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GBON National Contribution Plan of Jamaica

Systematic Observations Financing Facility

Weather and climate data for resilience

GBON National Contribution Plan
Jamaica

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Abbreviations

AWS	Automatic Weather Station
CHUAS	Cooperative Hurricane Upper Air Station
CIMH	Caribbean Institute for Meteorology and Hydrology
CMO	Caribbean Meteorological Organization
DMS	Data Management System
GBON	Global Basic Observation Network
FMI	Finnish Meteorological Institute
IDB	Inter-American Development Bank
IE	Implementing Entity
MSJ	Meteorological Service of Jamaica
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
QA/QC	Quality Assurance / Quality Control
QMS	Quality Management System
RCC	Regional Climate Centre
WMO	World Meteorological Organization
WRA	Water Resources Authority

Module 1. National Target toward GBON compliance

Table1. GBON National Contribution Target

Type of station	Baseline (Results of the GBON National Gap Analysis)				GBON National Contribution Target	
	Target (# of stations)[1]	GBON-compliant stations (#)	Gap		To improve	New
			New	To improve		
Surface	2	0	-	2	2	-
Upper-air	1	1	-	-	-	-
Marine	***when applicable**					

The target amount of GBON weather stations for Jamaica is two surface weather stations and one upper-air station based on the WMO criteria for SIDS[1]. Jamaica operates currently two manual surface weather stations that are registered in the GBON WDQMS database fulfilling the GBON spatial resolution and one upper-air station supported by the US National Weather Service Cooperative Hurricane Upper Air Station (CHUAS). GBON required temporal resolution of hourly reported observations is not fulfilled. In order to reach the required resolution SOFF is recommended to support the automatization of the nominated surface weather stations with full replacements.

[1] For SIDS, for the WMO GBON Global Gap Analysis in June 2023, the EEZ area has been added to the total surface area which is the basis for the target number of stations. The standard density requirements for SIDS have been calculated with 500 km for surface stations and 1000 km for upper-air stations.

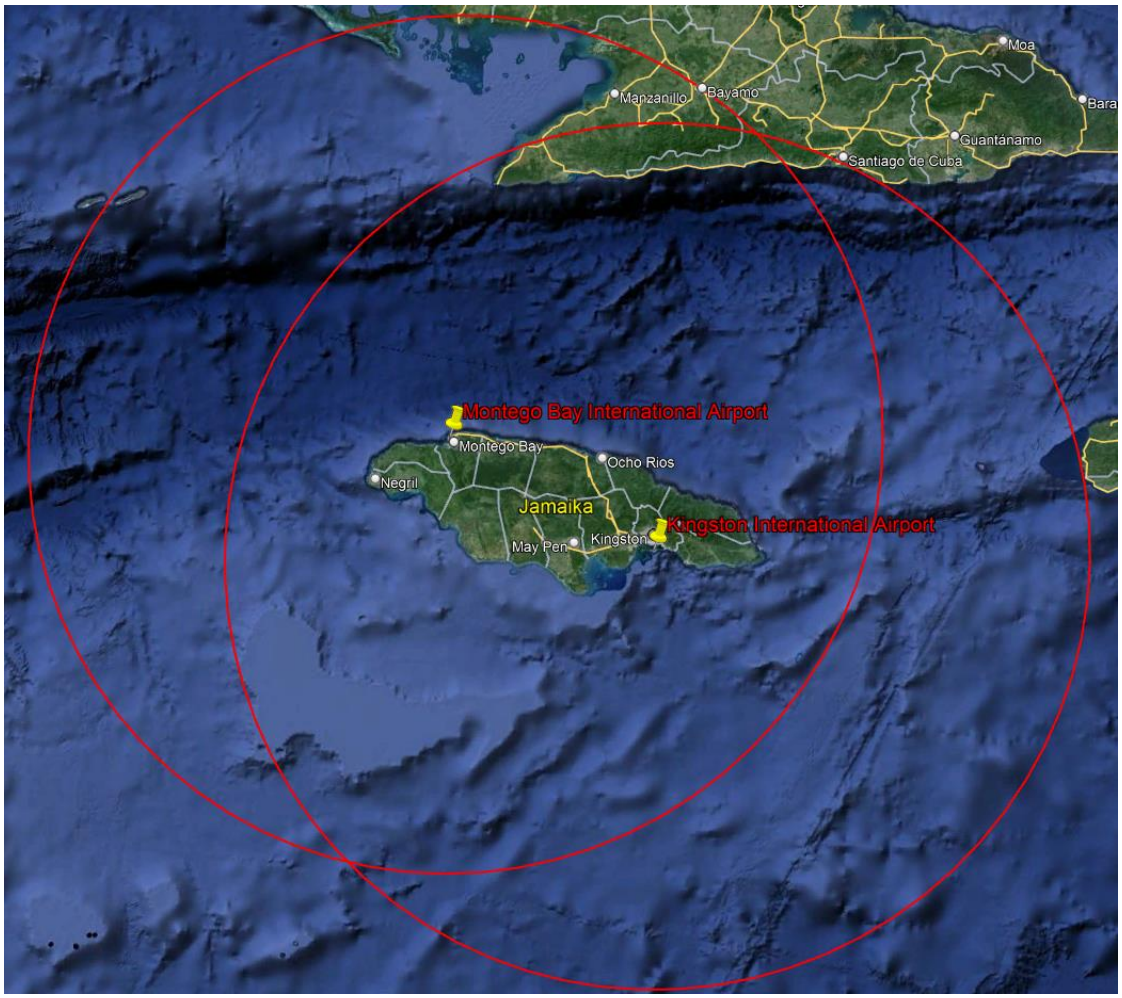

Figure 1 Map of existing GBON nominated surface weather stations in Montego Bay International Airport and Kingston International Airport. Circles indicated with a 500km diameter.

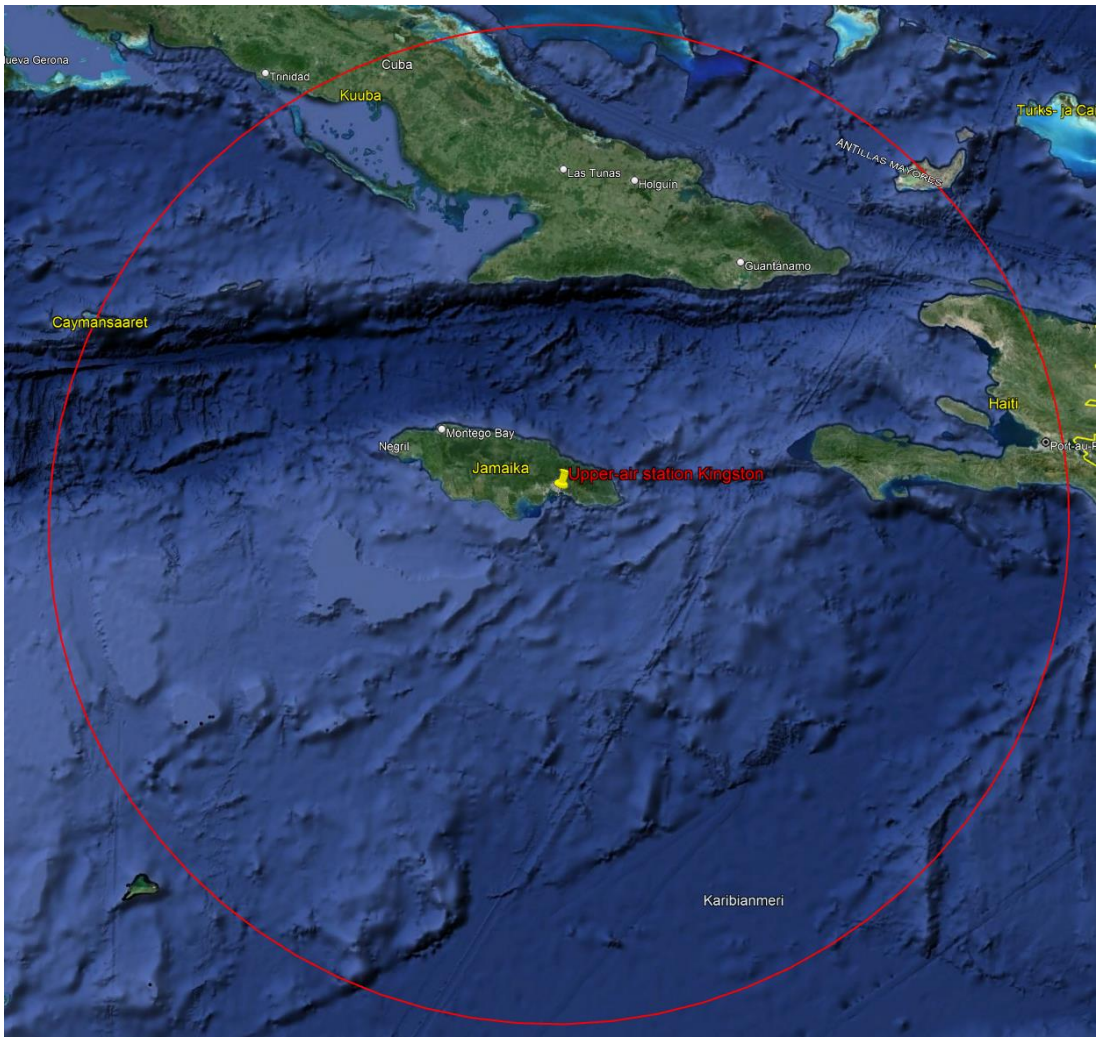

Figure 2 Map of existing upper-air station. Circle indicated with a 1000km diameter.

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 Service of Jamaica (MSJ) is endorsed as the meteorological and climatological service provider for Jamaica, although its mandate has not been formally enforced. MSJ is operating as a branch of the Ministry of Economic Growth and Job Creation and owned and primarily funded by the Jamaican Government. Although MSJ does not own all of the weather observation systems in Jamaica, it is the only entity operating them.

Nationally and regionally MSJ is very well known and connected to all relevant national stakeholders, and they collaborate and share data and services to a wide user group from different governmental organizations to private sector stakeholders. MSJ has formalized some of its key partnerships e.g. with Water Resources Authority (WRA), Maritime Authority and Civil Aviation Authority. MSJ has a strong partnership with WRA that includes free and open precipitation information sharing between the two entities.

Both GBON surface weather stations and the observation and forecasting office in Jamaica are located in or next to the airport area. Due to these circumstances MSJ is working closely with the private airport management operator. This collaboration relates to granting access to the sites, site operation and maintenance work e.g. mowing the lawn, and the site representativeness and surroundings e.g. trimming trees in the vicinity and restricting construction work next to the site. Airport weather observation systems (AWOS) on the international airports are owned by the Civil Aviation Authority and operated by MSJ but they are solely purposed for serving the aviation sector's needs. **MSJ is recommended to strengthen the open communication with the airport management operator and the civil aviation authority on the area plans** to ensure the observations sites remain operational and undisturbed and relieve tension between the entities.

There is a large network of passive rain gauges located in sugar plantations around the country. Not all of the systems are owned by MSJ, but MSJ is the centralized operator to collect and analyze the data from such systems.

The upper-air station in Jamaica is part of the Cooperative Hurricane Upper Air Station (CHUAS) network and therefore supported by the US National Weather Service (NWS) and the National Oceanic and Atmospheric Administration (NOAA). Through the CHUAS, NWS provides support that includes consumables, spares, and repairs for the systems. This support translates into direct support to the implementation of the GBON network. The collaboration has been ongoing successfully for decades. **It is also recommended that the existing Memorandum of Understanding between MSJ and US NWS as part of the CHUAS initiative is updated**

to ensure that long term support is provided sufficiently to maintain the upper-air station as required by GBON standards.

Currently there are large gaps in the weather observation network on the marine areas. These areas have a huge impact to the local weather and climate conditions and the large coastal population and active marine sector would benefit greatly from an improved coverage. MSJ has an existing close partnership with the Maritime Authority, and **it is recommended to further develop the partnership for mutual benefit of marine observations and to support the expansion of the observation network with marine stations when SOFF support extends to include marine areas. It is recommended to support the development of the marine network strategy including assessment of possible technologies.**

2.2. Assessment of potential GBON sub-regional collaboration

As a member of the Caribbean Meteorological Organization (CMO), Jamaica is participating actively in the regional projects and initiatives. Key activities related to the GBON compliancy have been the regional WIS2.0 solution and human capacity building. **It is recommended to expand the regional support also for the drafting of data policies.**

Jamaica is also a member in the Caribbean Institute for Meteorology and Hydrology (CIMH). 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 for observation technicians and meteorological forecasters, runs a regional numerical model as well as hosts the WMO regional calibration center and the Caribbean Regional Climate Center (RCC) and Climate Outlook Forum. MSJ shares the national observation data into the Caribbean RCC that disseminates observations and climate outlooks including drought forecasts for the entire Caribbean region.

CIMH has taken up the role of drafting a network homogenization plan for the surface weather network in the region. In order to provide effective support and services (calibration of the sensors, spare parts, repair and maintenance services and training) for the countries. The plan has not yet been published but has the potential to guide the regional harmonization of the network, although all countries will remain autonomous in selecting the preferred systems.

It is recommended that, when appropriate, regional training activities related 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. Besides directly GBON related activities, regional collaboration in **developing the marine networks, selecting technologies and benchmarking other institutes is recommended**.

To save resources (budget, staff, and time) throughout the region it **is recommended to continue supporting the regional calibration center activities**. Unfortunately, when writing this report, the service capability in CIMH is not up to the required standard to support GBON

observation requirements. Calibration services have been limited to pressure calibration and only to selected brands. **It is recommended to enhance CIMH capability to calibrate temperature and pressure sensors, to look into expanding the brand portfolio to reflect the member countries' networks and to have adequate staffing to provide the services in reasonable time.** Improvements in the regional calibration center will benefit the entire region. In the event that the improvements are not made, MSJ will need to consider forming new partnerships with calibration centers nearby, for example in US or consider investing in a national calibration facility. In this case, the **MSJ will need to include the service contract and related costs to the annual budget.**

NSW is directly supporting many of the region's countries including Jamaica in achieving GBON compliancy through the CHUAS program.

The collaboration that will directly support the GBON initiative is improving the regional calibration capabilities, facilitating region-wide training activities, continuing the regional support for the WIS2.0 protocol between the institutes, enhancing observation and 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

MSJ business model is fully publicly owned. MSJ owns and operates the related systems and infrastructure and receives the budget for this from the Government of Jamaica. The annual budget in 2024/2025 was 322,436 million Jamaican Dollars and 80% was allocated to staff costs. The annual budget has been quite stable with slow increases to cover the inflation. Besides annual budget allocations, MSJ can utilize project-based funding. Project-based funding is the main source for any new investments as the annual budget is mostly consumed by the operating costs. E.g. the annual budget has covered the maintenance personnel costs and the operating costs such as power and telecommunications, but procuring new replacement sensors or spare parts have mostly been invested from project-based funding. Currently there is no income from commercial services. **The SOFF is recommended to fully finance the upgrade of the two required GBON surface weather stations and to support the sustainable operation of these.**

To ensure sustainable operation of the observation systems it is important to systematically justify budget and project funding allocations for maintenance, spare parts and sensor replacement, calibration services and other updates. To support this, **MSJ is recommended to develop a lifecycle plan for AWS operations and related IT hardware and to link this to the annual budget planning.** To address the overall financial sustainability, **it is recommended to strengthen MSJ's funding and as part of the meteorological legislation development allow for cost-recovery mechanisms for customer or segment specific tailored services**. Public services and international data sharing is recommended to remain as cost-free and cost-recovery applied only to additional value-added services. A business plan

with the objective of improving MSJ's funding and introducing cost-recovery mechanisms was drafted for MSJ in 2018. A socio-economic benefits analysis is recommended to be conducted to provide proof and justification for the increased budget.

The existing collaboration and support in the upper-air observations from the CHUAS network will continue to directly support GBON targets. 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 stations as required by GBON standards.

Overall MSJ has good capacity to operate and maintain the GBON systems and has not been collaborating with private operators for the tasks.

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

MSJ has opted to use a mixed approach for the national surface weather station network where each parish should have at least one WMO standard fulfilling real-time transmitting weather station which is complemented by a denser network of stations with non WMO standard setting or real-time transmission. Jamaica also has a dense network of manual rain gauges located at sugar plantations and on other private properties, some of the stations have been replaced by non-WMO standard small complementary automatic station by MSJ. The observations from the rain gauge and small AWS network are provided free-of-charge to MSJ network to improve the local weather forecasts and services. MSJ can access independently the data from these small AWSs by utilizing the system supplier's portal. The collaboration with the landowners is built on mutual trust. MSJ maintenance team have some resources and spare parts to maintain and repair the network, but as it is seen as complementary, the main focus and budget is not directed there. This approach has been estimated to provide a cost-effective solution to serve meteorological forecasting and agricultural needs.

During recent years MSJ has worked within a World Bank project to receive a weather radar and automatic weather stations (AWS), and the Caribbean Community Climate Change Centre project to receive a couple of AWSs. Currently there are no ongoing development projects that are related to GBON. The selected GBON stations and a constant operation of them are of key importance for MSJ as they are located next to the largest hubs and the international airports. Future plans for the network expansion is targeted towards the parishes that still lack any WMO standard fulfilling automatic weather stations.

2.5. Review of the national legislation of relevance for GBON

No national legislation that describes MSJ's legal mandate or scope is in place. MSJ is a branch of the Ministry of Economic Growth and Job Creation and endorsed as the national meteorological authority for forecasts and warnings and responsible for the observation

network in Jamaica. A draft for the meteorological bill and regulatory policy for Jamaica has been drafted in 2021 but since the draft is not fully compliant with the national legislative standards, it will require further adjustment before submittal for the Ministry's approval.

The Jamaica Disaster Risk Management Act incorporates some elements for meteorology, but it does not specifically mention MSJ. MSJ's staff is governed by the Civil Service Act's Staff Orders for the Public Service.

To increase the financial sustainability of MSJ's operations it is recommended to consider including the cost-recovery possibilities in the meteorological legislation.

Procurement follows the national tendering process. MSJ utilizes a custom broker (Porter Brothers Ltd) and can receive an exemption for the meteorological system customs when requesting a wavier in advance.

Module 3. GBON Infrastructure Development

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

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

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

According to WMO-set GBON criteria, two surface weather stations and one sounding station is adequate to cover Jamaica. MSJ has registered the needed stations to WDQMS database. Both surface weather stations are manual and have difficulties in reporting in the required hourly time. The sounding system is fully compliant.

Based on the Gap Analysis findings, the following investments are recommended to be made to achieve full GBON compliancy in Jamaica:

- Renewal of both GBON nominated weather stations to AWSs with
    - Temperature sensor
    - Humidity sensor
    - Atmospheric pressure sensor
    - Rain sensor
    - Wind Direction and Speed sensors
    - Data logger including solar panel
    - Two spare sensors for temperature, humidity, atmospheric pressure and wind to be delivered one year after the initial delivery of AWS for a healthy maintenance and calibration cycle
    - Wind mast
- Maintenance toolkit and field calibration kit
- IT hardware for data transfer to WIS2.0. Corresponding open access software and capacity building.
- Marine surface observation stations as soon as SOFF will include the support for such capabilities.

The surface weather stations to be updated are Kingston Norman Manley and Montego Bay Sangster. Both stations are fenced and located in or next to the airport area. Safety of the sites is considered good and the sites receive excellent power supply and communications network from the Airports.

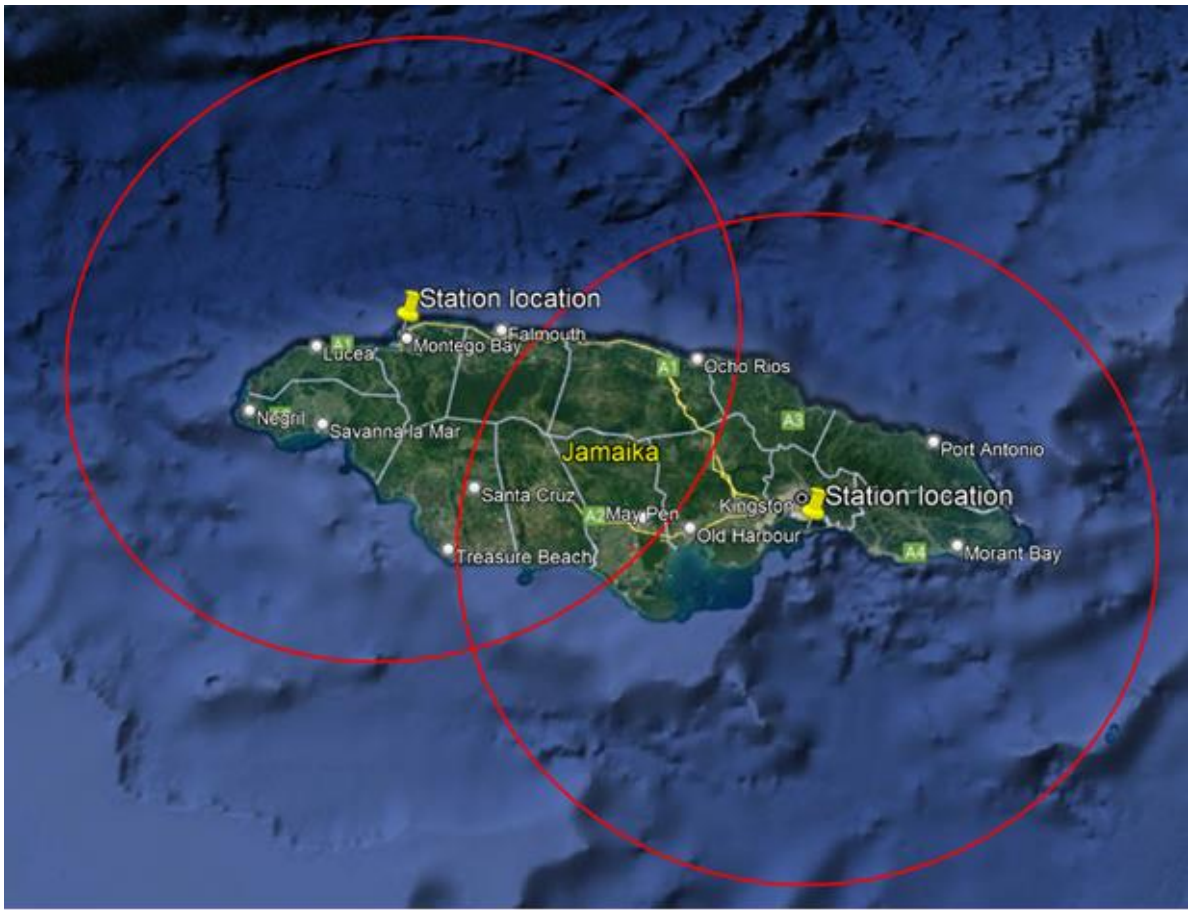

Figure 3 Locations (Kingston International Airport and Montego Bay International Airport) of the existing GBON stations that are recommended to be updated into automatic ones. Indicated circles have a 100km radius.

Both GBON stations are currently operated manually and have Stevenson screens containing thermometers (ordinary, maximum/minimum), anemometers (2m height), evaporation pans, rain gauges and sunshine recorders.

MSJ has a long history of successfully operating weather stations and upper-air soundings as well as maintaining the systems. It is recommended to review and update relevant SOPs as part of the implementation phase. The peer advisor will provide support in reviewing and benchmarking the procedures for the observation systems during the implementation phase.

An AWS network maintenance program will be designed together with MSJ and the selected equipment manufacturer. Initial maintenance plan includes annual preventive maintenance visits to the stations and annual calibration of at least temperature, humidity, pressure and precipitation sensors. The selection of the preferred calibration laboratory will be sought during the investment phase. (MSJ does not operate a calibration laboratory and the regional calibration laboratory operated by CIMH is currently not capable of serving GBON needs.)

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. Enough staff with the relevant skillset and IT knowledge relevant to meteorological data are needed to support the 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 pass through a database to allow centralized real-time monitoring of the system, real-time quality control and centralized source of metadata.

Currently MSJ is operating a simple internal database which is in need of upgrading to support real-time data input from automatic weather stations and other data sources. Data quality control is done mostly manually and only periodically. Besides the internal database, MSJ uses a separate manufacturer-specific database for most of the non-GBON compliant weather stations. This database access requires a subscription service and has limitations on the data download speeds. Neither of the current solutions are capable of supporting the real-time data management and quality control needed to achieve GBON compliancy efficiently.

Data reading and transfer processes are currently done mostly manually. This includes the data retrieval from synoptic stations (less than half of AWSs transmit data in real-time) and data uploading to archiving and dissemination. The upper air sounding information, which is currently transmitted as GBON requires, is done via NOAA.

The configuration requires a lot of manual labour 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.**

Main improvements needed for MSJ ICT environment to support the GBON data quality and dissemination are:

- Improving data management system. MSJ 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 the lifecycle and beyond. OpenCDMS is expected to allow seamless processing of real-time and non-real time data to WIS20 and the system to be fully available starting from 2025.
- Introducing automatic quality control and quality assurance methods and algorithms.
- Human capacity building on IT and programming skills.

The annual operating budget of the MSJ 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 acquisition to support full WIS2.0 compliancy. Based on budgetary restrictions it is recommended to prefer license free open software when possible.

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

3.3. Design the data management system

Data Management System (DMS) is a key element in the value chain of observation from measurement station to 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 on premises-based depending on national legislation and regulation, staff capacity as well as a decision of the organization. DMS must meet the following criteria/specification:

- Ability to ingest and store multiple different 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 made with a modular approach so that new data feeds may be added with minimal effort and modification to the already existing components and database structures.

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 made so that it is capable of producing quality control

regardless of the underlying database system. Additionally, the QC module must be able to perform real-time QC and should enable non-rea-time manual QC.

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

Regional and international observations that are received via GTS or WIS2.0 for the forecasting process should be stored to the same database following same data policy. The priority is to sort out dataflow from MSJ stations.

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

- WFS
- EDR
- WMS
- Export to SYNOP & BUFR message format and delivery to GTS-network
- 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. Sustainability of the systems is improved by budgeting and scheduling preventive maintenance and calibration and including these in the SOPs, thus lengthening the lifecycle of sensors.

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 the 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.

Proposed new AWS stations are recommended to replace existing stations with some of the existing civil infrastructure that is reusable for the site. Selected powering for the new stations

is solar panels. Annual preventive maintenance and calibrations will be scheduled and will require, as a rule of thumb about 1.3 times more sensors that there are station.

When possible, it is recommended to select stations that are compatible with the existing station network. This allows efficient maintenance and instrumentation management where spare sensors support the entire station network.

Module 4. GBON Human Capacity Development Module

4.1. Assessment of human capacity gaps

The number of permanent staff in MSJ is currently 69. All posts have preset classifications including pay classification that are stipulated in the Civil Service Establishment Act. Most of the staff are meteorologist and technicians. Staff numbers are relatively low and cases such as sick leave cause difficulties to find resources to stand in for the duties.

The maintenance unit is short of staff and will need several new requirements in the coming years. **One additional staff member has been proposed in the Gap Analysis to be recruited to support the upper-air soundings operation and maintenance and one to support the AWS maintenance team to alleviate the shortage.** SOFF is recommended to support 75% of the annual costs for the GBON maintenance and operational staff and MSJ will include the rest to the annual budget.

Table 1 Amount of staff per post

Post	Amount
Principal Director	1
Meteorologist 4	2
Meteorologist 3	3
Meteorologist 2	3
Meteorologist 1	4
Meteorological Systems Specialist	1
Meteorological Instruments & Equipment Specialist	1
Manager Support Services	1
Senior Meteorological Technician	10
Meteorological Technician 2	11
Meteorological Technician 1	18
Executive Secretary 1	1
Accounting Technician 2	1
Accounting Technician 1	1
Accounting Clerk 2	2
Secretary 2	1
Secretary 1	1
Telephone Operator/Receptionist	1
Driver 2	2
Attendant	2
Caretaker/Watchman	1
Messenger	1
Total:	**69**

The education and training level of the MSJ staff is overall very good. Most meteorologists have been studying in the University of West Indies' and Caribbean Institute for Meteorology and Hydrology's (CIMH) joint meteorological programmes. MSJ is a member of CIMH and can utilize the offered specific training courses and request additional assistance in training in topics such as observation system maintenance. MSJ staff also participates in other training opportunities such as training at the NWS tropical desk in US. Technical staff have attended

meteorology specific sensor maintenance and operation training courses for the different acquired technologies and systems, typically offered by the systems manufacturers.

MSJ utilizes the centralized human resource and procurement functions from the Ministry. This includes the Ministry's training policy and therefore MSJ does not have a separate one. MSJ proposes annual training plans for the Ministry.

The main shortcomings in staff capacity are **limited number of staff with adequate data management, processing and programming skills, need to increase the numbers in the maintenance unit and their technical capacity, little experience of QA/QC methods and limited QMS knowledge.**

4.2. Design capacity development activities for technical staff

The recommendations on training activities within SOFF framework to support work towards gaining minimum competence relative to WMO guiding no 1083[2]. The following training needs were identified in the Gap Analysis:

- **Quality management system (QMS)**: An effective and continuously developing QMS is the basis for the systematic operation and maintenance of observation networks. An effective development of observation process including lifecycle planning, will require support though benchmarking mature sub-processes for upper-air sounding and surface weather stations in other organizations. MSJ is recommended to develop the GBON related sub-processes in QMS. MSJ has been implementing QMS to aviation services and plans to expand this to cover also other provided services.
- **Observation process:** Effective development of observation process including lifecycle planning and support through benchmarking mature sub-processes in other organizations. Updating of SOPs related to the GBON system.
- **Data archiving:** Support in programming skills for strong and effective data archiving and benchmarking of other organizations with mature data archiving systems and tools to learn best practices.
- **Data transfer:** Support in programming skills on the automatization of data transfer.
- **Data quality control and assurance:** Training in programming skills and scientific understanding that support the applying of QA/QC methods and algorithms. The relevant staff members need capacity building to manage the scientific background knowledge behind the different QA/QC methods. Recommended to benchmark other organizations QA/QC methods. A roadmap for implementing relevant automatic QA/QC methods must be developed.
- **Instrument and station operation and maintenance at site:** Once sufficient technical training for maintaining different sensor types has been received, the technical staff would benefit from good quality SOPs and set competence requirement criteria. In the

[2] https://etrp.wmo.int/pluginfile.php/17116/mod_resource/content/1/WMO%20N%C2%B01083%20-%202015%20Edition.pdf

Gap Analysis it is recommended to hire one additional technical staff member to participate in operating and maintaining the upper-air soundings at the required level. New technical staff need to be trained to operate the system, this is recommended to be provided 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 on their capacity (e.g. programming skills and technical understanding) to ensure the 24/7 automatic operation of data pipeline 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 scientist is capable of analyzing calibration results to support sustainable lifecycle and maintenance planning. Benchmarking other organizations with mature calibration practices is recommended.
- **Marine observations:** Support in assessing the need to expand network to marine areas and potential technologies for observing. Recommended to benchmark other organizations.

It is recommended to develop a **detailed capacity building plan** with components to monitor and evaluate the trainings. It is also recommended to utilize **regional collaboration and coordination** for shared GBON specific training programs e.g. in instrument operation, maintenance and calibration training and utilize the standard technical training programs from the regional training center. All new staff should be trained to the required competency level.

4.3. Design capacity development activities for senior management

Key trainings for senior management level include:

- **Finance:** best practices on finance and compliance management and advanced financial management and planning techniques. Benchmarking processes in other organizations.
- **Strategy:** tools and practices for strategy development and follow-up and aligning project portfolio and financial planning with strategy. Benchmarking processes in other mature organizations.
- **Project management:** benchmarking of organizations with mature project and portfolio management and coordination culture. Training on efficient planning, executing and overseeing of projects for successful completion, covering international development collaboration projects and new business development.

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[3]. This is due to socioeconomic circumstances, cultural beliefs

[3] https://www.undp.org/publications/gender-adaptation-and-disaster-risk-reduction

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 crisis, are also included in the preparedness process[4]. This includes having equal access on political, social, and economic levels as well as being able to participate in decision making. Not only is it fair, that population is equally engaged in climate change adaptation and resilience building, but there is also substantial evidence that shows 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 rationale for organizations to pursue gender equality in governance, strategy, programs, and decision making, is highlighted in WMO's recently updated Gender Action Plan[5]. It emphasizes that organizations that respect and value gender equality and diversity attract and retain talented staff and improve overall organizational performance, have more satisfied employees, are more innovative and have better governance. Teams that have gender diversity have better decision-making processes and attract more external partnerships, as well as have better access to local communities. Encouraging women to take up leadership positions has also shown to lead to important achievements in the field of climate change adaptation and disaster preparedness.

According to Jamaica Gender Assessment[6] there has been significant progress in gender equality and women's empowerment but unequal access to economic opportunities is still a real obstacle. Jamaica has a National Policy for Gender Equality developed by the Bureau of Women's Affairs and the Gender Advisory Committee and National Strategic Action Plans developed based on the policy. In the Vision 2030 Jamaica the SGD5 Gender Equality has been assessed and discussed.

The current male to female ratio in MSJ is 38 to 22 (for the total of 60 staff that includes meteorologist and technical personnel). The male to female ratio in the management group is 2 to 2.

MSJ 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 MSJ develops their own institutional Gender Policy**. It is also recommended that the following gender quota as recommended by WMO is implemented at MSJ:

- 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,

[4] Disaster Recovery Guidance Series, 2018, Gender Equality and Women's Empowerment in Disaster Recovery
[5] WMO Gender Action Plan
[6]https://documents1.worldbank.org/curated/en/099154502222328619/pdf/P175282042506702e0a7d100b3087a5be64.pdf?_gl=1*c24p0x*_gcl_au*MTkyOTY4OTc2NS4xNzIxMjk5NDYx

- 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).
- 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 MSJ 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 in 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 its members to establish a Quality Management System (QMS) to ensure that customer and end user requirements are met (WMO no. 1100[7]). MSJ has been operating QMS for the aviation service, but the system has not been reinforced lately. MSJ is planning to expand QMS to cover also its other services and will require technical assistance to follow through with the plans.

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

Potential key risks during SOFF implementation	Mitigation measures and responsibilities	Monitoring and evaluation
US NWS to stop supporting upper-air observations through CHUAS network.	Updating of the MoU between NWS and MSJ. Highlight the value of the CHUAS initiative.	
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.	
Insufficient number of staff to operate the sounding systems twice daily.	Hiring and training one additional technical staff member.	MSJ responsible to monitor necessary human resources.
Insufficient technical specification of items and other quality criteria in tender process. Price should not be only criteria for choosing a vendor. Compatibility with existing infrastructure needs to be considered.	Seamless collaboration between IE (responsible for tender process), peer adviser (responsible for technical sensor specification), beneficiary (responsible for supporting in setting up quality requirements and technical specifications to best support the needs in the country)	IE (on request with support from beneficiary and peer adviser) will be responsible for monitoring and evaluating the quality of documents before opening the tender process.
Incompatible or suboptimal equipment chosen in bidding process.	Seamless collaboration between IE (responsible for tender process), peer adviser	IE (on request with support from beneficiary and peer

[7] 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

	(responsible for technical sensor specification), beneficiary (responsible for supporting in setting up quality requirements and technical specifications to best support the needs in the country). In addition of technical feasibility, also compatibility and synergies with existing infrastructure needs to be considered.	adviser) will be responsible for monitoring and evaluating the quality of documents before opening the tender process.
Failure in tax exemption when importing the goods.	Before shipment IE will be responsible to ensure that shipper and freight agent are aware of the tax exemption process. Beneficiary is responsible for providing all required documentation, information, and support for the tax exemption declaration process.	IE will be responsible for following up the shipment process until it has been tax exempted in the customs.
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 the regional calibration strengthening. MSJ is responsible for monitoring and evaluation of annual calibration practices.
Decrease in funding support for operations.	Sufficient lifecycle planning and subsequent annual budget planning combining different funding sources. (SOFF, budget, project, potential cost-recovery)	IE and the management of MSJ are responsible for monitoring and taking required actions.
Insufficient staff competence and changes in staff members	Internal capacity building plan is developed including the criteria of competence requirements for technical staff. Succession plan and duplication of skilled staff members for critical tasks.	Management of MSJ are responsible for monitoring and evaluation.

The management of observation and data processes is insufficient.	Frequent follow up on how strategic goals and annual targets have been achieved.	Management of MSJ is responsible for reviewing and monitoring that work has been conducted as expected.

Both GBON sites are considered as safe and are located inside or next to the airport area. The sites are fenced and have excellent power supply and network communication hosted by the airports.

Module 6. Transition to SOFF investment phase

The transition to SOFF investment phase is recommended to be carried out by following the Gap Analysis and National Contribution Plan. It is recommended that, on approval of the Investment Phase Funding Request, a virtual workshop with the peer adviser, IDB and the MSJ 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	Continue the development of the meteorological bill. Facilitate high-level dialogue to keep the development active and promote including cost-recovery mechanisms in the legislative framework.
	Continue close collaboration with key stakeholders.
	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 to the local forecasting process.
	Update GBON relevant SOPs. lifecycle plan and risk matrixes for GBON relevant observations and relating ICT infrastructure and training on QMS to support the plans on expanding QMS services.
	Update MoU with NWS on the continuous support for the upper-air observation station.
	Ensure strong coordination between different projects to avoid any overlap and to ensure sufficient maintenance budget for sustainable operation.
	Justify budget for maintenance, replacing of sensors and calibration services.
Module 3. GBON infrastructure development	Two new AWS with GBON relevant sensors and adequate amount of sensor replacements for a healthy calibration and maintenance cycle.
	Enhance operation processes and benchmarking equivalent operations in other organization.
	Field maintenance calibration and tool kit.
	Power line conditioner recommended by NWS to help avoid power spikes that can damage the hydrogen generator.
	Implement WIS2.0 compliant data sharing (automatic) including implementation of data management system.
Module 4. GBON human capacity development	Training in data transfer and data quality control and assurance, ICT systems and data management.
	Training on maintenance and calibration practices.
	Additional technical staff (2) recruited to operate upper-air soundings twice a day and to assist with sounding and AWS maintenance duties.
	Conduct a gender analysis and draft a new organizational Gender Policy, with specific actions that are measurable and regularly monitored, which are based on the WMO Gender Action Plan.
	Project management and product portfolio management training

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

Report completion signatures

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