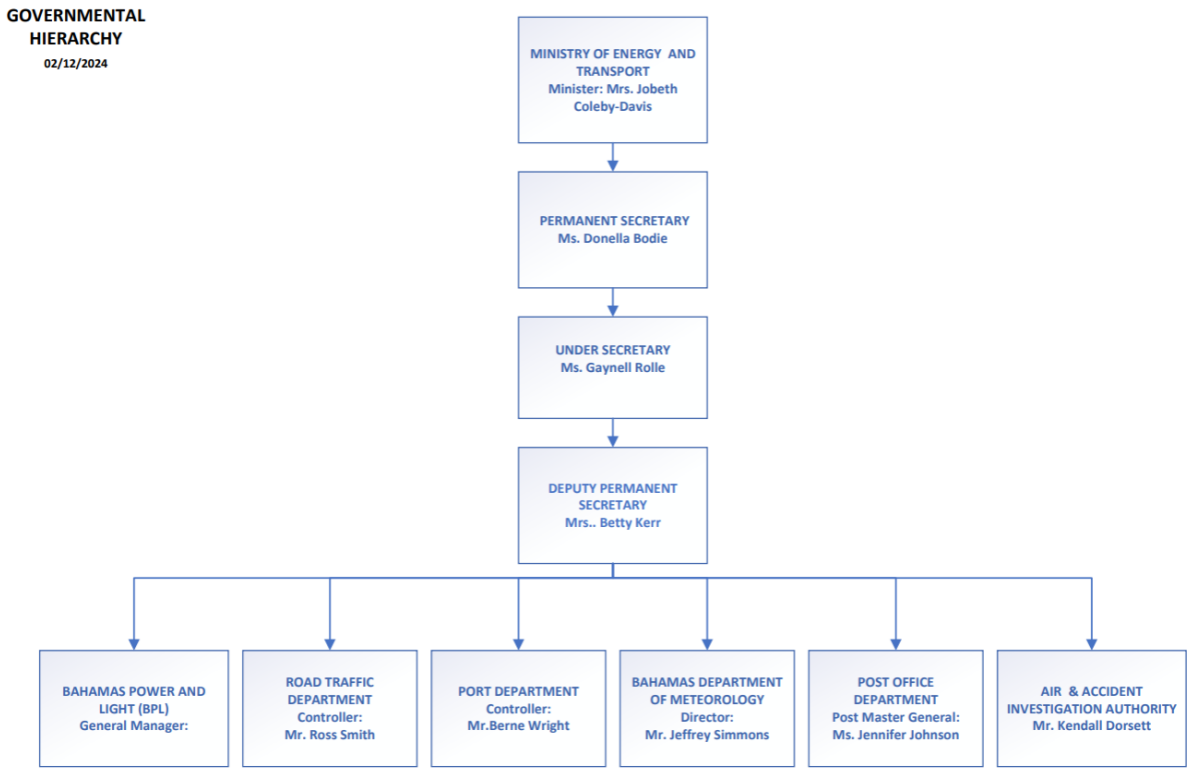

Figure 2 The Governmental hierarchy of the Ministry of Energy and Transport and how the BDM is situated.

Procurement follows the national tendering or preferrable vendor process from which the BDM has plenty of experience. Based on the invoice, the BDM requests a waiver of all customs, duties, and taxes from the Ministry of Finance. The only additional costs the BDM may encounter are modest broker and processing fees for the exemption.

The BDM sees no constraints imposed by the national legislation regarding the GBON.

Module 3. GBON Infrastructure Development

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

The aim of SOFF investment phase project is to maximize the impact of observations on global numerical weather prediction (NWP) skill through:

- Installing or rehabilitating upper-air sounding stations.
  Installing surface weather stations in significantly under-observed regions (far from current reporting stations)
- Foster a sub-regional optimization of the network design.

In the Bahamas the required GBON impacts are addressed with one upper-air station and a total of three surface weather stations. Two surface weather stations are existing and are GBON compliant.

Surface observations
The surface observation network consists of mostly automatic stations and two manual stations (in Freeport and Nassau). The inventory has 15 automatic stations, of which 8 have been installed. All stations in the inventory have the capability to report all GBON required parameters excluding snow-depth which is not applicable in The Bahamas. Besides synoptic stations, the BDM hosts a volunteer-based network of rain gauges and several airport observation stations. Station listings also include some old stations that still report some of the meteorological parameters but are mostly broken or obsolete and in need of full replacement. The BDM plans to reuse the sites for the installation of the new automatic stations. Unfortunately, the airport observation stations (AWOS) cannot be relied on for synoptic purposes as they are unable to function during tropical cycles and hurricanes (masts are unable to withstand winds above 40 knots).

Selecting the sites for the observation stations has been largely driven by the transport sectors, namely the aviation sector's needs and the population distribution in the islands. Hence, denser networks are hosted only on the most populated islands.

The BDM has already procured AWSs but lacks the funds for shipping and installation of the stations at the selected locations.

Existing two GBON stations are already reporting at the required GBON time resolution, but due to issues with the GTS and lack of WIS2.0 interface, data from these stations is not shared reliably.

The remoteness of the Crooked Island site presents some challenges that need to be included in the budgeting of the shipping, installation and site works. The needed investments and activities to the installation for the AWS to the Crooked Island have been estimated by the BDM as:

- Shipping of the equipment and materials 6 000 USD
- Rental of equipment and operator needed for installation 8 000 USD
- Labor and accommodation costs for the installation work 20 000 USD
- VAT 10% 3 400 USD
- Labor and accommodation costs for the BDM electronics 12 600 USD

The site security is assessed as good since the AWS will be located at the Colonel Hill airport. The AWS is solar-powered and not relying on the local power supply.

The site is recommended to have one annual preventive maintenance call (full cost estimated by the BDM to be 5 000 USD annually) and follow the annual calibration cycle. During the maintenance call sensors will be replaced with calibrated ones and the ones from the site send to calibration. The BDM is recommended to continue the calibration service from the sensor provider unless the regional calibration center services can provide a viable option.

Upper-air observations

There is currently one upper-air observation station in the Bahamas located in the Lynden Pindling International Airport on the island of New Providence. This site is part of the CHUAS network supported by the US NWS. It has not been operational in recent years due to problems with the balloon hydrogen generator. The hydrogen generator has been repaired several times with the support of the US Federal Government, several parts replaced with no success. It is recommended that a new hydrogen generator be purchased along with a line-conditioner for the site. NWS has not allocated a budget for this investment, and it is recommended that SOFF cover the costs. NWS will continue the support of the consumables: sondes and balloons necessary for the twice-daily soundings.

Prior to ceasing operation due to the generator malfunction, The BDM engaged in two radiosonde launches per day fulfilling GBON requirements. The frequency of launches may increase during the hurricane season due to specific requests from the US NWS. Launches were and will be performed manually with hydrogen-filled balloons using GRAW GP20 radiosonde. The support provided through CHUAS includes consumables, spares, calibration of the pressure sensor and repairs to the system.

Annual calibration of the upper-air sounding system has been provided by the NWS.

Based on the Gap Analysis, the following investments are recommended to achieve GBON compliancy in The Bahamas:

- Ship and install one AWS station to Crooked Island (existing GBON compliant station from the BDM inventory in Nassau), relevant site works included.
- Refurbish upper-air sounding station in Nassau with key components.
    - New hydrogen generator

        - GBON tender specification 6.2[2] chapter 7 to be followed
    - Line-conditioner.
- IT hardware for data transfer to WIS2.0.
- Corresponding open access software for data management solutions and capacity building.

The operation of the AWSs and upper-air sounding station requires a robust process including preventive and corrective maintenance together with Standard Operation Procedures (SOP). The BDM has a long history of operating weather stations and upper-air soundings as well as maintaining the systems. It is in the process of updating the relevant SOPs as part of the ongoing QMS development. The peer adviser will support in reviewing and benchmarking the procedures for the observation systems during the implementation phase.

The AWS -network maintenance program will be designed by The BDM and the equipment manufacturer. The existing maintenance plan includes annual preventive maintenance visits to the stations and annual calibration of the temperature, humidity, pressure, and precipitation sensors. The selection of the preferred calibration laboratory will be sought during the investment phase (the BDM does not have a calibration laboratory and the regional calibration laboratory operated by CIMH is currently not capable of serving BDM's needs).

The proposed locations of the SOFF target surface weather stations are shown on the map below. Yellow circles indicate the existing GBON stations, the one red circle shows the proposed new station.

[2] GBON tender specification

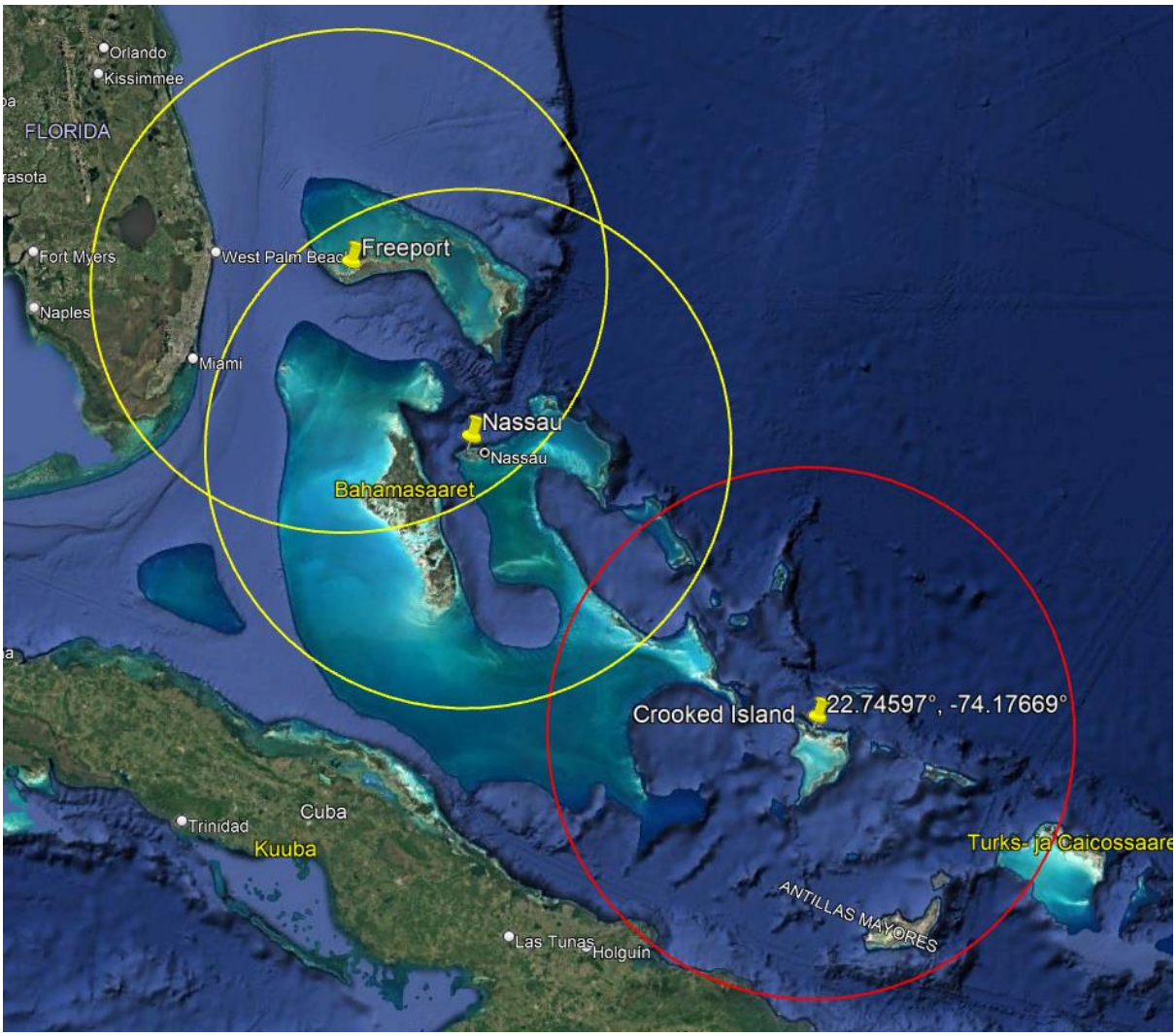

Figure 3 Location of the GBON surface weather station. Circles indicated with 250km radius. Yellow circles for Freeport and Nassau stations that are GBON compliant. Red circle for Crooked Island station that requires SOFF support for functioning.

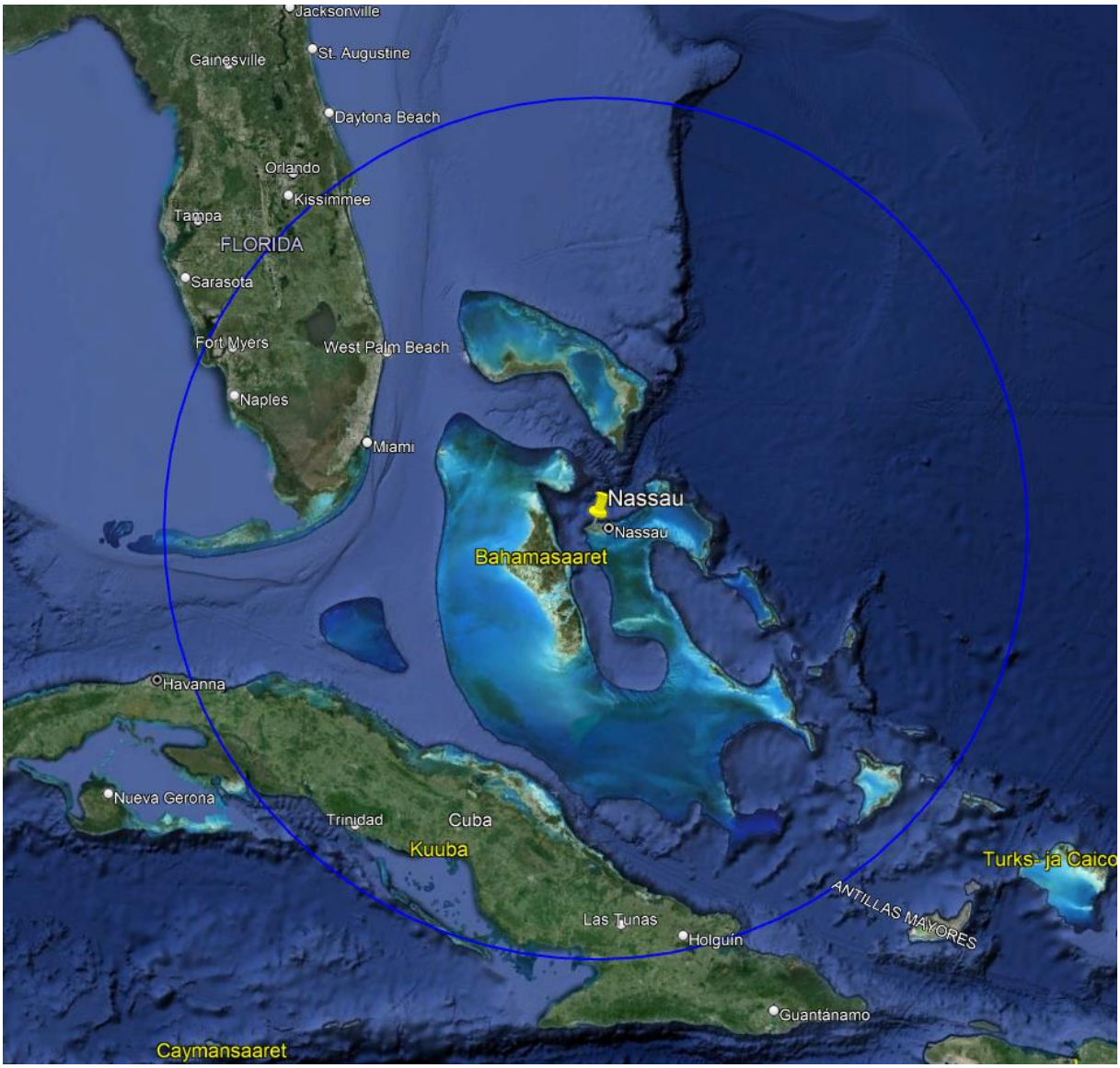

Figure 4 Location of the GBON upper-air station. Circle diameter is 1000 km.

3.2. Design of the ICT infrastructure and services

To support the meteorological observations throughout its value chain, a modern functional Data Management System (DMS) is key. The ICT infrastructure should support automatic data reception, automatic delivery from station to international and stakeholder distribution (supporting WIS2.0 protocol), storage of the data into a database with automatic Quality Control (QC) of observations and data processing. A sufficient staff complement possessing the relevant skillset and IT knowledge relevant to meteorological data is needed to support this infrastructure. 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, as well as web developing.

GBON dataflow is recommended to be done through a database to allow centralized real-time monitoring of the system, real-time quality control and a centralized source of metadata.

Currently The BDM is operating a central database with Climsoft as the front end. AWS dataloggers are transmitting messages via GOES satellite link and The BDM is receiving these through the NOAA Data Collection System (DCS). The downloading of data from DCS to the local database is currently done manually. Also, observation quality control is currently not real-time and done manually during the data download, The BDM is not fully using the WIS2.0 protocol as yet. Data can be shared with WIS2.0 protocol through manual input to a dissemination platform but fully automatic solution has not yet been implemented, nor has the dissemination yet support upper-air sounding messages. Metadata management has not been developed and there is a need to improve the capabilities to use WIGOS and OSCAR portals. The configuration requires a lot of manual labor and is **recommended to be improved to support automatic data downloading, automatic quality control, improved data management including metadata and tools to import and export data using WIS2.0 protocol and APIs and to strengthen related staff capabilities.**

The main improvements needed for the BDM ICT environment to support the GBON data quality and sharing are:

- Improving the data management system. The BDM is recommended to use systems based on open-source technologies and open protocols (e.g. OpenCDMS) to ensure sustainable and redundant operation, maintenance, and development throughout their lifecycles and beyond. OpenCDMS is expected to allow seamless processing of real-time and non-real-time data to WIS2.0 and to systems to be fully available starting from 2025.
- Introducing automatic quality control methods.
- Lack of WIS2.0 capable interface. Support is needed for the WIS2Box implementation. Mandatory requirement of the GBON hourly observation reporting per WMO guidance (no. 306) and GBON practices.

The BDM annual operating budget needs to include the operating costs of the DMS. A valid support contract with the hardware vendor is recommended. The lifespan of such hardware is typically between 5 to 8 years before it needs to be renewed. The SOFF project should include funds for the necessary acquisitions to support full WIS2.0 compliance. Based on budgetary restrictions it is recommended to obtain license-free open software when possible.

Regional coordination and support for the DMS selection is recommended. Supporting the region with e.g. OpenCDMS solution could be facilitated by CMO, CIMH and/or selected countries. The regional approach is expected to improve the sustainability of the solutions and the efficiency of use of the resources.

3.3. Design the data management system

Data Management System (DMS) is a key element in the value chain of observations from the measurement station to the end-user interface. Both technical and budgetary perspectives need to be considered in the selection and specification of the DMS to ensure a long-term sustainable solution. Additionally, a backup solution is required for the essential data.

DMS is recommended to use open-source technologies and open protocols (e.g. open CDMS) to ensure sustainable and redundant operation, maintenance, and development throughout their lifecycles and beyond. DMS can be built cloud-based or premise-based depending on national legislation and regulation, staff capacity as well as the decision of the organization. DMS must meet the following criteria/ specifications:

- The ability to ingest and store multiple types of weather observation data formats. Including, but not limited to the following:
    - surface weather observations
    - upper-air sounding observations
    - aviation weather observations
    - lightning observations

Since weather radar observation data volumes are considerably larger than the other observation sources, it requires much more storage capacity and is beyond the scope of GBON. Data ingestion to the data warehouse (database) should be done using a modular approach so that new data feeds can be added with minimal effort and modification to the already existing components of the database structures.

For smooth data acquisition, database systems must provide relevant APIs for data ingestion. Supported protocols for data transfer must include at least MSQT and SFPT, as defined in GBON specifications. The ability to receive and decode messages from 3rd party data collection systems must be provided. Additionally, a www-based tool for manual observation entry for stations must be provided.

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

The database system should support queries of time series with adequate performance, the system must be able to serve as real-time and long-term (climatological) data storage. Modules to calculate added value parameters and the use of data from the archive should be made possible. These may include aggregate parameters like daily means, minimums, and maximums.

Regional and international observations that the BDM receives via GTS or WIS2.0 for the forecasting process should be stored in the same database following the same data policy. The priority is to organize the data flow from the BDM stations.

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

- WFS
- EDR
- WMS
- Export to SYNOP & BUFR message format and delivery to GTS-network
- WIS2.0 (required for GBON compliance)

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

The delivery of GBON hourly observations should be reported by following WMO guidance (no. 306) and GBON practices.

3.4. Environmental and sustainability considerations

The key success factor of sustainable investment and day-to-day operation of GBON stations relies on highly competent and motivated management and staff in the organization. Generally, environmental and sustainability considerations should be included in any procurement process as part of the specifications.

The sustainability of the systems is improved by budgeting and scheduling preventive maintenance and calibration, including these in the SOPs will lengthen the lifecycle of sensors. The SOPs are currently under review as part of the ongoing QMS work and will address the preventive maintenance tasks. The frequency of the preventive maintenance can be modified based on the scientific experience and statistics gained through calibration. Additionally, holistic network management and planning including the selection of technologies, models, and suppliers will support sustainability as a smaller spare part stock is needed, sensor calibration circulation can be optimized, and all maintenance procedures and tools are well known. Using maintenance service providers from close by the site will not only improve the response time but also decrease the need for travel to the site.

Surface observations: The proposed new GBON stations are recommended to replace existing AWSs, some of the existing civil infrastructures are reusable. All new AWSs that The BDM has purchased are powered with renewable energy from solar panels. The BDM is recommended to continue preventive maintenance and calibration practices. It is recommended that The BDM focus on installing the existing stations from its inventory before procuring any new ones and use the maintenance service providers locally when feasible.

Scheduling preventive maintenance and calibration routines require, as a rule of thumb, about 1.3 times more sensors than there are stations. For example, for 10 stations with humidity sensors, it is recommended to have 13 sensors, of which 3 can be in kept in storage or used when r calibration procedures are conducted.

Upper-air observations: Consideration to the use of biodegradable material for upper-air observations should be made where possible. Generating the hydrogen for the balloons locally instead of importing gas increases the environmental sustainability and independence of the station. Maintenance and repair work to the existing station, including the buildings and related facilities, will enable the station to serve its purpose hence, lengthening the time and decreasing the environmental load.

Module 4. GBON Human Capacity Development Modul

4.1. Assessment of human capacity gaps

The number of permanent staff in The BDM is currently 30 (Figure 5) consisting mainly of meteorological and technical officers, in addition there are staff members attached to the administration section of the department. As indicated in Figure 5 there are several positions that have not been filled. The BDM has recently received approval to hire 15 new technical staff members. The shortage of staff has been a major limiting factor for The BDM and has significantly hindered expansion of new services, internal processes, system development and frequent engagement with key stakeholders. The BDM has identified a potential risk of losing human capacity during the coming years as several of the key senior staff are approaching retirement age. Succession planning and investing in the junior staff capacity building is needed to ensure a smooth transition. Currently, ongoing QMS work assesses the organizational structure and open vacancies.

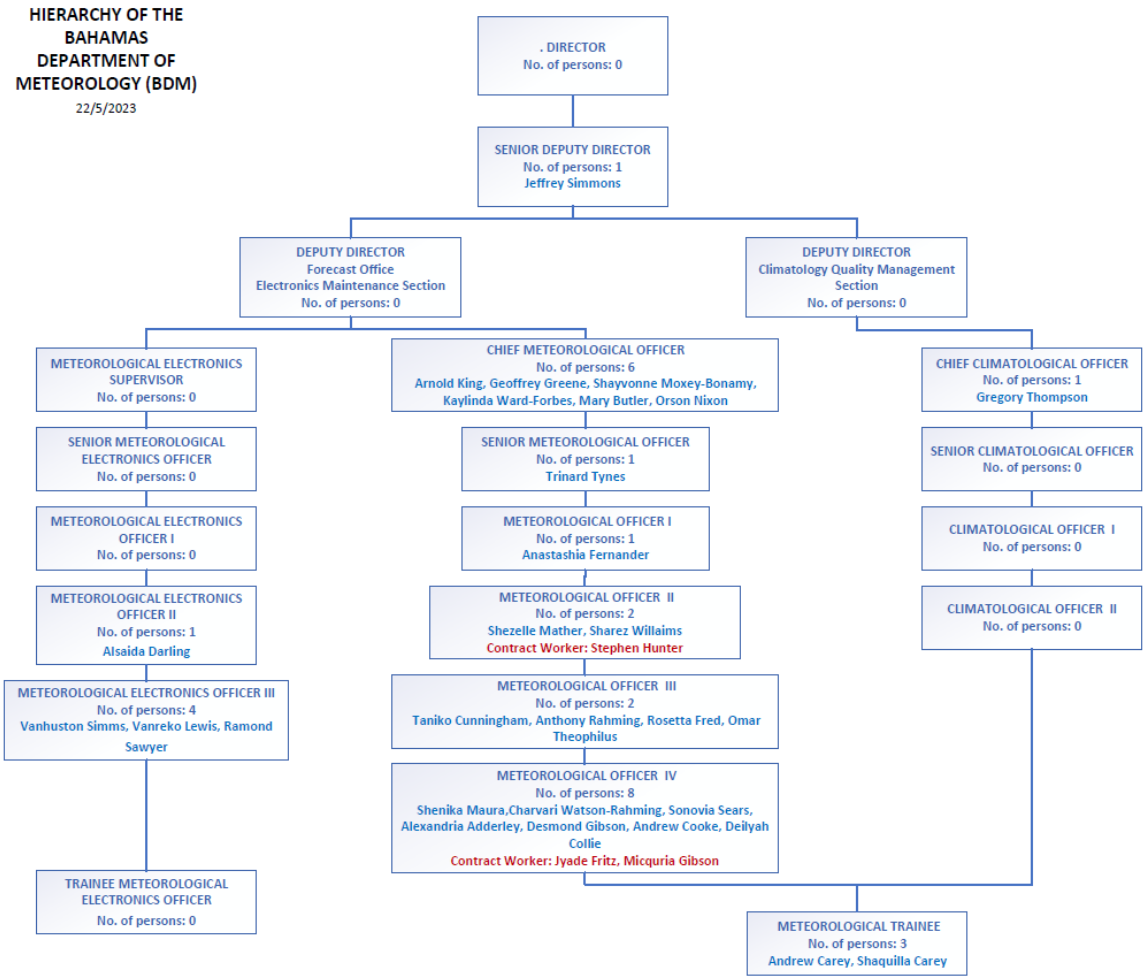

Figure 5 Organizational chart of the BDM's operational staff. All positions have preset education and skill level requirements and a set salary level.

Overall, the staff is well trained, and the majority of the BDM's meteorological staff have completed meteorological and scientific studies/training at the University of West Indies (UWI) and the Caribbean Institute for Meteorology and Hydrology (CIMH). The programs offered at CIMH include four WMO classified levels. The Electronics Officers possess educational background in the engineering field in addition to specific training in meteorological sensor maintenance. These specific courses are typically staged by the system manufacturers.

Based on discussions, the **main training needs are to advance junior-level staff capabilities (certified training courses and support for internal advancement), strengthen technical capabilities with regards to observation station operation and maintenance, and expand staff skills beyond traditional meteorological knowledge with ICT and data management skills, modern programming skills and tools, and expanding the project management skills.**

A Competency Assessment framework [3] is in place for the Aeronautical Meteorological Personnel. Presently, the quality management section is working to expand the competency assessment framework to include other positions. As the work of the QMS is still ongoing, all SOFF-supported training activities should be coordinated and aligned to support the QMS framework.

The estimated additional staff burden is the annual preventive maintenance calls to the Crooked Island AWS station and the initiation of the twice daily sounding operations. The BDM has assessed the operational staff costs for these to be:

- Preventive maintenance 5 000 USD annually
- rotational split shift for upper-air sounding operations twice a day 130 000 USD annually

4.2. Design capacity development activities for technical staff

The recommendations of training activities, within the SOFF framework, to support the achievement of the minimum competence outlined in the WMO Guide no. 1083[4]. The following training needs were identified in the Gap Analysis:

- **Observation process:** Effective development of the observation process including lifecycle planning and support through benchmarking mature sub-processes in other organizations. Supporting actions to the ongoing QMS development.

[3] Competency Assessment for Aeronautical Meteorological Personnel [BAHQMD009]

[4] https://library.wmo.int/records/item/35676-guide-to-the-implementation-of-education-and-training-standards-in-meteorology-and-hydrology-volume-i-meteorology

- **Data archiving:** Support in programming skills for strong and effective data archiving. Additionally, The BDM is recommended to benchmark other organizations with mature data archiving systems and tools to learn best practices.
- **Data transfer**: Support in programming skills for the automatization of data transfer from stations to database, especially to WMO WIS2.0. Complementary training in managing and updating information in OSCAR surface service is much needed by staff members.
- **Data quality control and assurance:** Training in programming and scientific understanding that support the application of the QA/QC methods and algorithms. The relevant staff members need capacity building to manage the scientific background behind different QA/QC methods. It is recommended that the QA/QC methods from other organizations be benchmarked. A roadmap for implementing relevant automatic QA/QC methods must be developed.
- **Instrument, station operation and maintenance at the site**: Once sufficient technical training in the maintenance of the different sensors have been received, the technical staff would benefit from good quality SOPs and the competence requirement criteria. Both the SOPs and the required competence support an increase in self-confidence. Training in the upper-air system operation and lifecycle maintenance is needed since this station has not been operational for some time. It is recommended that this initiative be supported by the US NWS who support the station as part of the CHUAS network.
- **Network monitoring and ICT system operations**: Training for staff members responsible for ICT to enhance their skill capacity (e.g., in programming and technical understanding) will ensure a continuous 24/7 automatic operation of data pipelined from station to international distribution.
- **Calibration and maintenance at workshop:** Training on the concept of quality through calibration and capacity building in scientific understanding and handling calibration results. It is critically important that scientists are capable of analyzing calibration results to support lifecycle and maintenance planning. The BDM is recommended to benchmark other organizations' calibration practices.

It is recommended to develop a **detailed capacity building plan** with the components to monitor and evaluate the training. It is also recommended to utilize **regional collaboration and coordination** for shared GBON specific training programs e.g. in the field of instrument operation, maintenance, and calibration training, and utilizing the standard technical training programs from the regional training center. It is essential to the sustainability of The BDM's capacity building to train all new staff members to the required level.

4.3. Design capacity development activities for senior management

Key trainings for senior management level that were identified in the discussions include:

- **Finance**: to equip the BDM staff with financial and compliance management best practices, advanced financial management and planning techniques. Benchmarking these processes in other organizations.
- **Strategy**: tools and practices for strategic development, follow-up, alignment of project portfolio and financial planning. Benchmarking these processes in other organizations.
- **Project management**: benchmarking of organizations with mature projects, portfolio management and coordination culture. Training on efficient planning, execution overseeing projects for successful completion, covering international development collaboration projects and new business development.
    - Based on lessons learned and new findings, developing actions to support the BDM project organization.

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[5]. 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. Therefore, it is important that in the pre-disaster context, those who likely will be the most affected by the crisis, are also included in the preparedness process[6]. 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 the population is equally engaged in climate change adaptation and resilience building, but there is also substantial evidence that shows that 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 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 in designing hydrometeorological and climate services directly leads to saving lives and livelihoods, as the needs of different groups have been better identified.

The rational for organizations to pursue gender equality in governance, strategy, programs, and making decisions, is highlighted in WMO's recently updated Gender Action Plan[7]. It emphasizes that organizations that respect and value gender equality and diversity attract and retain talented staff, 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.

The Bahamas Government has systematically adopted gender-responsive disaster risk reduction and resilience-building actions. In 2015, the Sendai Framework for Disaster Risk

[5] https://www.undp.org/publications/gender-adaptation-and-disaster-risk-reduction
[6] Disaster Recovery Guidance Series, 2018, Gender Equality and Women's Empowerment in Disaster Recovery
[7] WMO Gender Action Plan

Reduction 2015-2030 was adopted to provide resources and implement gender-sensitive disaster risk reduction policies, plans, and programs to empower women for disaster preparedness and recovery. The National Emergency Management Agency has provided gender sensitivity training for response teams, gender considerations have been included in the post-hurricane assessments. In addition, the Government has implemented gender and family-sensitive shelters for victims of natural disasters.

The current female to male ration in the BDM is 1:1 and it is reflected throughout the hierarchy of the organization.

As an employer, The BDM is governed by the Equal Opportunities Act No. 27 Employment[8] from 2001 that states "No employer or person acting on behalf of an employer shall discriminate against an employee or applicant for employment based on race, creed, sex, marital status, political opinion, age or HIV/Aids". The BDM does not have a gender policy nor measures for gender discrimination. According to discussions with the BDM, new staff members are hired based on their competence, not based on gender.

The BDM is recommended to conduct a gender assessment as part of the human capacity assessment. This could be included as part of a Gender Workshop. Based on the findings of the analysis, it is **recommended that The BDM develops its own institutional Gender Policy**. It is also recommended that the following gender quota as recommended by WMO be implemented:

- Women should represent at least 50 % of all participants in SOFF-related and supported trainings
- Women should represent at least 50 % of all participants in SOFF consultations, planning workshops, etc.
- Women should represent at least 50 % of staff for operating and maintaining GBON stations
- Women should represent at least 50 % of decision-making and project management positions where applicable

The following actions from the WMO Gender Action Plan, 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).

[8] Commonwealth of the Bahamas Act No. 27 of 2001 Employment

- 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).
- 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).
- 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

The engagement of the civil society is an important factor and including 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 program cycle:

- Conduct stakeholder engagement workshops on the implementation of the SOFF project deliverables (observational data exchange to support weather/climate and water services and products), bringing together key stakeholders and CSOs, to involve and collaborate with the BDM and the SOFF project team from the early onset, as well as ensure the stakeholders are consulted on operations and maintenance.
- Organize high level dialogues on benefits, co-production, and ownership of the new national GBON infrastructure.

During SOFF investment it is strongly recommended to promote 50% of women participating in capacity-building activities and consultations with civil society organizations.

Module 5. Risk Management Framework

5.1 Assess the risks of the observing network and propose mitigation measures

WMO recommends that its members establish a Quality Management System (QMS) to ensure that customer and end-user requirements are met (WMO no. 1100[9]). The BDM is currently in the process of QMS ISO9001:2015 certification. In this process risk SOPs and matrixes for observations and ICT operations are developed or updated.

As stated in the SOFF Operations Manual, the risk mitigation procedures of IE will be relied upon in the SOFF implementation during the Investment phase. The operational phase is supported by the risk mitigation procedures of beneficiary.

Main risks are the potential damages hurricane events may cause on the observation systems and infrastructure stopping the operation and data sharing. The risk is well known and the BDM mitigates it by having staff prepared for fast maintenance calls and selecting systems from trusted suppliers that have proven track record to sustain the extreme conditions. Other important risks are not making the annual maintenance calls as the travel costs have not been included in the annual budget and are needed to be specially applied for. SOFF covering part of the annual operating costs will significantly improve the BDM's ability to make the call for the remote GBON station, the two other GBON stations: in Freeport and Nassau, are located close to BDM offices and therefore do not experience the same problem. The third priority risk is the possibility of US NWS to stop or reduce the support for the upper-air CHUAS network. Highlighting the mutual value of the cooperation and upgrading the old MoU between the partners are seen as viable mitigation measures. In case the support would decrease, SOFF funding share for the station would need to be increased to cover the consumables needed.

Potential key risks during SOFF implementation	**Mitigation measures and responsibilities**	**Monitoring and evaluation**	**Risk level** **(low, medium, high)**
Damage from hurricane events to observation systems, buildings, electrical equipment, or communication infrastructure.	Preparedness to deploy staff and spares for fast maintenance. Selection of technology and infrastructure that endures high wind speeds.		Medium
US NWS to stop or reduce supporting	Updating of the MoU between NWS and		Medium

[9] https://library.wmo.int/records/item/50552-guide-to-the-implementation-of-quality-management-systems-for-national-meteorological-and-hydrological-services-and-other-relevant-service-providers

upper-air observations through CHUAS network.	BDM. Highlight the value of the CHUAS initiative.		
Maintenance and repair work is delayed in remote locations causing periods of missing data.	The annual operational budget needs to include travel costs for the maintenance visits or maintenance needs to be outsourced to private service providers near the locations.	Management of BDM is responsible for monitoring and evaluation.	Low
Annual calibration not performed in calibration laboratories; regional calibration center not capable of supporting the services.	Annual calibration costs need to be included in the budget. Strengthening the capabilities of the regional calibration laboratory, establishing relations with other calibration facilities or outsourcing calibration to system provider.	IE will be responsible for following up on strengthening the regional calibration system . The BDM is responsible for monitoring and evaluating annual calibration practices.	Low
Decrease in funding to support operations.	Sufficient lifecycle planning and subsequent annual budget planning combining different funding sources. (SOFF, budget, project, potential cost-recovery)	IE and the management of the BDM are responsible for monitoring and taking required actions.	Medium
Insufficient staff competence and changes in staff capacity	Internal capacity-building plan is developed including the criteria of competence requirements for technical staff. Succession plan and duplication of skilled	Management of The BDM is responsible for monitoring and evaluation.	Low-Medium

	staff members for critical tasks.		
The management of observation and data processes is insufficient.	Frequent follow-up on how strategic goals and annual targets have been achieved.	Management of The BDM is responsible for monitoring that work has been conducted according to QMS.	Low

As the observation sites are located at secure areas with stable power supply and reliable communication, or powered with solar-panels no significant risk considering these aspects has been identified.

Module 6. Transition to SOFF investment phase

The transition to the SOFF investment phase is recommended to be carried out by following the Gap Analysis and National Contribution Plan. It is recommended that upon approval of the Investment Phase Funding Request, a virtual workshop with the peer adviser, IDB and the BDM is arranged to review the outputs of the readiness phase and discuss the transition to the investment phase.

Summary of GBON National Contribution Plan

Components	Recommended activities
Module 2. GBON business model and institutional development	Follow-up on the development of the meteorological bill. Facilitate high-level dialogue to keep the development active and promote cost-recovery mechanisms in the legislative framework.
	Continue collaboration with other governmental organizations and private stakeholders. The BDM has active relations with both, but can improve these by formalizing key partnerships, more active stakeholder engagement and developing a stakeholder engagement plan that also extends to the academic sector.
	Improve regional collaboration with GBON topics including WIS2.0 protocol, maintenance, and calibration services. Establish ways to receive regional information on the surface weather observations and limited area models directly as raw data for input into the local forecasting process.
	The BDM to complete the QMS work and start implementation and follow-up on new strategies, updated SOPs, and risk matrixes.
	Update MoU with NWS to ensure continuous support for the upper-air observation station.
	Ensure strong coordination between different projects to avoid any overlapping and to maintain a sufficient maintenance budget for sustainable operation.
	Justify budget and project funding allocations for maintenance, replacement of sensors and calibration services. Updating of lifecycle plans and SOPs to support it (including plans for the ICT infrastructure). Including costs related to maintenance calls to the annual budget.
Module 3. GBON infrastructure development	Shipping and installation of AWS stations.
	Renewing the hydrogen generator and procuring a line-conditioner for the upper-air sounding station.
	Enhance operation processes and benchmarking equivalent operations in other organizations.
	Implement WIS2.0 compliant data sharing including implementation of data management system.
	Improve data sharing to WIGOS/OSCAR platforms.
Module 4. GBON human capacity development	Training in data transfer, data quality control and assurance, ICT systems and data management.
	Train newly recruited staff.
	Training on the maintenance and calibration practices.
	Training in the use of data-sharing platforms and protocols i.e. WIGOS/OSCAR and WIS2.0
	Conduct a gender analysis and draft a new organizational Gender Policy, with specific actions that are measurable and regularly monitored, based on the WMO Gender Action Plan.
	Project management and product portfolio management training.

Module 5. Risk Management	SOFF Risk Management Framework to be monitored and updated regularly. Any new risks and mitigation measures should be added to the matrix as soon as they are identified.
	Review risk matrix developed as part of the QMS for GBON related parts.
Module 6. Transition to SOFF investment phase	The transition of the SOFF investment phase is recommended to be carried out by following the Gap Analysis and National Contribution Plan documents.

Annexes (if any)

Report completion signatures

Peer Advisor signature

On behalf of Harri Pietarila, Director of expert Services,
Matti Eerikäinen, Head of Group International Projects

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