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Systematic Observations Financing Facility

GBON National Contribution Plan of The Seychelles

Systematic Observations
Financing Facility

Weather
and climate
data for
resilience

GBON National Contribution Plan

Seychelles

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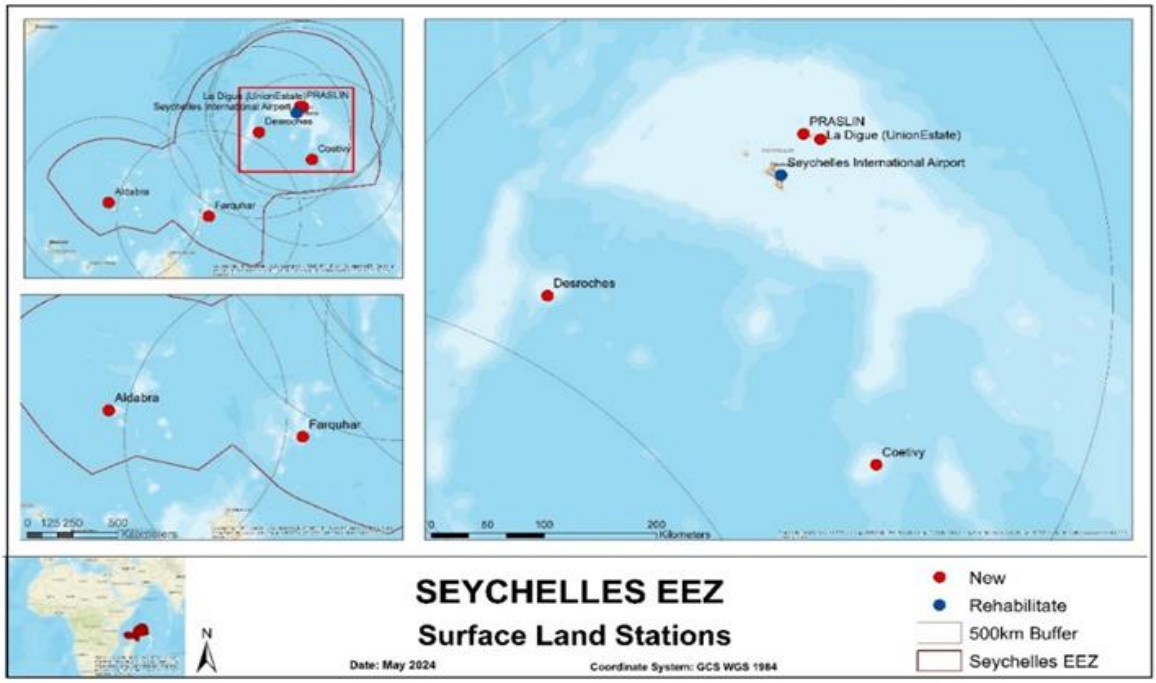
Module 1. National Target toward GBON compliance

The national target toward GBON (Global Basic Observing Network) compliance involves a strategic approach to enhance the number and quality of meteorological observations globally. Countries are working towards meeting GBON requirements by conducting gap analyses, improving existing stations, and installing new ones to ensure a comprehensive and reliable observing network.
The national target towards GBON compliance aims to ensure that the GBON stations meet the reporting frequency, the types of data they collect and to achieve a sustainable level of operations and maintenance for the SMA national observing network, ensuring that it can reliably contribute to the global meteorological community.

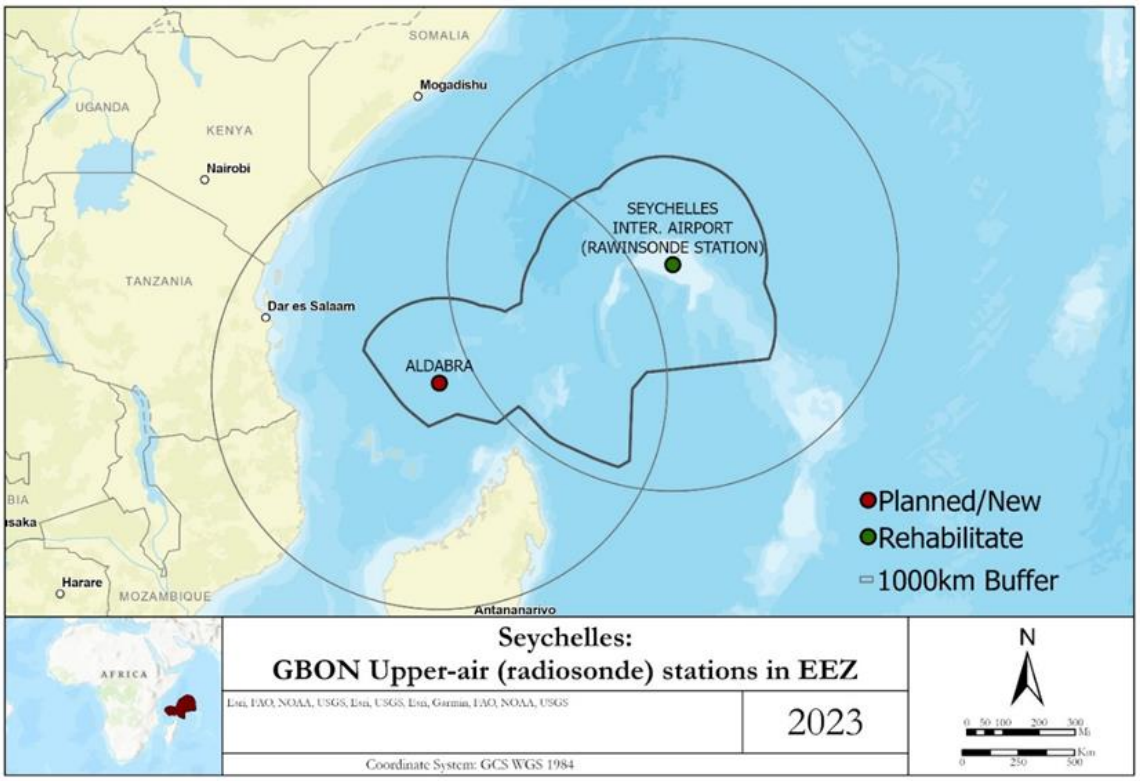
The National Gap Analyses of Seychelles Meteorological Authority (SMA) revealed the need to improve the surface land station located at the Seychelles International Airport and for the re-opening and replacement of five silent/non-reporting stations with new Automatic Weather Stations that meet the GBON requirements. Moreover, an additional surface land station will be installed on Coetivy Island located approximately 290km from the south of Mahe to cover the southern part of the Seychelles Exclusive Economic Zone (EEZ). As for the existing upper-air (radiosonde) land stations, the station at Seychelles International Airport will be rehabilitated and a new station will be established and installed on the outer island of Aldabra Island.

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	6	0	1	5	1	6
Upper-air	2	1	0	1	1	1
Marine	*when applicable					

Table 1. GBON National Contribution Target



Picture 1. Map of existing and proposed surface and upper-air stations



Picture 2. Map of existing and proposed upper-air stations.

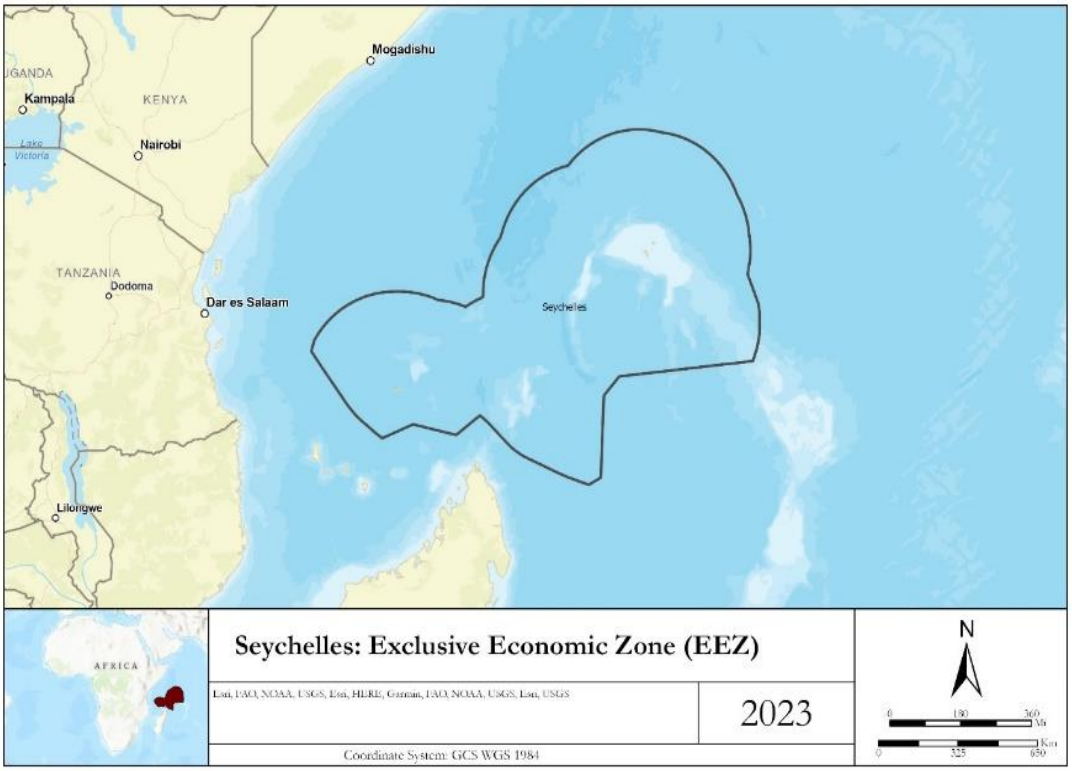
Module 2. GBON Business Model and Institutional Development

The Republic of Seychelles is an archipelago made up of 115 islands scattered over a massive Exclusive Economic Zone (EEZ) of about 1.37 million square kilometers, with a total landmass area of 455 square kilometers. The archipelago lies in the heart of the Indian Ocean between 4°S and 10°S; and 46°E and 54°E; northeast of Madagascar; and off the Eastern coast of Africa, the inner granitic islands include the main island of Mahé, followed by Praslin and La Digue, while the outer islands are both granitic and coralline. Despite the highest peak of the granitic islands Morne Seychellois being 905m, the coralline islands are low-lying islands with limited and no elevations that are especially threatened by climate change. The unique geography of the EEZ includes coral reefs, seagrass beds, mangroves, and a variety of coastal and aquatic ecosystems.

Meteorological activities in the Seychelles are closely monitored and studied by the Seychelles Meteorological Authority (SMA), responsible for providing weather forecasts, issuing warnings, and conducting a range of meteorological services. Given its geographical location, the archipelago is prone to monsoons, which are characterized by strong winds and substantial rainfall. These monsoons, influenced by the Indian Ocean Dipole and the El Niño-Southern Oscillation, are vital for Seychelle's agricultural sector as they provide the necessary water supply for crops. Furthermore, the position of the Inter-Tropical

Convergence Zone (ITCZ) governs the Seychelles weather and climate conditions. The rainfall varies according to the height above sea level, and ranges from 76.2 mm in July to 404.8 mm in January. The mean annual rainfall for Mahé is 2369.4 mm over the coast. Rainfall also tends to be higher on the west facing slopes and ridges of La Misere, since most rainfall occurs during the northwest monsoon. The heavy downpour normally occurs from late December to the beginning of January. Excessive rainfall can lead to flooding and landslides, posing risks to inhabitants and infrastructure.

In addition to monsoons, the Seychelles also experiences tropical cyclones, which typically form during the wet monsoonal season from November to April. The occurrence of cyclones can have severe impacts on the country's economy, particularly its tourism sector. Therefore, accurate forecasting and timely warnings are essential for preparedness and minimizing potential risks associated with these extreme weather events. Furthermore, climate change poses a significant challenge for the Seychelles, as its low-lying islands are vulnerable to rising sea levels. As a response, the Seychelles government has implemented various measures to combat climate change and adapt to its effects. These include the creation of marine protected areas, promoting sustainable tourism practices, and investing in renewable energy sources. As climate change continues to pose challenges, it is essential for local authorities, scientists, and international partners to collaborate and develop sustainable strategies to effectively mitigate and adapt to the impacts of climate change on the Seychelles.



Picture 3. Map Seychelles Exclusive Economic Zone (EEZ)

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

The Government has established the Disaster Risk Management Division (DRMD) and Seychelles Meteorological Authority (SMA) with sufficient funding to enable them to function. In line with the Disaster Management Act of 2014, Seychelles addresses the negative impacts of Climate Change through adaptation and reduces its carbon footprint through mitigation.

- Under Pillar 6 of the NDS, 2019-2023 a specific Strategic Intervention for increased resilience under the strategy `Disaster risk management, mitigation, and preparedness` is outlined.
- The recent Seychelles National Climate Change Policy (NCCP, May 2020) provides guidance aimed at strengthening the institutional mechanisms that will increase climate action at the local, regional, and international level.
- There is integration of adaptation guidelines into development planning, proposed setback lines for coastal development, use of Ecosystem based adaptation (EBA) alongside hard engineering structures for coastal protection and defense, strengthening of technical and institutional capacity in monitoring and research, changing crop and crop varieties to climate resistant ones, (NCCP,2020:10)

The following Private sector are providing meteorological observations and data services in Seychelles.

- Island development company limited (IDC)
- Seychelles Island Foundation (SIF)
- Public Utilities Corporation (PUC) has a number of manual rain gauge stations.
- Seychelles Coast Guard: the partnership is more to help with deployment and retrieval of SMA buoys since SMA do not have the capacity/resources to do it ourselves)

The following are Potential new partners and their roles.

- Island Conservation Society, an NGO with interests in environmental monitoring
- Seychelles Maritime Safety Authority (SMSA) which would have a shared interest in environmental monitoring with relevance to maritime safety.

It is hereby recommended that SMA works closely with Island development company limited (IDC), Seychelles Island Foundation (SIF) and the Public Utilities Corporation (PUC) in assessing the conditions of their weather observation infrastructure to consider incorporation into the national database through development of the national WIGOS plan.

2.2. Assessment of potential GBON sub-regional collaboration

- The WMO Regional Association RA1 (Africa) is responsible for the coordination of meteorological, hydrological, and related activities within Africa and in alignment with the African Ministers Conference on Meteorology (AMCOMET) strategy which seeks to: -
    - Increased political support and recognition of NMHSs.
    - Improved observational networks, data access and processing,
    - Enhanced capacities for the production and delivery of tailored weather, water, climate, and climate change services for sustainable development
    - Research, Innovation, Development and Training
    - Strengthened partnerships with relevant institutions and the private sector.
- There are several regional organizations / bodies of relevance for implementation of GBON within the sub-region from which Seychelles Meteorological Authority can leverage upon for collaborations such as the Southern African Development Community (SADC) Secretariat through its Sub-sectoral Committee on Meteorology (SCOM) and Climate Services Centre (CSC). The SADC ClimSA Programme aims contribution to the efforts of SADC Member States countries to adapt to climate change and climate variability by providing science-based climate prediction and information services into national and regional planning processes. It aims to strengthen the climate service value-chain through building the capacities of decision-makers at all levels to make effective use of climate information and services. Through this programme few weather observation stations were established within the Seychelles.
- The ClimSA Station is a platform for retrieving, processing and visualizing climate and earth observations (EO) datasets for the implementation of climate services. The platform is a full version of the climate station and is being integrated in the Climate Service Information Systems (CSIS) at the regional level and has already been deployed to the National Meteorological and Hydrological Services (NMHSs) of the SADC Member States.
- Seychelles is associated with the Regional WIGOS Centers (RWCs) for Southern for data availability and quality monitoring, Regional Telecommunication Hub (RTH)-Pretoria for data transmission through the Global Telecommunication System and part of the Global Information System Centre (GISC) for data collection and dissemination to the local and global data collection and producing centers, Regional Instrument Centre (RIC) for maintenance and calibration of observation systems, Regional Training Centers (RTC) for capacity development of Meteorological personnel, just to mention a few.
- RSMC SAWS provide SMA with severe weather guidance,
- RSMC La Reunion provide SMA with cyclone warning,
    - It is hereby recommended that SMA leverage on regional organizations / bodies of relevance for implementation of GBON within the sub-region,

The coverage of some of the upper art observation systems proposed for Seychelles cover the EEZ which overlaps with other SIDC. Consideration of their upper air station during the development of the GBON observation network will enhance the coverage of the vast open spaces within the EEZ (Exclusive Economic Zone)

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

The Seychelles Meteorological Authority was establishment through the Meteorological Act 16 of 2015 as the as a sole recognized national provider on meteorological and climate services in Seychelles, which shall be a body corporate with following objectives:

(a) To maintain, extend and improve the quality of meteorological services.
(b) to provide public. good services and commercial services;'
(c) to ensure ongoing collection and update of meteorological data
(d) to be the custodian of reliable national climatological record.
(e) to take measures to' fulfil the international obligations under the.' Convention of the World Meteorological Organisation.
(f) to provide for meteorological services to international air and sea navigation; and
(g) to fulfill any other weather-related obligations as may be prescribed.

This ACT also gives the sole responsibility of advice on installation of meteorological stations and climatological Centre in Seychelles to SMA. The funding of the SMA is through money appropriated by the National Assembly as well as any money collected through commercial activities.

Even though SMA has commercial section where data is seen as a commodity for income generation, it should therefore be noted that a fair and equitable exchange of data and products is essential for the success of the entire weather enterprise as data availability is crucial for life-saving missions, such as disaster risk reduction, food security and for meeting the breadth of societal demands that cannot be met by a single sector, especially in the least developed countries. There is thus a need for a business model that advocates for NMHS to maintain basic capacity related to the generation and exchange of observations. SMA operates and maintains its own network, however there are private entities that own and operate networks in the country. It is hereby recommends a public/ private partnership business model be considered.

Having considered the requirements for GBON assigned network, it is critical that the budget to operate and maintain this network must consider the entire life cycle requirement of the entire network which includes but not limited to:

a. Upgrading of the current assigned to GBON observation network.
b. Replacement of the full network at the end of this operational period
c. Consumables during the operational period
d. Communication costs
e. Transportation for maintenance
f. Tools required to maintain the network.

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

- The current SMA strategic plan for the period 2019-2023 is under review.
- This strategic plan provides a roadmap for SMA to fulfil its mandate of provision of timely weather and climate information and services for the safety of life, protection of property and conservation of natural environment. The plan provides a new strategic direction and will be useful for guiding SMA in the making of the day – to – day decisions and for evaluating the progress and changes in approaches needed when moving forward. The plan considers the Meteorology Act of 2015 – Covering the transition of Seychelles National Meteorological Services (SNMS) to the Seychelles Meteorological Authority (SMA), the National government plan, the sector plan, the WMO strategic plan, the Sendai Framework of Action (2015-2030) and UN Sustainable Development Goals (SDGs) among others.
- This plan recognizes global emerging issues such as implementation of the Global Framework for Climate Services (GFCS), Implementation of WMO Integrated Global Observation System (WIGOS) which is an integrated, coordinated and comprehensive observing system to satisfy, in a cost-effective and sustained manner, the evolving observing requirements of Member states in delivering their weather, climate, water and related environmental services together implementation of the WMO Information System (WIS), critical internation exchange of data and information. The strategy further recognizes the importance of Data rescue endeavors as well as climate action plan as climate change is a serious concern for Small Islands Developing State (SIDS).
- This strategy is driven by the increased responsibilities imposed by the Meteorology Act 2015, especially the new responsibility for marine services, and an increased emphasis on services related to climate change and climate risk.
- Implementation of the Regional Integrated Multi-Hazard Early Warning System (RIMES) is also a driving factor as there is the potential for a sub-regional hub of RIMES based in Seychelles.
- HYDROMET project, managed by the Indian Ocean Commission (IOC) with funding from GCF/AFD/EU is other project nationally that can be considered in support to GBON implementation.
- EWS for Floods, managed by WMO with funding from US-Aid, is also one of the projects for consideration in support to GBON implementation.

The outcome of the "Diagnostic of Multi-Hazard Early Warning Capacities in Seychelles" Country Report by Alice Soares, Rose Osinde-Alabaster and Yvette Ramos proposed a plan for Governance and Institutional Strengthening which was aimed at Governance, strategy, and Organisational structure as well as Human Resources and Capacities development.

2.5. Review of the national legislation of relevance for GBON

- Seychelles Meteorological Authority (SMA) is the Republic of Seychelles national weather service, established on 19th November 2015 as a corporate body having transitioned from Seychelles National Meteorological Services (SNMS) through the enactment of the Meteorological Act of 2015.
- SMA is the sole recognized national service provider on meteorological and climate services in Seychelles.

- SMA has expanded its mandate to provide other services such as public weather services, climate change, hydrology, and Agro-Meteorology. The main purpose and mandate of the authority is anchored on executive orders of the structure and organization of the Government of Seychelles and the World Meteorological Organization (WMO) convention which recognizes that National Meteorological and Hydrological Services (NMHS) to be the single and authoritative voices and sources on matters of severe weather and extreme climate events in WMOs member countries.
- The ACT requires the Seychelles Meteorological Authority under section 2 (h) through to (p)
  - to collect, process and record meteorological and climatological information, data, and advisory services, and include research.
  - conduct and assist research and investigations for the advancement of meteorological science.
  - advise the Government and other agencies on meteorological matters and provide supportive roles and responsibilities to disaster management authorities in relation to disaster management, response, and risk reduction.
  - develop, facilitate, and provide training and instructions for people whose duties and responsibilities concern matters relevant to meteorology and climate.
  - co-operate with national meteorological authorities of other countries and international organisations in relation to meteorological matters and support the principle of free and unrestricted exchange of meteorological data between such national meteorological services and international organisations.
  - conduct programmes for raising. Public awareness on climate change issues.
  - provide navigation weather forecasts for internal and international navigation purposes.
  - provide aviation weather reports for pilots such as route forecast and terminal aerodrome forecasts, significant weather charts to pilots.
  - perform such other functions as may be prescribed.
- The Seychelles Meteorological Authority also:
    - strive to provide quality meteorological services to safeguard life and property.
    - support national development and meet our international obligations.
- SMA have a data policy called "SEYCHELLES DATA DISTRIBUTION AND ACCESS POLICY" which sets out Climate data legislative mandate, sets out the custodian of climate data obligations, the enabling legislation, Climate data policy management and key roles, Climate data access and distribution scope, Role of data to enhance service delivery to all SMA stakeholders, public and private users. Climate data governance: limitations of use and restrictions, Climate data types, Data types available for access and distribution, Climate data guidelines, Procedures, and details to access and distribution, SMA pricing structure and Climate data definitions.
- The SMA distinguishes between two types of data, public task data and non-public data referred to as "Non-commercial services".
- Section 7.3.1 "Non-commercial Services" addresses SMA international obligations and in accordance with all relevant WMO resolutions and guidelines.
- Section 7.3.2 "Free data for designated groups" states that Members of the public, excluding students who need information for research and request data for non-commercial purposes, are part of public task designated groups, and can be entitled to data free of charge for nominal requests. These requests will be reviewed to determine compliance with the Public Good principles.

- The Public Procurement Act No.33 of 2008 as consolidated on 30 June 2012, applies to any other procurement effected by a public body unless otherwise prescribed by the Minister. This Act directs that a procuring entity shall, before entering into an international agreement relating to procurement, obtain the approval of the Procurement Oversight Unit, and the advice of the Attorney-General. The Act also states under 6 (1) "Where this Act conflicts with the procurement rules of a donor organisation, the application of which is mandatory pursuant to an obligation entered into by Seychelles under any treaty or any other form of agreement, those procurement rules shall prevail.

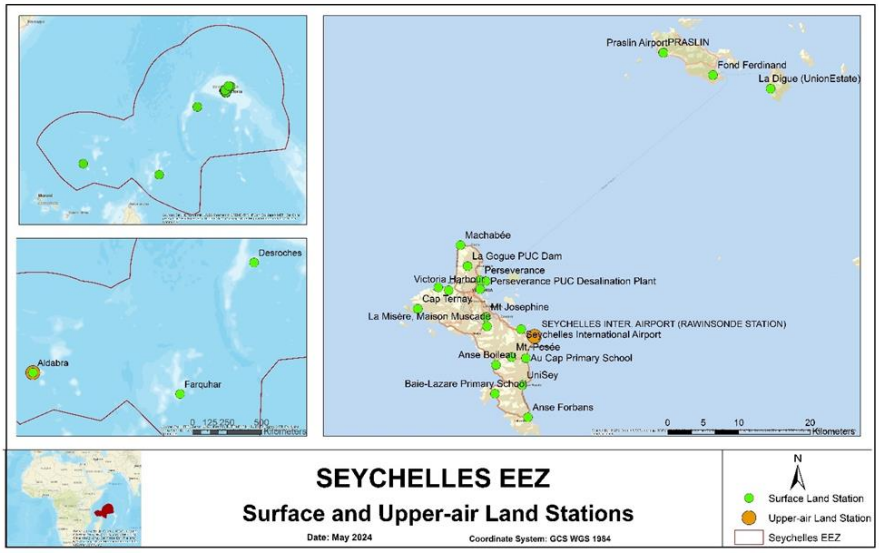
Critical to the successful implementation of GBON National is adherence to the national policies and guidelines. The procurement Policies and guidelines of the Seychelles does recognize the role of international donor organisations in expediting implementation of activities in the country. It is hereby recommended that where the Implementing Entity procurement policies are favorable for implementation of GBON, they be given priority.

Module 3. GBON Infrastructure Development

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

The Seychelles Meteorological Authority (SMA) owns, operates, and maintains a network of 24 surface land stations and one upper-air land station across the main island Mahe, and the outer island groups, Southern Coral Group, Amirante Islands, Alphonse Group, Aldabra Group and Farquhar Group.

The SMA surface land stations perform 3-hour observations for national except Seychelles International Airport AWS which exchanges data internationally every 3 hours. The upper-air (radiosonde) land station at the Seychelles International Airport, performs one ascent per day at 12h00 UTC.



Picture 4. Map Seychelles for surface and upper land station

Twenty-one surface and one upper-air (radiosonde) land stations are registered in the WMO OSCAR/Surface Tool and the monitoring results from WIGOS Monitoring Centres are displayed in the WIGOS Data Quality Monitoring System (WDQMS) are depicted in the table below.
OSCAR/Surface and WDQMS station information as in July 2024

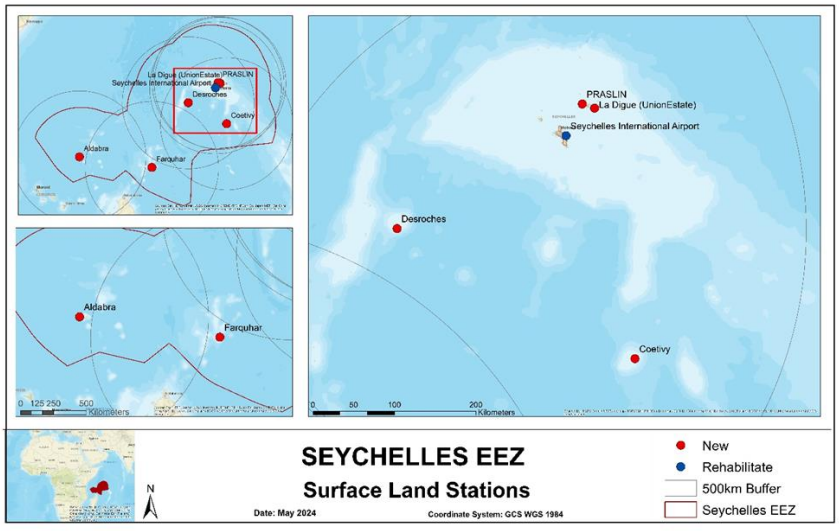
Network	Current #stations	OSCAR/Surface		WDQMS
		Declared status	Assessed status	
Surface land	21	• 6 Silent • 15 Operational	• 6 Unknown • 14 Silent • 1 Operational	20 Silent/Non-reporting 1 station (3 hourly observations, 100% data availability)
Upper-air (radiosonde)	1	• Operational	• Unknown	1 station (1 ascent per day)

Table 2: Surface Land Stations: New and existing stations

The WMO Global Basic Observing Network (GBON) gap analysis conducted in June 2023 showed a baseline and assessment of the status of the observational data exchange in Seychelles measured against GBON requirements. The preliminary results indicated the need for the improvement of one surface land station, the establishment and installation of five new surface land stations, and the improvement and installation and establishment of one new upper-air station, respectively.

The results of the GBON National Gap Analysis however indicated that there is a need to rehabilitate the surface land station located at the Seychelles International Airport and for the re-opening and replacement of five silent/non-reporting stations with new Automatic Weather Stations that meet the GBON technical requirements. Moreover, an additional surface land station will be installed on Coetivy Island located approximately 290km from the south of Mahe to cover the southern part of the Seychelles Exclusive Economic Zone (EEZ). The existing upper-air (radiosonde) land station at Seychelles International Airport will be rehabilitated and a new station will be established and installed on the outer island of Aldabra Island.

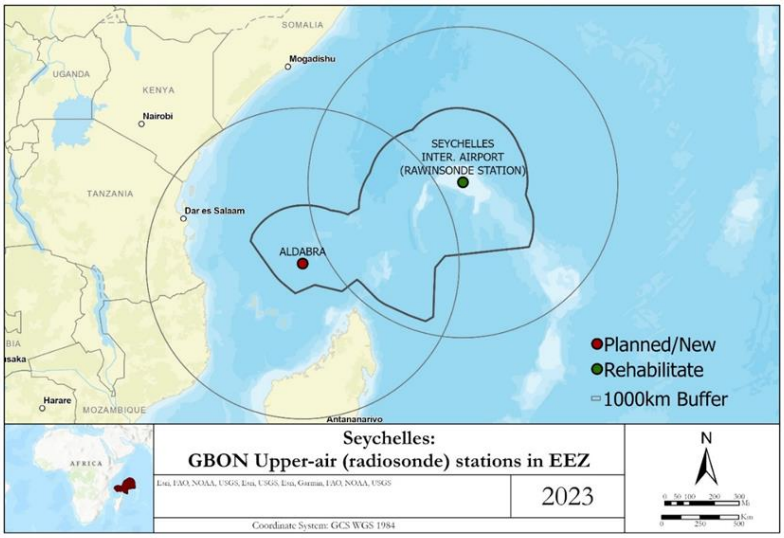
a. A map of observing network distribution and a list of the required new or rehabilitated GBON stations



Picture 5: Surface Land Stations: New and existing GBON stations

#	Station name	WIGOS-ID	Station type (S/UA)	Type (Manual/AWS)	Date Established	Activity required
1	ALDABRA	0-20000-0-63995	S	AWS	1968-01-01	New
	DESROCHES	0-20000-0-63994	S	AWS	2001-01-01	New
3	FARQUHAR	0-20000-0-63996	S	AWS	2001-01-01	New
4	LA DIGUE	0-690-0-UNIO	S	AWS	2021-12-01	New
5	PRASLIN	0-20000-0-63981	S	AWS	2001-01-01	New
6	SEYCHELLES INTERNATIONAL AIRPORT	0-20000-0-63980	S	AWS	1894-01-01	Rehabilitate
7	COEVITY	To be registered	S	AWS	n/a	New

Table 3: Surface Land Stations: New and existing GBON stations



Picture 6: Upper-air Land Stations

#	Station name	WIGOS-ID	Station type (S/UA)	Type	Date Established	Activity required
1	SEYCHELLES INTER. AIRPORT (RAWINSONDE STATION)	0-20000-0-63985	UA	Radiosonde	1976-01-01	Rehabilitate
2	ALDABRA	0-20000-0-63995	UA	n/a	1968-01-01	New

Table 4: Upper-air Land Stations

b. List of observation instruments and systems per site

A technical assessment of the surface land stations revealed that Seychelles International Airport is the only surface land with operational observing instruments and systems. Aldabra was operational when the National Gap Analysis was conducted in July 2024 and currently has a declared status of "Silent". Moreover, the remaining stations consisted of manual instruments that required human reading. The mercury-containing observing instruments were phased out and the stations were subsequently closed. Coetivy is a planned station.

i. Surface land stations

Station name	Status	Atmospheric pressure	Air Temperature	Humidity (RH)	Horizontal Wind Direction	Horizontal Wind Speed	Precipitation Amount/ Intensity	Data Logger: Data transfer protocol
ALDABRA	Silent	A	A	A	A	A	A	A (FTP)
DESROCHES	Silent/no station	NA	NA	NA	NA	NA	NA	NA
FARQUHAR	Silent/no station	NA	NA	NA	NA	NA	NA	NA
LA DIGUE	Silent	NA	NA	NA	NA	NA	NA	NA
PRASLIN	Silent/no station	NA	NA	NA	NA	NA	NA	NA
SEYCHELLES INTERNATIONAL AIRPORT	Operational	A	A	A	A	A	A	A (FTP)
COETIVY	Planned	NA	NA	NA	NA	NA	NA	NA

Table 5: Surface land stations instruments and systems per site (**A**: Available, **NA:** Not Available)

The results of the technical and local assessment of the existing GBON surface land stations against the GBON Tender Specifications for AWSs were used to determine the investment activities needed to ensure compliance with the GBON requirements. The results revealed that the sensors installed at Aldabra do not meet GBON requirements and that Seychelles International Airport sensors except for the horizontal wind speed meet GBON requirements. The data loggers at Aldabra and Seychelles International Airport do not have the required data transfer protocol for WIS2.0 implementation.

Station name	Atmospheric pressure	Air Temperature	Humidity (RH)	Horizontal Wind Direction	Horizontal Wind Speed	Precipitation Amount /Intensity	Data Logger: Data transfer protocol
	500 – 1080 hPa	**-80 °C to +60°C**	**0-100 %**	**0-360 degrees**	**Max: 0-75 m/s Extended: 0-100 m/s**	**0-500mm/hr.**	**MQTT/SFTP**
ALDABRA	NC	NC	NC	NC	NC	NC	NC
DESROCHES	N/A	N/A	N/A	N/A	N/A	N/A	N/A
FARQUHAR	N/A	N/A	N/A	N/A	N/A	N/A	N/A
LA DIGUE	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PRASLIN	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SEYCHELLES INTERNATIONAL AIRPORT	C	C	C	C	NC	C	NC
COETIVY	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 6: GBON Compliance: Sensor analysis: (**C**: Compliant, **NC**: Non-compliant, **NA**: Not Available)

Other AWS components

The site assessment of the other AWS components was conducted to determine if the components are required or applicable to each site. Moreover, the results will determine if the components are available or applicable to each site. The components at Aldabra replaced with new components and those at Seychelles International Airport will be assessed and rehabilitated if needed.

Station name	AWS Cabinet	Power/Main	Solar panel	Battery	Voltage regular	Lightning protection	Grounding systems	Junction and terminal boxes	Cables, wires, and connectors	Communication (SIM cards and airtime, modem, satellite communication)
ALDABRA	A	A	A	A	A	A	A	A	A	TBD
DESROCHES	NA	TBD	TBD	NA	NA	NA	NA	NA	NA	TBD
FARQUHAR	NA	TBD	TBD	NA	NA	NA	NA	NA	NA	TBD
LA DIGUE	NA	TBD	TBD	NA	NA	NA	NA	NA	NA	TBD
PRASLIN	NA	TBD	TBD	NA	NA	NA	NA	NA	NA	TBD
SEYCHELLES INTERNATIONAL AIRPORT	A	A	N/A	A	A	A	A	A	A	A
COETIVY	NA	TBD	TBD	NA	NA	NA	NA	NA	NA	TBD

Table 7: Other AWS components (**A**: Available, **NA**: Not Available, **N/A**: Not Applicable, **TBD**: To Be Determined)

Masts, Stands, Fencing and Security

An assessment of the masts, stands, fencing and security will be conducted to determine the condition of the masts, stands, fencing and security requirements at the existing GBON stations. New fencing and solar panel brackets are to be considered and installed at all sites for increased security and to prevent vandalism of the stations.

Station name	Wind mast	Temperature/Humidity stand/bracket	Rain gauge stand	Temperature/Humidity enclosures	Fencing
ALDABRA	A	A	A	A	N/A
DESROCHES	NA	NA	NA	NA	TBD
FARQUHAR	NA	NA	NA	NA	TBD
LA DIGUE	NA	NA	NA	NA	TBD
PRASLIN	NA	NA	NA	NA	TBD
SEYCHELLES INTERNATIONAL AIRPORT	A	A	A	A	N/A
COETIVY	NA	NA	NA	NA	TBD

Table 8: Masts, Stands, Fencing and Security **(A**: Available, **NA**: Not Available, **N/A**: Not Applicable)

Instrument/component	Available/ Compliant	Available/Non-compliant	Not Available	Not Applicable	To Be Determined
Atmospheric pressure	1	1	5		
Air Temperature	1	1	5		
Humidity (RH)	1	1	5		
Horizontal Wind Direction	1	1	5		

Horizontal Wind Speed	0	2	5		
Precipitation Amount/Intensity	1	1	5		
Data Logger: Data transfer protocol	0	2	5		
AWS Cabinet	1	1	5		
Power/Main	1	0	0		6
Solar panel	1	0	0		6
Battery Voltage regular	1	1	5		
Lightning protection	1	1	5		
Grounding systems	1	1	5		
Junction and terminal boxes	1	1	5		
Cables, wires, and connectors	1	1	5		
Communication (SIM cards and airtime, modem, satellite communication)	1	0			6
Wind mast	1	1	5		
Temperature/Humidity stand/bracket	1	1	5		
Rain gauge stand	1	1	5		
Temperature/Humidity enclosures	1	1	5		
Fencing				1	6

Table 9: Summary of the instruments and systems

ii. Upper-air land stations

The SMA operates and maintains an upper-air station at the Seychelles International Airport. The station performs one ascent per day at 12h00UTC. The site has a building/balloon room, storage and computer rooms, a hydrogen generation system, an upper-air system, computer and communication infrastructure, and consumables. However, there is a need to rehabilitate the buildings/facilities, hydrogen generation system, and ICT resources and procure additional consumables to improve the site. Furthermore, Safety, Health, Environment, and Quality (SHEQ) measures need to be implemented with an emphasis on water, electricity, and hydrogen gas handling.

The Aldabra site requires establishing the building and facilities, installing new upper-air and hydrogen generation systems, ICT infrastructure, SHEQ items, and procuring consumables. Auto launcher to be considered and train local people on basic maintenance. The automated radiosonde launcher will be considered as an alternative option because of the low population density and the subsequent availability of human resources.

Station name	Status	Building/Facilities	Hydrogen Generation System	Upper-air ground system	Consumables
SEYCHELLES INTER. AIRPORT (RAWINSONDE STATION)	Operational	A	A	A	A
ALDABRA	Planned	NA	NA	NA	NA

Table 10: Surface land stations instruments and systems per site (**A**: Available, **NA**: Not Available)

Upper-air buildings and Facilities

ITEMS	SEYCHELLES INTER. AIRPORT (RAWINSONDE STATION)	ALDABRA
Building/Facilities		
Water and static-proof building (Balloon room)	A	NA
Lighting	A	NA
Power/Mains power supply (backup solution)	A	NA
Direct water supply to balloon room	A	NA
Water tank, water pump piping, and connectors (backup)	A	NA
Generator for emergency power supply (backup)	A	NA
Storage for upper-air consumables	A	NA
Hydrogen Generation System		
Hydrogen generator (0.5 Nm3/hr (20 SCF/hr/500l/hour).	A	NA
Water Purification System with piping, valves, and connectors	A	NA
Hydrogen storage tank with piping, valves, and connectors	A	NA
Balloon fill nozzle with piping and connectors	A	NA
Safety, Health, Environment and Quality (SHEQ)		
Personal Protective Equipment (PPE) i.e., special garments	NA	NA
Fire protection (extinguishers and adequate warnings according to national regulations)	NA	NA
First aid kit	NA	NA
Hydrogen presence detecting tools/ Gas leak detection unit	NA	NA
ITEMS	**SEYCHELLES INTER. AIRPORT (RAWINSONDE STATION)**	**ALDABRA**
INVESTMENT AND ACTIVITIES FOR THE RUNNING OF THE UPPER-AIR NETWORK		
Ground System, Computer systems, and Communication		
Upper-air ground system	A	NA
Uninterruptable Power Supply (UPS)	A	NA
Desktop computer	A	NA
Network connectivity (network switch and cabling) / mobile network connection	A	NA

ITEMS	SEYCHELLES INTER. AIRPORT (RAWINSONDE STATION)	ALDABRA
Consumables		
Radiosondes	A	NA
Balloons (350g)	A	NA
Helium gas as backup (As and when required)	A	NA
Balloon string	A	NA

Table 11: Upper-air buildings and Facilities (**A**: Available, **NA**: Not Available)

c. Investments and activities needed for the installation of new stations and the improvement of existing stations

The results of the technical and local assessment of the existing GBON surface land stations against the GBON Tender Specifications for AWSs and Upper-air systems, Hydrogen Generation Systems and radiosondes to determine the investment activities needed to ensure compliance with the GBON requirements.

Investment and activities needed for the Surface Land Stations

The start-up investment and the activities required to establish the surface land stations are depicted in the table below. There is a need for Seychelles International Airport to be rehabilitated and six new Automatic Weather Stations (AWS) to be installed on the outer islands.

Station name	Type	Action required	Comment/Motivation
ALDABRA	AWS	New	• New installation. Replace All-in-one station
DESROCHES	AWS	New	• New installation. Re-establish a station at the site
FARQUHAR	AWS	New	• New installation. Re-establish a station at the site
LA DIGUE	AWS	New	• New installation. Re-establish a station at the site
PRASLIN	AWS	New	• New installation. Re-establish a station at the site
SEYCHELLES INTERNATIONAL AIRPORT	AWS	Rehabilitate	• Replace/Upgrade data logger and wires/cables to meet MQTT/SMTP data transfer protocol • Upgrade/Replace the wind sensor • Rehabilitate the AWS components
COETIVY	AWS	New	• New installation.

Table 12: GBON New infrastructure required

Activity #	Activity	Quantity	Unit Price	Costing USD ($)
1.	Installation of New AWS	6	18000	108000
2.	Rehabilitate/replace data loggers to meet MQTT and SFTP data transfer protocol requirements. Rewiring of AWS required	1	5560	5560
3.	Upgrade of Air temperature sensors that do not meet the required measurement range	1	485	485
4.	Upgrade of Wind sensors that do not meet the required measurement range	1	993	993
6.	Replacement of batteries	1	150	150
7.	Replacement/installation of lightning protection unit	1	155	155
8.	Replacement of junction and terminal boxes	1	650	650
9.	Upgrade communication at all sites (sim cards and data/airtime)	7	460	3220
10.	Installation/Replacement/rehabilitation of fences	6	404	2424
11.	Material to build solar panel brackets as part of the security upgrade (6 stations)	6	200	1200
Total				**122837**

Table 13: Investment Proposal: AWS Sites

Investment Proposal: Upper-air (radiosonde) Land Stations

The start-up investment and the activities for the establishment and installation of the upper-air network are:

- Rehabilitation of the balloon rooms/sheds to ensure that the building design complies with national standards and codes of practice concerning the risks presented by explosive gas.
- Lighting, power/mains and water supply including backup solutions
- Hydrogen generation systems and helium gas cylinders for backup
- Ground systems and hardware
- Consumables
- Fire protection (extinguishers and adequate warnings according to national regulations) and first aid kit
- Personal Protective Equipment (PPE) i.e., special garments
- Hydrogen presence detecting tools/ Gas leak detection units.

ITEMS	SEYCHELLES INTER. AIRPORT (RAWINSONDE STATION)	ALDABRA
Building/Facilities		
Water and static-proof building (Balloon room)	R	N
Lighting	N	N
Power/Mains power supply (backup solution)	N	N

ITEMS	SEYCHELLES INTER. AIRPORT (RAWINSONDE STATION)	ALDABRA
Direct water supply to balloon room	N	N
Water tank, water pump piping and connectors (backup)	N	N
Generator for emergency power supply (backup)	N	N
Storage for upper-air consumables	R	N
Hydrogen Generation System		
Hydrogen generator (0.5 Nm3/hr (20 SCF/hr/500l/hour).	N	N
Water Purification System with piping, valves, and connectors	N	N
Hydrogen storage tank with piping, valves, and connectors	N	N
Balloon fill nozzle with piping and connectors	N	N
Safety, Health, Environment and Quality (SHEQ)		
Personal Protective Equipment (PPE) i.e., special garments	N	N
Fire protection (extinguishers and adequate warnings according to national regulations)	N	N
First aid kit	N	N
Hydrogen presence detecting tools/ Gas leak detection unit	N	N
ITEMS	**SEYCHELLES INTER. AIRPORT (RAWINSONDE STATION)**	**ALDABRA**
INVESTMENT AND ACTIVITIES FOR THE RUNNING OF THE UPPER-AIR NETWORK		
Ground System, Hardware installation and Training		
Upper-air ground system	N	N
Uninterruptable Power Supply (UPS)	N	N
Desktop computer	N	N
Network connectivity (network switch and cabling) / mobile network connection	N	N
Consumables		
Radiosondes	800 p/a	800 p/a
Balloons (350g)	800 p/a	800 p/a
Helium gas as backup (As and when required)	12 bottles p/a	12 bottles p/a
Balloon string		

Table 14: Statues of the Upper systems and buildings

START-UP INVESTMENT AND ACTIVITIES FOR THE ESTABLISHMENT AND INSTALLATION OF THE UPPER-AIR NETWORK			
ITEMS	**SEYCHELLES INTER. AIRPORT (RAWSONDE STATION)**	**ALDABRA**	**Estimated cost (USD)**
Building/Facilities			
Water and static proofing (Balloon room)	55 000	220 000	275 000
Lighting			
Power/Mains power supply (backup solution)			

START-UP INVESTMENT AND ACTIVITIES FOR THE ESTABLISHMENT AND INSTALLATION OF THE UPPER-AIR NETWORK			
ITEMS	**SEYCHELLES INTER. AIRPORT (RAWSONDE STATION)**	**ALDABRA**	**Estimated cost (USD)**
Building/Facilities			
Direct water supply to balloon room			
Water tank (2000litres), water pump piping and connectors (backup)	465	465	930
Generator for emergency power supply (backup)			0
Hydrogen Generation System			
Hydrogen generator (0.5 Nm3/hr (20 SCF/hr/500l/hour).	319 000	319 000	638 000
Water Purification System with piping, valves, and connectors			0
Hydrogen storage tank with piping, valves, and connectors	29 150	29 150	58 300
Balloon fill nozzle with piping and connectors			0
Safety, Health, Environment and Quality (SHEQ) and ATEX regulations			
Personal Protective Equipment (PPE) i.e., special garments	0	0	0
Fire extinguishers and adequate warnings according to national regulations	0	0	0
First aid kit	0	0	0
Hydrogen presence detecting tools/ Gas leak detection unit	0	0	0
Total	**403 615**	**568 615**	**972 230**

Table 15: Building/facilities, Hydrogen Generation System and SHEQ and ATEX regulations cost

ITEMS	**SEYCHELLES INTER. AIRPORT (RAWSONDE STATION)**	**ALDABRA**	**Estimated cost (USD)**
INVESTMENT AND ACTIVITIES FOR THE RUNNING OF THE UPPER-AIR NETWORK			
Ground System, Hardware installation and training			
Upper-air ground system	6 248	6 248	12 496
Uninterruptable Power Supply (UPS)			
Desktop computer			
Ground System, Lease (3300USD per year)	10 890	10 890	21 780
Ground System and consumables, Shipping	4 400	4 400	8 800
Insurance for shipping	2 145	2 145	4 290
Network connectivity (network switch and cabling) / mobile network connection	1320	1320	2 640
Total	**25 003**	**25 003**	50 006

Table 16: Investment and Activities for The Running of the Upper-Air Network

Item	Unit Price (USD/Local Currency)	Quantity per annum	Year 1	Year 2	Year 3	Year 4	Year 5	5-Year estimated cost (USD)
Upper-Air Observing System (Spare parts and consumables)								
Radiosonde	100	1600	80 000	168 000	184 800	203 280	223 608	859688
Balloon	16	1600	12 800	26 880	29 568	32 525	35 777	137550
Parachute				0				
Spare parts for hydrogen generator*				0				
Spare parts for fire extinguishing system*				0				
Spare parts for ground receiving system (antennas, computers, etc.) *				0				
Operational Cost (electricity, water, chemicals, data transmission, maintenance of the equipment)			2200	2 420	2 662	2 928	3 221	13431
Helium (back-up. If needed)	435	12	0	5 736	6 310	6 941	7 635	26621
Water purification system*				0				
Hydrogen detection tool*				0				
Balloon fill nozzle (piping and connectors) *				0				
Total			**95 000**	**203 036**	**223 340**	**245 674**	**270 241**	**1 037 290**

Table 17: Spares and Consumables (*To be included in the Service Level Agreement with the Service Provider)

Activity#	Items	Quantity	Costing USD ($)
1.	Personal Protective Equipment (PPE) • special garments, • safety boots, • fireproof overall for welder • overalls • welding helmet • Masks 3M • Insulating gloves • Goggles		

Table 18: Safety, Health, Environment and Quality (SHEQ)

Activity #	Activity	Preferred Material	Means of transportation	Labour/Human resources required	Estimated cost (USD)
1.	Transportation of AWS and components to the outer islands (combined cost)	n/a	By air and ferry	SMA	22100
2.	Site – civil works for AWS	Cement/Crusher dust	By air and ferry	By staff on the islands + SMA	18400
3.	Installation of AWS (if not done by SMA staff)	n/a	By air and ferry	SMA (could also include staff from the islands)	3700
4.	Environmental Impact Assessment for the Hydrogen Generator at Aldabra	n/a	n/a	Yes, by the Ministry of Environment staff	750
5.	Transportation of Upper-air equipment, hydrogen generator and resources	n/a	By air and boat	Yes	14800
6.	Rehabilitation/Construction of Aldabra Upper-air building (building structure, roof, electricity connection, water supply and health and safety requirement (signage, antistatic flooring)	Construction materials	By air and ferry	Foreign expert (+ SMA technical staff)	258000
7.	Disposing of any waste generated during the installation of the AWSs, Construction/rehabilitation of the upper-air building etc.	n/a	By boat	Staff on the island (could also include SMA staff)	5,000.00
8.	Additional expenses (Unplanned)				10000
Total					**328130**

Table 19: Building material, Transportation, Labour/human resources

Activities	Estimated cost (USD)					
	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Supply, installation and commissioning of four 40kVA silent diesel generator with a 200lt build-in fuel storage tank including maintenance	30303	16060	16868	6323	6386	**75940**
Supply, Installation, commissioning and testing of a new 10kVA UPS including maintenance	4798	2368	2508	967	1064	**11705**
TOTAL	**35101**	**18428**	**19376**	**7290**	**7450**	**87645**

Table 20: Backup Power supply (Generator and UPS)

d. Observational practices defined per network

The World Meteorological Organization (WMO) provides guidelines and standards for climate observations, including those related to the GBON surface land stations. The following key points regarding observational practices for surface land stations are to be considered when designing and establishing surface observing networks, including GBON:

Siting Classification

The Siting Classification for Surface Observing Stations on Land is a common ISO/WMO standard published by ISO as ISO standard 19289:2014 (EN) and the WMO in the WMO Guide to Instruments and Methods of Observation (WMO-No. 8). The purpose of the Siting Classification is to estimate how well the siting of an instrument meets the recommendations provided in WMO-No. 8. It helps network planners and installers consider good practices even when compromises are necessary. Furthermore, the Siting Classification provides a "middle ground" between acceptable and unacceptable siting conditions.

Climate Observations Standards

WMO standards cover various aspects of climate observations, including defining the minimum set of variables to be observed/measured at the surface, subsurface, and upper air stations. These standards also address the type, quality, and characteristics of instrumentation, station siting, network design, reporting procedures, quality control, station documentation, and metadata.

Quality Control and Quality Assurance

Guidelines and quality control procedures are available NMHSs for the processing of observational data of observational data and to ensure data quality and consistency. NMHSs process surface observational data and apply quality control procedures. GBON Surface Land Observing Stations:

The Global Basic Observing Network requires surface land observing stations to report 24 observations per day for Surface land and two ascents per day for upper-air land stations for the required variables.

It is therefore recommended that SMA staff, responsible for the GBON Surface land stations, receive training in the installation and management of AWSs. Equally important is the understanding of meteorological instruments and methods of observations, the site classification for variables, the performance of preventative and corrective maintenance on instruments and systems following Standard Operating Procedures (SOPs) to ensure quality and availability of observations and the calibration of instruments and metadata management.

SMA has upper-air sounding technicians capable of performing daily safety checks and basic maintenance of an upper-air system. It is however recommended that the upper-air sounding technicians receive refresher training on conducting upper-air soundings, basic upper-air coding and quality control, and system and hydrogen generator checks. The Original Equipment Manufacturer (OEM) will also be required to provide training during the installation of the ground system, and hydrogen generation systems.

The competency requirements to perform a balloon-borne upper-air observation consist of the following prescribed practices and procedures:

- Prepare and deploy balloons and their payload.
  - Balloon shed safety check.
  - Balloon preparation and filling.
  - Instrument ground check.
  - Balloon release.
- Track balloon flight.
- Compute and record upper air and other specialised upper-air observations as required.
- Compute and transmit upper-air observations using prescribed codes and methods.
  Care and handling of instruments.

e. Preliminary maintenance plan for existing and improved/new stations, including calibration practices

The WMO has guidelines to ensure that the meteorological observations made by meteorological stations meet the required level of quality throughout their lifetime. NMHSs are therefore required to have a maintenance plan or strategy. Regular maintenance is crucial for accurate observations e.g. preventive maintenance to prevent failures, corrective maintenance to address issues when they occur and calibration management to ensure the effective operation of the systems.

The efficiency in the maintenance and calibration activities of the meteorological stations depends on the existence of qualified technicians and the availability of technical resources. Furthermore, the planned maintenance and calibration intervals, activities for each observing system, individual sensors, and components, should be aligned to WMO and SMA manuals, guides, and SOPs. The maintenance and calibration recommended by the manufacturers or suppliers should also be taken into consideration.

Preventative and Corrective maintenance

The SMA envisage the implementation of a preventative maintenance schedule of 90 days for GBON stations based on their national operations and available resources. Corrective maintenance activities will be attended to within 5 days to ensure that the GBON observing stations meet the WMO and National monthly data availability performance target of 80% for all variables.

All maintenance activities are done by the technical team located at the SMA Head Quarters (HQ) at Seychelles International Airport. Furthermore, the maintenance plan seeks to have staff available to assist with the basic maintenance of the stations located on the outer islands. The preventative and corrective maintenance will be conducted by the maintenance personnel located at SMA HQ. The technologists will perform advanced fault diagnostics and instrument calibration. The preventative maintenance may also include field calibration activities.

Maintenance type	Location	Responsible person	Interval (Days)
Basic maintenance and housekeeping	Locally (on-site)	Lay-observer	ad hoc
Preventative maintenance/field calibration	Locally (on-site)	Maintenance Technician	90 days
Corrective maintenance	Locally (on-site) Remotely/off-site	Maintenance Technician Technologist	Within 5 days

Table 21: Maintenance type and interval

Calibration

There are two types of calibration of measuring instruments of GBON station namely laboratory calibration and field calibration with laboratory calibration performed in a laboratory operated following IEC/ISO 17025. The national or international measurement and traceability standards should be used to perform the required calibrations. Field calibrations are conducted for certain sensors that should be calibrated at laboratory-defined intervals to ensure measurements and traceability.

SMA does not have an operational laboratory but has technical staff with the required skills and knowledge to operate a laboratory. The plan is to rehabilitate one of the existing buildings to meet the calibration laboratories requirements and to procure a climate chamber and pressure calibrator for the calibration of the temperature, humidity, and atmospheric pressure sensors. Furthermore, wind system calibration and field calibration devices will be acquired for the calibration of anemometers and rain gauges.

The estimated cost for the rehabilitation of the calibration building is USD15000.

Calibrator	Sensors	Quantity	Estimated cost (USD)
Climate chamber	Temperature Humidity	1	
Pressure	Atmospheric pressure	1	

Table 22: Laboratory calibration equipment

Equipment#	Test equipment	Quantity
1.	Temperature/Humidity sensor	3
2.	Radiation shield	3
3.	Barometric Pressure Transfer Standard	3
4.	Rain gauge field calibration device	1
5.	Wind system calibration	2

	• Anemometer drive • Propeller torque disc • Vane Angle Bench stand Vane Torque gauge	

Table 23: National Standard and Field Calibration Equipment

Maintenance schedule

The successful execution of the maintenance plan is subject to the availability of field test equipment, transportation, and human resources. The planned maintenance schedule for the GBON surface land stations will be conducted as follows:

Stations	YEAR 1 (2025)												YEAR 2 (2026)												YEAR 3 (2027)											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
ALDABRA			C			C			C			C			C			C			C			C			C			C			C			C
DESROCHES			C			C			C			C			C			C			C			C			C			C			C			C
FARQUHAR			C			C			C			C			C			C			C			C			C			C			C			C
LA DIGUE			C			C			C			C			C			C			C			C			C			C			C			C
PRASLIN			C			C			C			C			C			C			C			C			C			C			C			C
SEYCHELLES INTERNATIONAL AIRPORT			C			C			C			C			C			C			C			C			C			C			C			C
COETIVY			C			C			C			C			C			C			C			C			C			C			C			C

Table 24: Maintenance Schedule (P: Preventative Maintenance, C: Corrective Maintenance)

Maintenance cost (USD)

#	Station name	Means of transportation	Estimated cost for a return trip (USD) – per person	Estimated cost for accommodation if required (USD) – per person/day	Other costs e.g. transport of equipment for maintenance purposes (USD)	Estimated Cost (USD)
1	ALDABRA	By air from Mahe to Assumption then boat from Assumption to Aldabra	3700	370	1850	**5920**
2	DESROCHES	By air	1850	1110	1480	**4440**
3	FARQUHAR	By air	2220	740	1110	**4070**
4	LA DIGUE	Ferry	190	150	115	**455**
5	PRASLIN	By air or ferry	230	190	115	**535**
6	Coetivy	By air	2220	1110	1110	**4440**
Total			**10410**	**3670**	**5780**	**19860**

Table 25: Estimated transportation cost per person to each island (USD)

Station	Year 1	Year 2	Year 3	Year 4	Year 5	5 Year Total
ALDABRA	23680	26048	28653	31518	34670	**144569**
DESROCHES	17760	19536	21490	23639	26002	**108427**
FARQUHAR	16280	17908	19699	21669	23836	**99391**
LA DIGUE	1820	2002	2202	2422	2665	**11111**
PRASLIN	2140	2354	2589	2848	3133	**13065**
SEYCHELLES INTERNATIONAL AIRPORT	0	0	0	0	0	**0**
COETIVY	17760	19536	21490	23639	26002	**108427**
Total	**79440**	**87384**	**96122**	**105735**	**116308**	**484989**

Table 26: Preventative maintenance Estimated cost (USD)

Station	Year 1	Year 2	Year 3	Year 4	Year 5	5 Year Total
ALDABRA	11840	13024	14326	15759	17335	**72284**
DESROCHES	8880	9768	10745	11819	13001	**54213**
FARQUHAR	8140	8954	9849	10834	11918	**49696**
LA DIGUE	910	1001	1101	1211	1332	**5556**
PRASLIN	1070	1177	1295	1424	1567	**6532**
SEYCHELLES INTERNATIONAL AIRPORT	0	0	0	0	0	**0**
COETIVY	8880	9768	10745	11819	13001	**54213**
Total	**39720**	**43692**	**48061**	**52867**	**58154**	**242495**

Table 27: Corrective Maintenance (Break-down response) – Estimated cost (USD)

Other maintenance cost - USD

The table below depicts the investments required to maintain the AWS fences, stands and solar panel brackets.

Activity#	Items	Quantity	Costing USD ($)
1.	Welding machine	1	795
2.	Angle grinder	1	198
3.	Drill	1	198
4.	Bench vice	1	100
5.	Ironwork toolkit	1	750
6.	Pipe wrenches (small, medium, large)	1	165
7.	Mallets (small, medium, large)	1	110
8.	Ear Hammer	1	55
Total			**2371**

Table 28: Investments required to maintain the AWS fences, stands and solar panel brackets

Item	Unit Price (USD)	Quantity p/a	Year 1	Year 2	Year 3	Year 4	Year 5	Total (USD)
Automatic Weather Stations (Spare parts)								
Datalogger (Data Collection Unit)	3058	3	9174	10091	11101	12211	13432	42577
Air temperature and humidity sensor	858	3	2574	2831	3115	3426	3769	11946
Radiation Shield with bracket	185	3	555	611	672	739	813	2576
Precipitation sensor	423	3	1269	1396	1535	1689	1858	5889
Wind Speed Sensor	1092	3	3276	3604	3964	4360	4796	15204
Wind Direction Sensor								
Pressure Sensor	2959	3	8877	9765	10741	11815	12997	41198
Wind Mast	2276	3	6828	7511	8262	9088	9997	31689
Stands (temperature/humidity, precipitation, radiation)	115	3	345	380	417	459	505	1601
Solar Power supply – solar module with mountings 12V 50W	115	3	345	380	417	459	505	1601
12V 33AH Battery with F11 terminals	155	3	465	512	563	619	681	2158
Power regulator	92	3	276	304	334	367	404	1281
16 or 32 Channel Relay Multiplexer	979	3	2937	3231	3554	3909	4300	13631
Modem 4G LTE CAT1 Cellular module	633	3	1899	2089	2298	2528	2780	8813
Antenna	29	3	87	96	105	116	127	404
Other components								
Lightning protection units	11	3	33	36	40	44	48	153
Grounding systems	29	3	87	96	105	116	127	404
AWS cabinet with mountings and battery holder	288	3	864	950	1045	1150	1265	4010

Item	Unit Price (USD)	Quantity p/a	Year 1	Year 2	Year 3	Year 4	Year 5	Total (USD)
Junction and terminal boxes	112	3	336	370	407	447	492	1559
Cables, wires, connectors	55	3	165	182	200	220	242	766
Maintenance Tools and Test Equipment								
Field test equipment (for sensors and data logger) - travel standard	9900	3	29700					29700
National standard (equipment (for sensors and data logger) – office standard	9900	3	29700					29700
Toolset for maintenance (Cutter, Allen key set, screwdriver, crescent wrench, open-ended wrench, wrench set, cable stripper, etc.)	575	2	1150					2100
Multimeter (field test equipment)	385	3	1155					1400
Multimeter (National standard)	385	3	1155					1400
Ground Resistance Meter	385	2	770					1400
Other/Calibrators								
Oscilloscope	290	2	580					1060
Calibration/recertification of Calibrators	2500	6	15000	16500	18150	19965	21962	69615
Total			**119 602**	**60 931**	**67 024**	**73 727**	**81 099**	**323834**

Table 29: Spare for surface land stations

#	Activity	Start date	End date	YEAR 1 (2024)				YEAR 2 (2025)				YEAR 3 (2026)			
				JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND
1.	**Maintenance of the surface observing stations**														
1.2	Procurement of maintenance tools and Test equipment	2024-01-01	2024-06-30												
1.2	Procurement of AWS Spare parts and components	Q1 of Year	Q2 of Year												
1.3	Procurement of Calibration/recalibration services for field test equipment	Q1 of Year	Q2 of Year												
1.4	Procurement of Calibration/recalibration services for Calibrators	Q1 of Year 1 and Year 3	Q1 of Year 1 and Year 3												

Table 30: Activity Plan: Procurement for surface observing network

The skills, and knowledge of the SMA staff are fundamental to the sustainability, effective and efficient operation of the upper-air network, to meet the GBON requirements and the design principles.

It is recommended that daily safety checks should be conducted for the balloon room/shed, and the hydrogen generating system. Furthermore, regular training (at least every 4 years) should be conducted, to ensure that all staff are updated on standards and practices, benefits and requirements for upper-air observations, technology improvements, system maintenance and quality management. The Hydrogen Generating Systems should also be serviced and recertified at every 5-year intervals to ensure their safety and reliability.

Activity	Interval	Cost USD ($)
Daily maintenance and gas leak detection checks	Daily	n/a
Hydrogen Generator Systems - service and recertification	Every 5 years	

Table 31: Costing for Recertification of Upper-Air Hydrogen Tank

f. Technical specification for new instruments and observing systems for the procurement process

The following documents are to be considered during the procurement of the GBON Automatic Weather Stations (AWSs) and radiosonde-related procurement.

- GBON Tender Specifications for AWSs (Version 1.1) see annex 1 on page 83
- WMO IOM Report No. 136: Generic Automatic Weather Station (AWS) Tender Specifications (IOM-136)

- Requirement document to be used as input to tender specifications for radiosonde-related procurements (Version 1.1)
- https://community.wmo.int/en/activitareas/wigos/gbon/implementation-global-basic-observing-network-gbon/task-teams/task-team-gbon-implementation-tt-gbon/tt-gbon-approved-material

g. Considerations for stations' security, constant power supply, communication, and related contingencies (risks can be incorporated in section 5).

Station Security:

- Install fencing around critical meteorological stations, particularly remote sites, to prevent unauthorized access and vandalism.
- Utilize CCTV systems, especially at high-value stations, to monitor activities around the equipment.
- Ensure that AWS sites on outer islands are equipped with tamper-resistant enclosures to protect sensitive instruments.

Constant Power Supply:

- Primary Power: Ensure a reliable power supply from local grids where feasible and reinforce connections with surge protection.
- Solar Power: Equip remote stations with solar panels and battery storage to support off-grid operations.
- Backup Generators: Deploy backup diesel generators, especially at primary locations such as the Seychelles International Airport and Aldabra, to sustain operations during outages. Implement regular maintenance to ensure generator reliability.
- Uninterruptible Power Supplies (UPS): Install UPS systems at stations with high data processing needs to provide short-term backup and prevent data loss during brief power interruptions.

Communication Systems:

- Data Transmission: Upgrade communication protocols from GSM/GPRS to 4G LTE or higher, especially for AWS in remote locations, to improve data reliability.
- Backup Communication Links: Establish redundancy in communication lines, such as satellite or alternative GSM providers, to ensure continuity in case of primary network failures.
- Real-Time Monitoring: Integrate remote monitoring software to track station status and enable technicians to respond quickly to communication disruptions.

Contingencies and Risk Management:

- Risk Assessment: Perform a risk assessment for each station, including natural hazards (e.g., cyclones, flooding) and human threats (e.g., vandalism).
- Equipment Redundancy: Provide spare parts and backup equipment for critical components, such as data loggers and sensors, to minimize downtime.
- Data Backups: Regularly back up data to cloud storage or offsite facilities to prevent data loss.
- Emergency Response Plans: Develop emergency protocols for station failures, ensuring technical staff are prepared to troubleshoot issues swiftly**.**

3.2. Design of the ICT infrastructure and services

SMA has a vast array of meteorological instruments and equipment distributed across strategic locations. The Server Room houses crucial data processing units, including Rimes MKIII, Transmet AMSS servers, CLIMSOFT Server, PUMA Servers, AWOS Server, and LAN communication devices. The Upper-air Sounding Station, equipped with a Vaisala Digicora sounding system and other significant instruments, adds to the comprehensive setup.

The engineering and technical staff are tasked with ensuring the functionality and performance of all instruments and information systems. Their duties involve routine checks, maintenance, calibration, and corrective measures to ensure minimal downtime and optimal operation of equipment. The approach includes daily, weekly, and monthly checklists and periodic calibrations documented meticulously as per the SMA's Quality Management System.

Daily tasks are governed by checklists outlined in MET FORM (71 A) & MET FORM (71 B), which guide the staff through procedures at both the Main Met Office and RAWINSONDE station. Fault reporting and resolution are streamlined through MET FORM 37, ensuring timely intervention and service continuity.

The Server Room

Picture 7: The Server Room

A comprehensive overview of the infrastructure and operational systems employed by the Seychelles Meteorological Authority (SMA) was investigated. This includes equipment, network, and procedures in place to facilitate SMA's meteorological services, with a focus on the technical and engineering tasks that underpin SMA's daily operations. We also investigated the recent addition of the Data Management System "SMAONE" and SMA's preparedness for WIS 2.0 implementation.

The following ICT infrastructure are installed in the server room:

- 2 x Servers for the SMAONE system used for monitoring and receiving AWS data then transfers the Data to the ClimSoft system.
- ClimSoft system dissemination of data to the GTS
- 3 x PUMA servers
- Their email services are hosted and provided for by the Government
- Vaisala AviMet
- SADC ClimSA (Climate Station) system was installed recently.

Backup power:

- Small UPSs for each unit (lasts for about 30 minutes or so)
- The Generator is not in a good working condition, but there is a plan to buy a second generator.

Network service providers:

1. Primary link is provided by: Cables & Wireless Seychelles at 10 Mbps upload and 10Mbps download.
2. Secondary link provided by: Airtel at 2 Mbps
3. AWS data transmission is currently utilising GSM/GPRS technology.

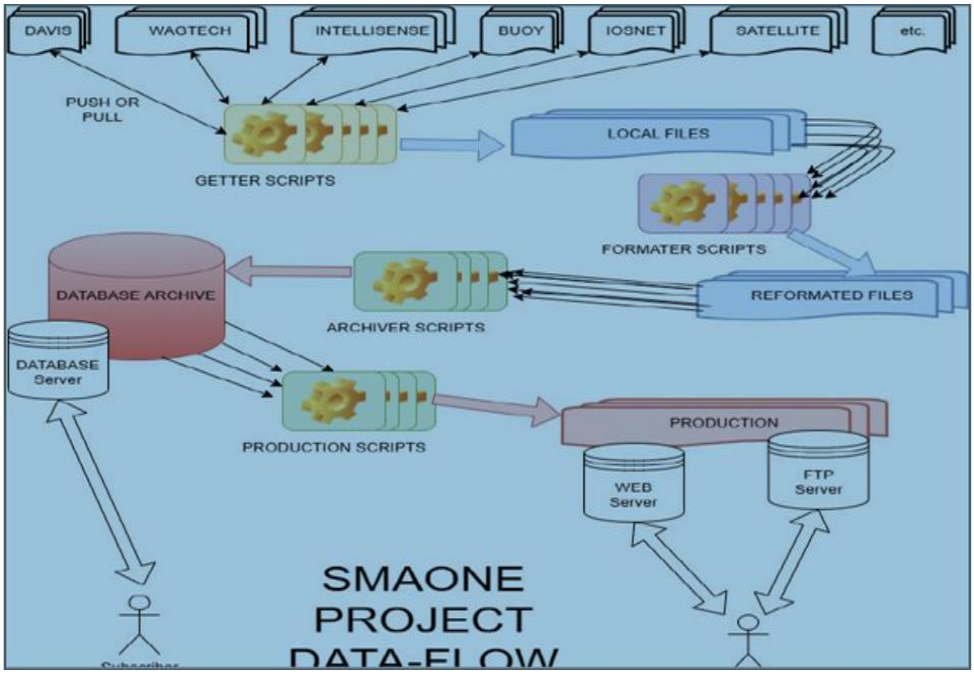
The recent acquisition of the "SMAONE" Data Management System represents a significant upgrade in monitoring AWS Stations and enhancing data dissemination capabilities. A detailed network infrastructure diagram and a list of all AWS Stations, including logger types and connection types, were provided for a thorough understanding of the data sharing framework.

a. Technical specifications of the data services (compatible with the requirements of WIS 2.0)

The critical component to the success of the GBON implementation is Information and Communication Technology (ICT) capability to support data communication from the remote AWS to the Global Telecommunications System (GTS). There is therefore a need for an ICT infrastructure and services design as well as the solutions on data transmission from an observing station nationally, on real-time bases through data management system and to the GTS. The designed system must have the capability to transmitted in Binary Universal Form for the data Representation (BUFR) format from the source (AWS) to the GTS.

The requirements for WIS 2.0 are that the AWS should have data logger that meet data transfer protocols, MQTT and SMTP. Data collected from the station must be converted automatically to generate BUFR reports for WMO international data exchange through GTS and WIS 2.0.

Below is the diagram depicting the data flow communication system of SMA



Picture 8: Data flow communication system of SMA

An assessment was conducted to evaluate SMA's readiness for the implementation of WIS 2.0. The recommendations from this assessment will be instrumental in shaping the National Contribution Plan, ensuring that SMA's infrastructure and processes align with global meteorological standards and practices. It is recommended that WIS 2.0 node be implemented nationally to fast tract data transmission from the Seychelles network.

b. Technical specifications for the data collection system from the observing station to the collection point

See Annex 3 on page 83 for detailed information.

Configuration and Diagnostic System

The main function of a configuration and diagnostic system are:

- Automatic Weather Station Configuration

The control, management and configuration of an automatic weather station are performed remotely through a network connection or in-site using direct access to the data logger from a laptop. The configuration includes data transfer in terms of protocols, schedule, data retention and recovery mechanism.

- Observation network monitoring

The monitoring of the stations' network is performed remotely through a network connection and must provide a real-time view of the status of the stations' connection, sensors, batteries, and other functional components.

c. *Detailed description of the measures to ensure resilience and continuity of the full data processing chain*

ID	Requirement Heading	Requirement
124	Messaging Requirements	The system must be capable of handling (coding, decoding, automatic generation) data encoded in BUFR, GRIB and NetCDF as required in the Manual on Codes Vol. I.2. The system is capable to handle the following data formats for national exchange: [as required by the NMHS].
209	Removal of old meteorological reports	The national message generation (NMG) should automatically remove old meteorological reports; the number of days after which the reports are removed is configurable by the NMHS.
208	Generation of meteorological reports 1	The NMG should generate standard meteorological reports according to the specifications provided in the Manual on Codes Vol. I.2 and store them for a configurable period of time. The content of the reports should be configurable be manageable by the system operator. Reports from AWSs must be encoded in BUFR using template 307096 according to the reporting practices in the Manual on Codes Vol. I.2.
1125	Generation of meteorological reports 2	In addition to the functionality defined in Generation of Meteorological Reports 1, it should also be possible to define reports of own composition consisting of arbitrary data that can be chosen freely from the available data. The MDMS should have a user-friendly tool to define such report templates. This tool should include but is not limited to the following functionality: • Definition of a report name. • Definition of the structure of a report. • The elements from the database. • The format of the elements to be included.

ID	Requirement Heading	Requirement
		• The order in which report elements are placed in a report. The following report elements are required: • Fixed text. All ASCII characters (also characters such as a carriage return and line feed) can be entered • Date and time • Meteorological data • Visual observations. A limited amount of computation capacity should be required to generate reports from the database.

Table 32: Data processing chain description

3.3. Design the data management system

Meteorological Data Management System

The main functions of a Meteorological Data Management System (MDMS) are:

- Data collection

The AWSs must be configured to send data to one or more MDMS via a suitable data transfer protocol: MQTT (Message Queue Telemetry Transport) or SFTP (Secure Shell File Transfer Protocol). Whenever possible MQTT should be preferred on SFTP. Data transfer must be performed in a way that communication failure does not result in data loss. For this purpose, MQTT must be configured to implement a quality of service of 1 (at least one message is received) or 2 (exactly one message is received). For SFTP a recovery mechanism must be provided to resend data lost during connection down time.

Data must be sent in a format well documented and easy to process. It is suggested the use of comma-separated values (CSV) or JSON (JavaScript Object Notation). Proprietary formats must be avoided, and the CSV or JSON schemas must be well documented. MDMS should be able to provide easy configuration based on templates, for both csv and JSON, for simultaneous collection from stations belonging to different observing networks or providing different data formats.

- Data format conversion

Data collected from the station must be converted automatically to generate BUFR reports for WMO international data exchange through GTS and WIS 2.0. Data should be converted to BUFR without any need to be loaded on a database. For GBON purposes the data received from the station must be directly encoded in BUFR after basic QC and without any further processing. Generation of meteorological reports for purposes other than GBON can be performed automatically in the MDMS but must not affect the timely production and exchange of GBON data.

- Data exchange

The MDMS must be able to automatically distribute meteorological data and reports. Reports for WMO international exchange have to be:

- Sent to a GTS Meteorological Message Switching System
- made available to WIS 2.0 through an HTTP service and new data must be notified by an MQTT broker. WIS 2.0 technical specifications for data exchange and an open-source reference implementation are available from https://docs.wis2box.wis.wmo.int.

MDMS must be able to download data from various sources and in particular form any WIS 2.0 source.

- Data services

MDMS should provide the following data services to satisfy NMHS's operational needs, national and international duties:

- Web API (OGC-API)
- Web Accessible Folder (WAF)
- Publication/subscription service (MQTT)
- Shared filesystem (Samba, NFS, S3, …)

Applications used by forecasters, scientists, warning systems, governmental and research organizations will access and use the data through the data services available. Web based data access will be guaranteed from remote locations with optional access control to designated datasets. The wide range of applications and programming languages able to connect to Web APIs (R, python, Excel, …) will ensure an ecosystem of data processing and visualization solutions, as well as web-based GUIs. The data services should be sufficient to cover the needs of existing operational platforms by means of traditional data transfer, direct data access through shared file systems or modifying the existing software to access data through the Web API service. A reference implementation of the data services described is available at https://docs.wis2box.wis.wmo.int.

- **Data storage and processing**

Data collected by a MDMS must be retained for at least one month before being transferred to a long-term archiving facility. Data will be stored in a NoSQL system (Elasticsearch, SOLR, MongoDB, …) or a Relational Database Management System (RDBMS). The required processing to provide quality-controlled data and statistics for climate purposes should be performed in an appropriate Climate Data Management System (CDMS) connected to the DMS for purpose of accessing the data (see https://github.com/opencdms). Processing in the MDMS should be reduced to the

minimum as the main purpose of the MDMS is to provide data services and should not be designed as a data processing facility.

In addition to the functional requirements, there are additional requirements related to the level of service required. One MDMS for the observing networks of a NMHS is a single point of failure that must be avoided with redundancy of the MDMS hardware, network connections and processing workflows or by deploying the MDMS on cloud-based services with the required level of resilience.

The SMA plays a pivotal role in supporting various sectors, including aviation, marine, tourism, and public services, through continuous meteorological observations and data dissemination. The effectiveness of these services relies heavily on the operational readiness and advanced infrastructure maintained by SMA. SMA recently acquired the "SMAONE" Data Management System, a significant upgrade in monitoring AWS Stations and enhancing data dissemination capabilities. SMA is also using CLIMSoft.

Recommendations

1. **Upgrade of Server Infrastructure**: To modernize the existing server infrastructure by transitioning from physical servers to a virtualized environment, enhancing performance, scalability, and cost-efficiency. e.g. (VMware / Hyper-V). Install advanced air-cooling systems to maintain optimal server temperatures and Implement fire suppression systems to protect server infrastructure.

2. Upgrade UPS: Increase UPS capacity to extend backup beyond 30 minutes.

3. Generator Upgrade and Maintenance: Repair existing generator; expedite purchase and installation of a second generator and implement dual-generator setup with automatic transfer switches.

4 Upgrade Internet/Network connectivity
Upgrade the primary link from 10 Mbps to a higher bandwidth 100 Mbps or 200 Mbps to support growing data demands. Upgrade the secondary link from 2 Mbps to at least 10 Mbps or 50 Mbps to provide a more robust failover option.

5. **Upgrade AWS Data Transmission**
Upgrade from GSM/GPRS to 4G LTE or 5G technology for faster and more reliable data transmission. Implement dedicated data channels (APN) or VPNs for secure and efficient data transfer from AWS.

WMO advocates for the implementation of WIS 2.0 as soon as possible which is aimed at replacing the GTS which will be switched off in 2035. The requirements for WIS 2.0 are that the AWS should have data logger that meet data transfer protocols, MQTT and SMTP. Data collected from the station must be converted automatically to generate BUFR reports for WMO international data exchange through GTS and WIS 2.0. It is strongly recommended that WIS 2.0 be implemented through this project.

Costing: ICT infrastructure requirements

Activities	COST Implications forecast in USD			
	Year 1	Year 2	Year 3	
Server Infrastructure Virtualization	150000	10000	15000	175000
Raised Floor and Windows	20000	N/A	N/A	20000
Fire Detection and Suppression	15000	N/A	N/A	15000
2 X MHS servers and SLA	40000	9000	10000	59000
2 X WIS 2.0 Servers	Virtualization	N/A	N/A	N/A
3 X Laptops for AWS maintenance	6000	N/A	N/A	6000
Networking Equipment	5000	N/A	N/A	5000
Storage for backup purposes	30000	5000	5000	40000
Internet/Network connectivity	20000	10200	10500	40700
TOTAL				**342700**

Table 33: ICT infrastructure requirements costing

3.4. Environmental and sustainability considerations

The Seychelles' natural environment is very fragile, and any environmental stress arising from local over-exploitation or Environmental and economic sustainability are inextricably linked. SMA addresses the environmental impact of observing technologies as they strive towards GBON compliance. The surface observing networks are designed, implemented, and operated with the aim of having sustainable weather and climate observing systems.

Recommendation

a. *Development and use of specifications that consider environmental sustainability for procurement of measurement instrument equipment to meet the GBON requirements*

Activity #	Activity	Preferred Material	Means of transportation: ship or aircraft	Labour/Human resources required	Estimated cost (USD)
1.	Transportation of AWS and components to the outer islands (combined cost)	n/a			
2.	Site – civil works for AWS				
3.	Installation of AWS (if not done by SMA staff)	n/a			

Activity #	Activity	Preferred Material	Means of transportation: ship or aircraft	Labour/Human resources required	Estimated cost (USD)
4.	Environmental Impact Assessment for the Hydrogen Generator at Aldabra	n/a	n/a		
5.	Transportation of Upper-air equipment, hydrogen generator and resources	n/a			
6.	Rehabilitation/Construction of Aldabra Upper-air building (building structure, roof, electricity connection, water supply and health and safety requirement (signage, antistatic flooring)				
7.	Disposing of any waste generated during the installation of the AWSs, Construction/rehabilitation of the upper-air building etc.	n/a			

Table 34: Building material, Transportation, Labour/human resources

Environmental Sustainability

At the World Meteorological Organization (WMO) INFCOM-1 meeting in 2019, Resolution 4 requested that the future development of the Global Basic Observing Network (GBON) addresses the environmental impact of observing technologies as member states advance towards GBON compliance. The goal of this work is to deliver recommendations for amendments to WIGOS regulatory material that will result in more environmentally sustainable weather and climate observing systems, technologies and practices.

The recommendations related to environmental sustainability are to be considered by SOFF peer advisors in the development of the instrument specifications for the procurement of AWSs to meet the GBON requirements.

b. Integration of sustainability considerations for the management of operations of GBON stations, including installation, calibration, and maintenance

The upper-air consumables used, meet environmental regulatory compliance for batteries, packaging and hazardous substances and mercury with the consideration of biodegradable packaging will be used where possible.

c. Careful material selection for the development, shipping, and day-to-day operations of GBON stations, with a focus on developing and using reusable instruments and sustainable methods of observation (e.g., elimination of single-use plastics).

SMA also considers the use of instruments that have the option for sub-components or sub-systems to be replaced rather than to dispose of the whole instrument. The plan is also to review a SOP that will guide the re-use of instruments and the elimination of single-use plastics or all-in-one sensors.

Module 4. GBON Human Capacity Development Module

4.1. Assessment of human capacity gaps

- The Seychelles Meteorological Authority is a small organisation. According to its organogram, it has defined roles: CEO Leadership at the top, supported by middle-management and three operational divisions.
- The operational divisions that would be involved in the implementation and management of the SMA's GBON network would, primarily, be the **Technical/Support Services** division and both its **Observation & Infrastructure'** and **'Computing & Information Systems'** sub-divisions
    - Observation & Infrastructure is manned by three persons: A Principal Engineer, a Senior Engineering Technician, and an Engineer. This means that these individuals carry (between them) the full responsibility of infrastructure maintenance. When increasing the number of SMA's GBON stations, this will further increase these employees' workloads, especially if station up-time is expected to meet the GBON Standards
    - It would be necessary then for SMA to consider increasing its human capacity to have an adequate number of staff to manage the geographically widespread network across the inner and outer islands.
- It is advisable that SMA develop an Education and Outreach Strategy that would engage the Seychellois youth to consider a career in the meteorological science space and reach out to those that are already in possession of relevant qualifications. This would then form a pool of potential recruits for the SMA
    - In terms of gender split in the organisation, 43% of staff members are female. Drilling down further, however, one finds that Technical/Support Division is made up of all male staff, showing that it is extremely skewed toward a male dominance. Empower SMA's Marketing and Outreach Officer to embark on a recruitment drive that will decisively target young females to join the ranks of the organisation.
- It is recommended that SMA engage it's end users (of their services and information products) to understand the vulnerabilities of women and girls and other vulnerable social groups when designing improved service. This undertaking would have to be unpacked, and take into consideration, the services and products that are provided, and how these can be fine-tuned, to cater for the vulnerabilities of women and girls.

4.2. Design capacity development activities for technical staff

The qualification level and work experience of current technical staff varies. The Job Description will be the guiding resource on what the standards and requirements are currently.

Surface Land Stations

Performance components: install instruments and communication systems
1. Assemble and test instruments before transport to site
2. Transport instruments to site
3. Install instruments and communication systems (including simple site preparation)
4. Coach observing and technical staff in the operation and maintenance of the instruments (including provision of SOPs), standard operating instructions, system manuals, wiring diagrams, and the like
5. Thoroughly test on-site instrument and communications performance, prior to operational cutover
6. Complete site classification for variable(s) concerned, prepare and submit instrument and variable metadata to WIGOS via the Observing Systems Capability Analysis and Review Tool (OSCAR)
7. Switch instrument(s) to operational mode.
Performance components: Maintain instrument and system performance
1. Schedule and carry out preventive maintenance and site inspection following prescribed procedures (for example, change wet bulb wick or recorder charts, clean pyranometer dome or ceilometer window, change anemometer bearings, and carry out preventive maintenance on more sophisticated pieces of equipment such as radars and AWSs as specified in the SOPs)
2. Ensure availability of prescribed spare parts inventories
3. Monitor data availability and the performances of instruments and communications systems
4. Routinely verify correct functioning of instruments, following prescribed procedures
5. Perform on-site calibration checks to ensure that instrument performance is within tolerance, following prescribed procedures
6. Provide guidance and refresher training, remotely, if necessary, to on-site staff, to maintain compliance with prescribed methods of operating the instruments, for making observations and with procedures for the reduction of observations
7. Inspect the exposure of instruments and remove any obstacles nearby if necessary
8. Record maintenance and site inspection4 events, calibrations, sensor/instrument replacements in the maintenance log or metadata repository.
Performance components: Diagnose faults
1. Detect abnormality in data acquisition and system operation;
2. Inspect observational instruments, communications systems, power supply facilities and auxiliary infrastructure for faults;

3. Provide guidance, remotely, if necessary, to on-site staff to identify and diagnose minor faults;
4. Record all faults and their occurrence time in a maintenance log or metadata repository
5. If repair is required, order delivery of requisite spare parts.
Performance components: Repair faulty instruments and systems
1. Provide guidance, remotely, if necessary, to on-site staff to repair minor faults;
2. Assess spare parts requirements and ensure availability;
3. Repair faulty components following prescribed procedures and processes;
4. Perform tests after repair to ensure compliance with performance requirements
5. Record repair actions taken and time of resuming data acquisition in a maintenance log or metadata repository.

Table 35: Training requirements for technical personnel

Meteorological Instrument Technician Training (based on "*Compendium of WMO Competency Frameworks* (WMO-No. 1209), Competency framework for personnel installing and maintaining instrumentation"		
Training course		**Cost (per 5 persons) ***
Install, manage, and maintain an Automatic Weather Station	WMO Integrated Global Observing System	**8500 USD**
	Surface meteorological instrumentation operating principles	
	AWS instrumentation and basic electronics (power and communications)	
	Installation of instruments and communications	
	AWS maintenance and inspection	
	Fault diagnosis	
	Monitoring performance of instruments / systems	
	Basic programming for systems configuration	
	Repair of faulty instruments and systems	
	Safety (OHS practices and creating a safe working environment)	

Table 36: Training requirements for meteorological technicians and technical personnel (*Excluding travel related costs)

Upper-air (radiosonde) land stations

Performance components
Prepare and deploy balloons and their payloads: • Balloon shed safety check. • Balloon preparation and filling. • Instrument ground check.

• Balloon release.
Track balloon flight
Compute and record: • Upper-air pressure, temperature, and humidity. • Upper-air wind speed and direction. • Other specialized upper-air observations as required (for example, ozone).
Encode and transmit upper-air observations using prescribed codes and methods.
Knowledge and skill requirements
1. Hydrogen safety and generation
2. Understanding of general meteorology as described in BIP-MT, including physical meteorology, dynamic meteorology, synoptic and mesoscale meteorology, climatology, meteorological instruments, and methods of observations;
3. SOPs and prescribed practices for performing upper-air observations
4. On-site instrumentation and systems (including software)
5. Care in handling instruments
6. Accuracy in reading instruments and recording observations;
7. Use of meteorological codes to record observations

Table 37: Training requirements for upper air sounding personnel

Conducting an Upper Air ascent and interpretation of Upper Air Data. (based on the necessary knowledge and skills elements contained in "*Compendium of WMO Competency Frameworks* (WMO-No. 1209), Competency framework for personnel installing and maintaining instrumentation"		
Training course		**Cost (per 5 persons) ***
Performing upper an air ascent and interpreting upper air data	**WMO Integrated Global Observing System	**4500 USD**
	Conduct an upper air ascent	
	Interpret upper air coded messages	
	Interpret upper air diagrams	
	**Safety (OHS practices and creating a safe working environment)	
Upper air equipment maintenance	Monitoring performance of instruments / systems	**To be included in the OEM installation quotation**
	Repair of faulty instruments and systems	

Table 38: Training requirements for upper air sounding personnel

The training on the automated radiosonde launcher will be included based on the upper air system design considered for Aldabra

4.3. Design capacity development activities for senior management

In addition, the Management-level training listed below would be beneficial for SMA's stakeholder management and understanding their unique stakeholder ecosystem (with an emphasis on tools for resolving real world complexities and understanding stakeholder interdependencies

Stakeholder Ecosystems, Shared Value partnerships and Sustainability

a. Create 'Shared Value'/'Shared Value Partnerships'

b. The triple-bottom-line: People, Planet, Profit, congruent with ESG (Environmental, Social & Governance (corporate governance)).

Systems understanding and awareness - with an emphasis on tools for real world complexities. Understanding interdependencies

1. Understanding technology as an enabler for any business, especially in the 4IR era.

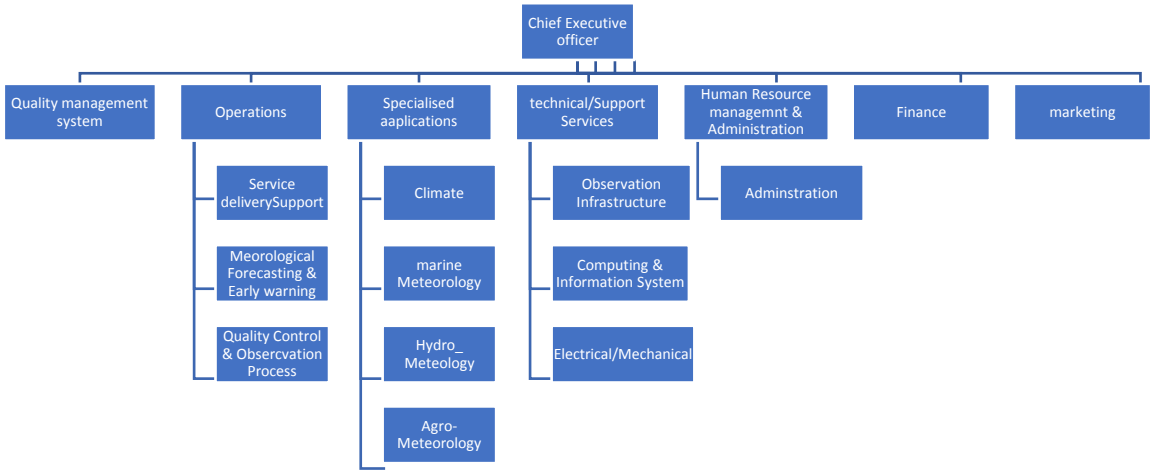
2. Decision-making and Change Management
3. Effective communication
   a. Internal communication and reporting structure
   b. Determining internal and external communications relevant to GBON, including ‘who’, ‘what’, when’, ‘how’ and ‘by whom’
4. Adaptability, agility and an organizational learning culture
   a. Understanding VUCA: **V**olatility, **U**ncertainty, **C**omplexity, and **A**mbiguity, and a catchall for “Hey, it's busy out there!"
   b. Building a mindset open to 'the next'
   c. Understanding the strengths of flexibility of using a learning organisational culture to underpin adaptability & agility, and

Building organisational resilience

Training course	**Cost per person***
Strategic partnership management	**1400 USD**
Creating shared value partnerships, with an emphasis on public-private partnerships	

Table 39: Resilience building costing (*Excluding travel related costs)

Organizational structure



4.4. Gender and CSOs considerations

The rollout of the GBON network is spread across the main island Mahe, and the outer island groups, Southern Coral Group, Amirante Islands, Alphonse Group, Aldabra Group and Farquhar Group. The Seychelles Meteorological Authority (SMA) conduct national awareness campaigns to sensitise the communities of the significant role which data collected from the weather observation infrastructure is playing toward climate resilience and food security. During these workshops the specific roles of CSOs across the main island Mahe, and the outer island groups, Southern Coral Group, Amirante Islands, Alphonse Group, Aldabra Group and Farquhar Group will be defined and communicated.

Communities will be adequately informed and involved in the initiative by SMA in close coordination with CSOs. This aim to translate into better understanding of the initiative throughout the Exclusive Economic Zone (EEZ) and consequently leading to a reduction of vandalism of the observation network and improve on data availability.

The SMA has a fair gender split throughout the organisation. However, when it comes to the key operational division 'Technical/Support Services' and its 'Observation & Infrastructure' and 'Computing & Information Systems' subdivisions is predominantly male. To address this imbalance education and recruitment efforts target the inclusion of female professionals (as Communication and Information engineers), as well as 'Observation and Infrastructure Engineering Technicians'. Recommended activities to address these gender considerations include:

- **Youth awareness raising outreach activities** targeting learners and students, that will make them aware of these professions/roles, and their importance to the operations of the SMA and the maintenance of the GBON
- **Gender sensitization consultations** based on the Gender Protocol on Development (and the national Gender Policy) in partnerships with women advocacy groups, ie. Gender and Media Plus Association of Seychelles (GEM Plus) which has already established a strong presence on the ground, and works with different spheres of government, and societal groups.
- **Stakeholder awareness outreach activities** aimed at all levels of society (in sector-specific audience groupings). These outreach activities will raise awareness of the Global Basic Observation Network (GBON), and how it contributes to the vital Early Warnings 4 All (EW4ALL) initiative of the WMO, with tailored stakeholder-relevant information sharing

SMA have existing collaboration with CSOs such as its main stakeholder organisations are the Islands Development Company Ltd (IDC) and the Seychelles Island Foundation (SIF). The IDC's role is to ensure that outer islands actively contribute to the socio-economic development of the Seychelles through various administrative and logistical services such as operating transport links to the islands, manage electricity generation and distribution, maintain efficient telecom links to the islands, infrastructure construction and maintenance. All these activities would be key considerations to the establishment of operations on the inner and outer islands that would form part of the GBON in the Seychelles. Stronger collaboration between the SMA and IDC would be mutually beneficial to both organizations' operations.

The SIF has an active Education and Outreach programme that targets the wider Seychelles community. SIF engages the community on relevant topics (GBON and EW4ALL would be some such topical subjects) by attending national and regional events for the sake of building public awareness. Their track record has revealed that local community involvement and support is vital to the success of projects. Working with established community engagement NGOs, (like SIF) will help in securing community support

- It is recommended that SMA engage it's end users (of their services and information products) to understand the vulnerabilities of women and girls and other vulnerable social groups when designing improved service. Furthermore. installation of weather station should be in location where communities can take responsibility for the upkeep of instrument sites.
- Seychelles Met Authority will, further, need to train personnel in Aldabra Island to ensure sustainability maintenance of the upper air sounding station in that area.

Module 5. Risk Management Framework

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

Risk category	Description	Probability	Mitigation action
Contextual risks Risks related to conflicts, safety and political insecurity jeopardizing the delivery of the Readiness phase outputs	Risks of disease outbreak or natural disasters (e.g., covid-19)	*Unlikely*	Ensure population is vaccinated and implementing WHO recommendations.
	Insufficient political commitment	*Unlikely*	Ensure SMA Legislation covers WMO requirements/activities. Involvement of SMA Board of Directors
	Not able to mobilize sufficient resources.	*Unlikely*	Move towards commercialization and cost recovery.
	Changes in government policies	*Unlikely*	Build institutional capacities to adapt to changes
Institutional risks Risks related to the beneficiary country's institutions participation in the Readiness phase activities	Insufficient human capacity / resources to manage the Readiness phase	likely	Recruit, train, and retrain existing staff, in accordance with the WMO Standards for Education and Training in Meteorology and Hydrology.

Module 6. Transition to SOFF investment phase

The Implementing Entity as the key role player should consolidate the proposed cost implication the report and align them to the current market prices to ensure GBON Compliance for the Seychelles.

Furthermore, the Implementing Entity should consider it procurement process and evaluate the feasibility of procurement of required instrumentation and services for rehabilitation of the identified GBON station for the Seychelles to be compliant.

Summary of GBON National Contribution Plan

Components	Recommended activities
Module 2. GBON business model and institutional development	1. It is hereby recommended that SMA works closely with Island development company limited (IDC), Seychelles Island Foundation (SIF) and the Public Utilities Corporation (PUC) in assessing the conditions of their weather observation infrastructure to consider incorporation into the national database through development of the national WIGOS plan
	2. It is hereby recommended that SMA leverage on regional organizations / bodies of relevance for implementation of GBON within the sub-region,
	3. Having considered the requirements for GBON assigned network, it is critical that the budget to operate and maintain this network must consider the entire life cycle requirement of the entire network
	4. Governance and Institutional Strengthening aimed at development of review of the strategy, and Organisational structure.
	5. Critical to the successful implementation of GBON National is adherence to the national policies and guidelines. The procurement Policies and guidelines of the Seychelles does recognize the role of international donor organisations in expediting implementation of activities in the country. It is hereby recommended that where the AfDB procurement policies are favorable for implementation of GBON, they be given priority.
Module 3. GBON infrastructure development	1. The results of the GBON National Gap Analysis however indicated that there is a need to rehabilitate the surface land station located at the Seychelles International Airport and for the re-opening and replacement of five silent/non-reporting stations with new Automatic Weather Stations that meet the GBON technical requirements. Moreover, an additional surface land station will be installed on Coetivy Island located approximately 290km from the south of Mahe to cover the

	southern part of the Seychelles Exclusive Economic Zone (EEZ). The existing upper-air (radiosonde) land station at Seychelles International Airport will be rehabilitated and a new station will be established and installed on the outer island of Aldabra Island
	2.a Upgrade of Server Infrastructure: To modernize the existing server infrastructure by transitioning from physical servers to a virtualized environment, enhancing performance, scalability, and cost-efficiency. e.g. (VMware / Hyper-V). Install advanced air-cooling systems to maintain optimal server temperatures and Implement fire suppression systems to protect server infrastructure. 2.b Increase UPS capacity to extend backup beyond 30 minutes. 2.c Repair existing generator; expedite purchase and installation of a second generator and implement dual-generator setup with automatic transfer switches. 2.d Upgrade the primary link from 10 Mbps to a higher bandwidth of 100 Mbps or 200 Mbps to support growing data demands. Upgrade the secondary link from 2 Mbps to at least 10 Mbps or 50 Mbps to provide a more robust failover option.
Module 4. GBON human capacity development	1. It would be necessary then for SMA to seriously consider increasing its human capacity to have an adequate number of staff to manage the geographically widespread network across the inner and outer islands
	2. It is recommended that SMA engage it's end users (of their services and information products) to understand the vulnerabilities of women and girls and other vulnerable social groups when designing improved service. This undertaking would have to be unpacked, and take into consideration, the services and products that are provided, and how these can be fine-tuned, to cater for the vulnerabilities of women and girls
	3. SMA, during the workshops to clearly define and communicate the specific roles of CSOs across the main island Mahe, and the outer island groups, Southern Coral Group, Amirante Islands, Alphonse Group, Aldabra Group and Farquhar Group.
Module 5. Risk Management	1. Considering the challenge insufficient political support, SMA to Ensure SMA Legislation covers WMO requirements/activities and Involvement of SMA Board of Directors in development of SMA Strategy.
	2. The risk of Insufficient human capacity / resources to manage the Readiness phase can be overcome through re recruit, train and retrain existing staff, in accordance with the WMO Standards for Education and Training in Meteorology and Hydrology.
Module 6. Transition to SOFF investment phase	The Implementing Entity as the key role player to consolidate the proposed cost implication the report and align them to the current market prices to ensure GBON Compliance for the Seychelles.

Annexes 1
Automatic Weather Station WS Sensor specifications

Atmospheric Pressure

ID	Requirement Heading	Requirement
27	Measurement Range	The measurement range must be 500 – 1080 hPa (for both station pressure and mean sea level pressure). [The NMHS may adapt this range in response to expected pressure range for the installation region]
29	Sensor Performance Constant	The instrument time constant, under controlled conditions must be 2 s or shorter.
31	Operational Conditions	As a minimum, the equipment installed outdoors must be capable of operating in a Temperature Range [-40 °C to +55 °C], Humidity Range [0-100 %RH, Non-condensing] and Wind Speed up to 50 m/s. Resistance to (vibration) shocks must be included. A NMHS may modify this requirement to meet meteorological conditions normally expected.
508 (and 40)	Achievable Sensor Uncertainty	The sensor uncertainty must be 0.15 hPa or better. For the tendency it must be equal or better than 0.2 hPa. Maximum difference: 0.3 hPa/year [Normal Use]. No more than 0.3 hPa/30 °C temperature change. For the tendency it must be equal or better than 0.2 hPa. Hysteresis less than 0.3 after change of 50 hPa and back again.
42	Static Head	To achieve the required uncertainty of the pressure measurements, a static head, should be used. If used, the static head should be located in an open environment, not affected by the proximity of buildings. The supplier should provide documentation specifying any additional uncertainty introduced by the use of their static head.
502	Sensor Type	The sensor/instrument for measuring pressure must be based on an electronic pressure sensor. However, any sensor type compliant with the requirements in this section must be considered.
524	Temperature Correction in Calibration	If the instrument is applying a correction for the ambient air temperature (measured internally or with a separate thermometer), the temperature compensation function should be fully taken into account in the calibration procedure.
28	Reporting Resolution	The resolution of reported measurement and tendency must be 0.1 hPa.
30	Sampling Frequency	The pressure should be sampled at least 4 times over the interval of the sensor time constant. For example, if the sensor time constant is 2 seconds, then there should be a sample at least every 0.5 s.
56	Units	Whatever physical quantity measured; pressure must be presented in/by the instrument/ system in hectopascals (hPa).
32	Calculated Parameters	Averages of all valid samples of pressure must be produced over 1-minute intervals. The 1-minute average must be used as the instantaneous value for pressure.
35	Rate of Change Check	After each signal measurement, the current value should be compared to the preceding one. If the difference between two samples is more

		than 0.3 hPa, the current sample is identified as suspect and is not used for the computation of an average.
38	Stuck Sensor	If over a 60-minute interval the value of 1-minute values of pressure have not changed by 0.1 hPa, then the data should be flagged as suspect for further investigation.
39	Jump Check	If the difference between consecutive 1-minute averages is more than 0.5 hPa, then the data should be flagged as suspect for further investigation. If the difference is more than 2 hPa, then the data should be flagged as erroneous for further investigation.
949	Derived Parameters	The pressure tendency should be determined using the difference between the current pressure measurement, and the pressure values over the previous 3 hours
1015	Derived Parameters 2	The NMHS may request that QFE and QNH be calculated by the sensor, as well as statistics (maximum, minimum, standard deviation) to meet local or Regional Association requirements. These should be outlined here.
1123	Derived Parameters 3	A Mean Sea Level should be determined, and WGS-84/EGM96 be applied to determine the altitude (to which the station pressure relates) with respect to Mean Sea Level

Air Temperature

ID	Requirement Heading	Requirement
1	Measurement Range	The measurement range must be -80 °C to +60 °C.
4	Sensor Performance Constant	The instrument time constant under controlled conditions must be 20 s or shorter over the entire operational range. For field measurements in non-actively aspired radiation screens this may not be achievable.
6	Operational Conditions	As a minimum, the equipment installed outdoors must be capable of operating in a Temperature Range [-40 °C to +55 °C], Humidity Range [0-100 %RH, Non-condensing] and Wind Speed up to 50 m/s. Resistance to (vibration) shocks must be included. A NMHS may modify this requirement to meet meteorological conditions normally expected.
25	Sources of Error	The Tendered equipment must demonstrate that the following common sources of error have been adequately compensated for: a) Self heating of the thermometer element b) Inadequate compensation for lead resistance c) Inadequate compensation for non-linearities in the sensor or processing instrument d) Sudden changes in switch contact resistance.
400	Achievable Sensor Uncertainty	The sensor uncertainty must be 0.2 ºC or better.
2	Units	Whatever physical quantity is measured Air Temperature must be presented in/by the instrument/system in degrees Celsius (°C).
3	Reporting Resolution	The resolution of the reported temperature must be 0.1 °C.
5	Sampling Frequency	The air temperature should be sampled at least 4 times over the interval of the sensor time constant. For example, if the sensor time

		constant is 20 seconds, then there should be a sample at least every 5 seconds,
7	Calculated Parameters	Averages of all valid samples of Air Temperature must be produced over 1-minute intervals. The 1-minute average must be used as the instantaneous value for air temperature.
8	Observation Extremes	The maximum and minimum temperature 1-minute (average) temperature values measured over a 24-hour period must be determined [=daily maximum/minimum]. The time of occurrence must also be stored.
34	Rate of Change Check	After each signal measurement, the current value should be compared to the preceding one. If the difference between two samples is more than 2 °C, the current sample is identified as suspect and is not used for the computation of an average.
36	Jump Check	If the difference between consecutive 1-minute averages (calculated one minute apart) is more than 3 °C, then the data should be flagged as suspect for further investigation. If the difference is more than 10 °C, then the data should be flagged as erroneous for further investigation.
37	Stuck Sensor	If over a 60-minute interval the value 1-minute values of air temperature have not changed by 0.1 °C, then the data should be flagged as suspect for further investigation.
1012	NMHS Calculated Parameters	Additional Air Temperature Statistics should be requested by the NMHS, to meet local or Regional Association requirements. These should be inserted here.

Humidity

ID	Requirement Heading	Requirement
69	Sensor Performance Constant	The instrument time constant under controlled conditions must be 40 s or better over the entire operational range. If used for Dewpoint Temperature measurement, then the sensor time constant must be 20 s. For the field measurements in non-actively aspired radiation screens this may not be achievable.
160	Operational Conditions	As a minimum, the equipment installed outdoors must be capable of operating in a Temperature Range [-40 °C to +55 °C], Humidity Range [0-100 %RH, Non-condensing] and Wind Speed up to 50 m/s. Resistance to (vibration) shocks must be included. A NMHS may modify this requirement to meet meteorological conditions normally expected.
475	Sensor Type	The sensor/instrument for measuring RH should be based on an electrical capacitance measurement probes. Sensors for measuring Dew Point directly are usually based on dewpoint mirror. However, any sensor type compliant with the requirements in this section should be considered by the customer.
481	Achievable Sensor Uncertainty	The sensor measurement uncertainty must be better than 3 %RH. If the sensor reports directly a Dew Point Temperature, the sensor uncertainty must be 0.25 °C.
57	Units	Whatever physical quantity measured, humidity must be presented in/by the instrument/system in %RH.

61	Measurement Range	The maximum measurement range must be 0-100 %RH. If presented as Dew Point Temperature, the maximum temperature range must be -80 °C to +35 °C.
68	Reporting Resolution	The Reporting Resolution for humidity must be 1 %RH (or better). If reported as Dew Point Temperature, the reporting resolution must be 0.1 °C
138	Sampling Frequency	The humidity should be sampled at least 4 times over the interval of the sensor time constant.
139	Calculated Parameters	Averages of all valid samples of humidity must be produced over 1-minute intervals. The 1-minute average must be used as the instantaneous value for relative humidity
141	Rate of Change Check	After each signal measurement, the current value should be compared to the preceding one. If the difference between two samples is more than 5 %RH, the current sample is identified as suspect and is not used for the computation of an average.
142	Jump Check	If the difference between consecutive 1-minute averages if more than 10 %RH, then the data should be flagged as suspect for further investigation. If the difference is more than 15 %RH, the data should be flagged as erroneous for further investigation.
143	Stuck Sensor	if over a 60-minute interval the value of the one-minute values of RH have not changed by 1 %RH and RH < 95 %, then the data should be flagged as suspect for further investigation.
462	Dewpoint Temperature calculations from Air Temperature and RH	If Dewpoint Temperature is calculated from Humidity and Air Temperature, the 1 and 10-minute averages of Dewpoint Temperature should be calculated from the instantaneous Humidity and Air Temperature measurements, after which the averages for Dewpoint Temperature can be calculated. It is not allowed to calculate averages for Dewpoint Temperature from averages of Air Temperature and Humidity.
947	Derived Parameters	If relative humidity is measured, then a Dew Point Temperature should also be calculated, using the formula from the *Guide to Instruments and Methods of Observation* (WMO-No. 8), Volume I, Chapter 4, Annex 4.B.
1014	NMHS Calculated Parameters	Additional Humidity Statistics should be requested by the NMHS, to meet local or Regional Association requirements. These should be inserted here.

Horizontal Wind Direction

ID	Requirement Heading	Requirement
71	Sensor Performance Constant	For Mechanical Wind Sensors, the Sensor Damping Ratio must be > 0.3.
157	Operational Conditions	As a minimum, the equipment (and supporting infrastructure) installed outdoors must be capable of operating in a Temperature Range [-40 °C to +55 °C], Humidity Range [0-100 %RH Non-condensing] and Wind Speed up to maximum wind speed required to be observed. Resistance to (vibration) shocks and lightning protection must be included. A NMHS may modify this requirement to meet meteorological conditions normally expected.
650	Sensor Type	The sensor/instrument for measuring WD must be an electrical recording wind direction instrument. The most common instruments in use are vanes,

		combined propeller anemometers/vane and ultrasonic instruments for measuring both wind speed and wind direction. However, any sensor type compliant with the requirements in this section must be considered. [[NMHS may edit if they have a preference for a particular sensor type]]
657	Achievable Sensor Uncertainty	The sensor uncertainty must be 5°.
973	Sampling Frequency	If the sensor is to be used to report wind gust, then wind speed should be sampled at 1 Hz or greater (4 Hz is preferred).
59	Units	Whatever physical quantity measured; Wind Direction must be presented in/by the instrument/system in degrees clockwise from true north.
63	Measurement Range	The maximum measurement range must be 0-360 degrees.
66	Reporting Resolution	The Reporting Resolution for Wind Direction must be 1 degree.
651	Wind Direction Sensor Orientation	Wind direction is defined as and must be reported as the direction from which the wind blows, and it is measured clockwise from geographical north, namely, true north (referred to the World Geodetic System 1984 (WGS-84) and its Earth Geodetic Model 1996 (EGM96)).
654	Practical Range	The maximum measurement range must be 0 – 360°. If two successive samples differ by more than 180°, the difference is decreased by adding or subtracting 360° from the second sample to obtain a wind direction between 0 – 360°.
78	Vector Averaging	Vector averaging should be used for the average values of wind speed and direction.
83	Minimum Data	At least 75% of the wind direction samples should be available to enable the computation of both the 2-minute and 10-minute averages. If insufficient data, the 2-, 10-minute average should be marked as invalid/missing.
87	Stuck Sensor	If the average values of wind direction do not vary by more than 10 degrees over a 60-minute interval, the data should be flagged as suspect for further investigation.

Horizontal Wind Speed

ID	Requirement Heading	Requirement
70	Sensor Performance Constant	For a mechanical wind speed sensor, the distance constant must be in the range 2-5 m. [A distant constant is not required for an ultrasonic sensor]
73	Sampling Frequency	If the sensor is to be used to report wind gust, then wind speed should be sampled at 1z or greater (4 Hz is preferred).
158	Operational Conditions	As a minimum, the equipment (and supporting infrastructure) installed outdoors must be capable of operating in a Temperature Range [-40 °C to +55 °C], Humidity Range [0-100 %RH Non-condensing] and Wind Speed up to maximum wind speed required to be observed. Resistance to (vibration) shocks and lightning protection must be included. A NMHS may modify this requirement to meet meteorological conditions normally expected.
613	Sensor Type	The sensor/instrument for measuring Wind Speed must be based on an electrical anemometer. The most common instruments in use are cup anemometers, propeller anemometers and ultrasonic anemometers.

		However, any sensor type compliant with the requirements in this section must be considered.
619	Achievable Sensor Uncertainty	The sensor uncertainty must be 0.5 m/s for Wind Speed ≤ 5 m/s and 10% > 5 m/s.
60	Units	Whatever physical quantity measured, Wind Speed and Wind Gust must be presented in/by the instrument/system in metres per second (m/s).
64	Measurement Range	The maximum measurement range must be 0-75 m/s. In regions of extremely high winds, an extended range of 0-100 m/s should be requested. Wind Gust may reach 150 m/s.
65	Reporting Resolution	The Reporting Resolution for Wind Speed must be 0.5 m/s. The Reporting Resolution for Wind Gust (if measured) must be 0.1 m/s.
72	Calculated Parameters	Averages of all valid wind speed samples over 10-minute intervals must be produced. This 10-minute average must be used as the instantaneous value for wind speed. A standard deviation of wind speed must also be calculated. If the wind sensor is in support of an aerodrome, then an additional 2-minute average must be calculated.
74	Calculated Parameters 2	If an observation of wind gust is required, then this must be the running mean of all valid wind speed samples in a 3-second period.
77	Vector Averaging	Vector averaging should be used for the average values of wind speed and direction.
82	Minimum Data	At least 75% of the wind speed samples should be available to enable the computation of both the 2-minute and 10-minute averages. If insufficient data, the 2-, 10-minute average should be marked as invalid/missing
84	Rate of Change Check	If the difference between a wind speed sample and the preceding one is more than 20 m/s, then the data should be flagged as a suspect for further investigation and not used for the calculation of the average.
85	Jump Check	If the difference between consecutive 2-minute wind speed averages is more than 10m/s the data should be flagged as a suspect for further investigation. If the difference is more than 20m/s it should be flagged as erroneous for further investigation.
86	Stuck Sensor	If the average values of wind speed do not vary by more than 0.5 m/s over a 60-minute interval, the data should be flagged as a suspect for further investigation

Precipitation Amount/Intensity

ID	Requirement Heading	Requirement
559	Sensor Type (Intensity)	The sensor/instrument for measuring precipitation intensity must be based on an electronic recording instrument. Any sensor type compliant with the requirements in this section must be considered. The Precipitation Amount and Intensity Sensor should be the same piece of equipment.
110	Collecting Gauge Orifice Area	In case the sensor/instrument for measuring Precipitation is based on collection of precipitation, the area of the collector orifice must be at least 200 cm^2 and no larger than 500 cm^2. The area of the orifice must be known to the nearest 0.5%, and the construction must be such that this area remains constant while the gauge is in normal use. The construction must be such as to minimize wetting areas. The container must also have a narrow entract and be sufficiently protected from radiation to minimize the loss of water by evaporation.

159	Operational Conditions	As a minimum, the equipment (and supporting infrastructure) installed outdoors must be capable of operating in a Temperature Range [-40 °C to +55 °C], Humidity Range [0-100 %RH Non-condensing] and Wind Speed up to maximum wind speed required to be observed. Resistance to (vibration) shocks and lightning protection must be included. A NMHS may modify this requirement to meet meteorological conditions normally expected.
531	Sensor Type	The sensor/instrument for measuring Precipitation must be based on an electronic recording instrument. Any sensor type compliant with the requirements in this section must be considered.
568	Sensor Time Constant (Intensity)	The instrument time constant under controlled conditions must be better than 30 s.
538	Achievable Sensor Uncertainty	The sensor uncertainty must be the larger of 5% or 0.1 mm.
566	Achievable Sensor Uncertainty (Intensity)	The sensor uncertainty must be: • Under constant flow conditions in laboratory: o 5% for > 2 mm/h, o 2% for > 10 mm/h. • In the field: o 5 mm/h, o 5% above 100 mm/h.
541	Heating	If appropriate for local conditions, the precipitation sensor should be equipped with rim heating and funnel heating (tipping bucket). The heating should be controlled by a thermostat, and it should be switched on below an ambient temperature of 5 °C. The heating should avoid snow and ice building up at the rim, and it should melt solid precipitation falling into the funnel. The heating should keep the rim and funnel above 0 °C, but the heating should be as little as possible to avoid evaporation of the precipitation. For other types of instruments, heating should be offered as required for the local conditions.
58	Units	Whatever physical quantity measured, Precipitation Amount must be presented in/by the instrument/system in millimetres.
561	Units (Intensity)	Precipitation intensity must be presented in mm/hour (based on a 1-minute average).
62	Measurement Range	The maximum measurement range must be 0-500 mm/day. This should be increased to meet local conditions.
562	Measurement Range (Intensity)	The maximum measurement range must be: 0.02 – 2,000 mm/hour.
67	Reporting Resolution	The Reporting Resolution for Precipitation Amount must be 0.1 mm. If reporting daily totals, 0.2 mm should be used. If reporting weekly or monthly totals, 1 mm should be used.
564	Reporting Resolution (Intensity)	The resolution of reported measurement must be: 0.1 mm/hour.
111	Calculated Parameters	The individual measurements are providing the instantaneous readings. The system must calculate/make available amounts over 1 minute, 3 hours and 24 hours.

Annexes 2
Upper Air Stations systems Sensor specifications

Table 36: Rehabilitation of Upper air buildings

ID	Requirement Heading	Requirement
	Rehabilitation of 4 balloon rooms/sheds	Refurbishment of the balloon room/shed • Fix building structure. The balloon room should be well ventilated, static and waterproof. • Replace corrugated iron roof. • Replace broken windows • Install flame/spark-proof electric-light fittings inside and outside balloon room/shed. • Install mains power to the building. • Connect water supply to the building. • Installation of fire protection (extinguishers, signs, and alarms) • Installation of complete earthing (grounding) system with all fittings, with the hydrogen equipment and the lightning conductor separately connected to a single earth. Installation must comply with national safety standards. • Provision of first aid kits

1. Environmental Sustainability

Table 37: Environmental Regulatory Compliance

ID	Requirement Heading	Requirement
1-01	General Compliance	The proposed instruments must comply, at a minimum, with recognized European Environmental regulations. Applicable* regulations must apply to the instrument itself, all of its sub-systems, its packaging, and associated consumables. **'Applicable' requires knowledge of the materials and components. Where certain materials, chemicals, and components are used – compliance to regulations controlling their use must be confirmed.*
1-02	Batteries *(example)*	Batteries and Accumulators and Waste Batteries and Accumulators Directive (2006/66EC)
1-03	Packaging *(example)*	Packaging and Packing Waste Directive (1994/62/EC)
1-04	Hazardous Substances *(example)*	RoHS 2 - Restriction of Hazardous Substances Directive (2011/65/EU)

1-05	Chemical Registration *(example)*	REACH – Registration, Evaluation, Authorization, and Restriction of Chemicals (2006/1907/EC)
1-06	Mercury *(example)*	Minamata Convention on Mercury - COP
1-07	Local Jurisdiction	Where recognized regulations, applicable in the jurisdiction where the instrument is installed, are equivalent to or stricter - the local regulation must be applied over the European regulation.

Table 38: Material Use – Instrument

ID	Requirement Heading	Requirement
1-08	Material Identification	The material of each component part of the proposed instrument must be identified by its applicable recognized recycling code.
1-09	Recycled Content	The mass and percent of recycled raw material must be disclosed for each component part made of a homogenous material (coatings excluded).
1-10	Biodegradability	Biodegradable* components in the proposed instrument must be identified. *Biodegradability is defined as >90% of the original material is converted into CO2, water, and minerals by biological processes within 6 months.

Table: 39: **Material Use – Packaging**

ID	Requirement Heading	Requirement
1-11	Material Selection	Where packaging material selection allows, without degradation of the instruments' performance or shelf life, only recyclable materials must be used.
1-12	Material Identification	The material of each packaging element must be identified by its applicable recognized recycling code.
1-13	Biodegradability	Where packaging material selection allows, without degradation of the instruments' performance or shelf life, only biodegradable* materials must be used. *Biodegradability is defined as >90% of the original material is converted into CO2, water, and minerals by biological processes within 6 months.

Table 40: Instrument design

ID	Requirement Heading	Requirement
1-14	Design for Repair	Where instrument performance requirements allow, without degradation of, for example, water intrusion or temperature range, replaceable sub-components and sub-systems of the proposed instruments must

		be serviceable or replaceable, without the requirement to discard the whole instrument.
1-15	Efficient Packaging	Packaging for the instrument must minimize transport volume and mass wherever possible, without compromising transport durability and equipment performance following long-term storage.
1-16	Recyclability	The instrument design must consider end-of-life disposal and maximize the recyclability of the assembly by facilitating efficient separation of all recyclable materials.

Table 41: Operations and Maintenance

ID	Requirement Heading	Requirement
1-17	Energy Performance	Where feasible, without degradation to the proposed instrument's performance under its specified operating range, the instrument's energy use must be minimized.
1-18	Chemical Disclosure	All chemicals used in the operation, calibration, and maintenance of the proposed instrument must be disclosed and a Material Safety Data Sheet must be provided. Environmentally harmful chemicals must be avoided or minimized where no suitable alternative is available.
1-19	Internal Batteries	Details of the battery or accumulator design, covering, cell type, voltage, capacity, and any necessary safety information must be supplied for the proposed instrument if the design includes a battery or accumulator. Safety information must include instructions for the safe disposal of the battery or accumulator, consistent with local regulations, or the 2006/66/EC directive – whichever is stricter.

1 Documentation, maintenance, and safety

Table 42: Documentation and Training

ID	Requirement Heading	Requirement
2-01	Tender Language	All Tender documents must be in English
2-02	Project/Tender Schedule	The supplier must provide a Project Schedule/Implementation Plan with the offer.
2-03	Documentation	The supplier should provide documentation in electronic format [with permission for the customer to reproduce for internal use] outlining: - basic theory/principles of operation of equipment - step-by-step instructions on the required maintenance and the frequency with which this maintenance is recommended to be performed.

		- recommended spare parts and test equipment (for maintenance and repair).
2-04	Serial Number	Each instrument must be supplied with a unique serial number.
2-05	Site Drawings	Where the supplier provides Site design, clear site drawings showing the location of cables must be provided to the customer for each site.
2-06	Training	Customer technicians should receive training onsite or at a location designated by the NMHS, on calibration, installation, maintenance, software, QC/inspection [if appropriate], software and operational procedures for the instrument, and on all aspects of the operation of the upper-air systems.

Table 43: Maintenance and Operation

ID	Requirement Heading	Requirement
2-07	Maintenance from a remote location	The control/processing system should support maintenance from a remote location. At least the following functions are supported: • inspection of the real time meteorological observations that are ingested/recorded by the upper-air system • inspection of log records • facilities to change parameter settings and/or station configuration To perform these maintenance functions, a system operator password [or other NMHS determined security] is required.
2-08	Reliability detection of failures	The unavailability of either hardware or software parts that could prevent the execution of the systems' primary function should not go unnoticed.
2-09	Equipment design	The design of equipment and cabinets must facilitate routine inspections.
2-10	Off-line test	The system allows for off-line testing in an isolated environment before and after installation.
2-11	Pre-implementation test	The system allows for testing in the operational environment before implementation, without affecting the operation of the rest of the system.
2-12	Standard components currently in use	It is the customer's policy to maintain uniformity in inspection and maintenance procedures for all meteorological facilities and to keep a minimum level of spare parts. Therefore, it is recommended to consult the list of currently used makes for mechanical, electrical and software components. List of component types currently in use by the customer (Item/Manufacturer) PCs [xxx]; Servers [xxx];

		Network components [xxx]; Modems [xxx]; Routers [xxx]; Cabinets [xxx]; Rack equipment [xxx] [xxx to be completed by the customer]
2-13	On-line help	The system should provide built-in help facilities which are able to replace user documentation. The online help should be detailed enough to aid a user trained in the general principles of the system.
2-14	Recommended Spare Parts List	The Contractor must submit a Recommended Spare Parts List (RSPL) based upon the Maintenance Conditions as specified in the Maintenance Conditions document and the required availability (MTBF, MTTR) as specified in the Requirement Specifications document. This list must contain spare parts recommended by the Contractor to support/maintain the System and System Components during their respective lifetimes regarding the following: • For consumables the Contractor must recommend an amount of spare parts sufficient for two years for the System and System Components. • For repairable System Components (or modules of the System • Components, if applicable), the Contractor must recommend a number of spares based on the mean time between failure (MTBF) for that specific System Component. • For modules that can only be replaced as a whole in case of • malfunctioning, the Contractor must recommend a number of spares based on the lifetime of the System and on the MTBF as provided in the Requirement Specifications document. • The Contractor must make a recommendation for COTS-items.
2-15	Design life for the systems	The system should be designed for a life cycle of at least 10 years.
2-16	Operational hours of system components	Under normal circumstances, system components must perform their primary functions 24 hours a day and 7 days a week.
2-17	Requirements for materials and components	All materials and components furnished must be new and designed to meet the customer's requirements. The supplier has to take into consideration that the installation must not cause any damage to installations and systems.

Table 44: Safety and standards

ID	Requirement Heading	Requirement
2-18	Environment: EMC	Electromagnetic Compatibility (EMC) susceptibility must be according to EC- regulations (or other relevant national or international standards), but special care must be taken to withstand static electric shocks, as well as the use of handheld radio and telephone equipment in the vicinity of the systems.
2-19	Environment: shock and vibration level	The upper-air system should be able to operate in an environment with a shock and vibration level not exceeding 0.1 kB (DIN 4150/ISO 4866).
2-20	Electrical Safety	All installed equipment must comply with applicable local requirements for electrical safety. In the absence of local requirements, IEC 60950-1 is used.
2-21	Electrical regulations	The equipment and installation must conform to the regulations of local authorities. The most common international standards are (latest versions must be applicable): • CE marking • FCC Declaration of Conformity • ISO 9001: quality management systems and quality assurance • In addition, local standards and regulations apply, the supplier to define which ones are valid for the installation region (latest versions): • Safety regulations for low voltage installations, including supplements and alterations • Lighting conductor installations • Telecommunication colours of cores of cables for use inside buildings and for mounting wires • Telecommunication regulations for wireless (data)communication, use of available frequencies • Factories built low voltage switch gear and control cabinets • Safety transformers • Electrical symbols The supplier must be responsible for the correct application of local standards (latest editions) and regulations necessary to achieve conformity with local legislation. In the absence of local requirements, IEC 60950-1 is used.
2-22	Electromagnetic Compatibility	Installed equipment should have suitable electromagnetic compatibility for operation in the installed environment. In the absence of a local standard, IEC 61326:1997 + A1:1998 + A2:2000 + A3:2003 can be used.

2-23	Regulations	The equipment and installation must conform to the latest editions or regulations of local authorities and the customer. The supplier must be responsible for the correct application of valid European/US/applicable standards (latest editions) necessary to achieve conformity with the local legislation on machinery safety. For electrical and control systems particularly, all relevant components, apparatuses, panels, boards, systems and installations, which are part of the scope of work, have to comply with the applicable standards.
2-24	Workmanship Rules	Cabinets are assembled by the supplier. High-qualified workmanship and extreme care should be applied when assembling the equipment. At least the following aspects should reflect this: • All process specification steps should be rigorously followed. • All quality assurance specifications should be rigorously followed. • High-quality soldering with a good reflow, it should be free of excessive solder, pits, and cracks, and is not subjected to mechanical stress. • All cabling should be properly guided and bundled, and attached every 30 cm (no loose cables, no free hanging cables). Unnecessary extra cable loops should be avoided. Cables have always to be installed as close as possible to grounded surfaces. All cable connections in cabinets should be terminated on connector plugs with metal enclosures. The cabling inside cabinets should be routed in an orderly manner in fixed traces and tied up. • The presence of loose cabling over lengths of more than 30 cm is not permitted. • Bolts should be properly torqued and sealed. • All parts should be properly attached by screws, adhesive or brazing (no loose parts). • Painting and coatings should be applied smoothly and with constant thickness, without the presence of drops and non-treated areas. • All equipment should be adequately cleaned and free of dust and dirt. Cabinets, enclosures, and housings should be free of scratches and dents.
2-25	ISO 9001	All suppliers, and their subcontractors were appropriate, should have ISO 9001 certification. Documentary evidence of this certification should be included with the Tender documents.

2-26	Physically disconnection of equipment	When equipment is switched OFF, e.g., by means of a physical ON/OFF switch, the total equipment can be physically disconnected from the power supply. If not so, provisions will be supplied enabling a physical disconnection.
2-27	Minimising risk of injury and damage	The system must be designed in such a way as to prevent the risk of personal injury or system damage.
2-28	Grounding compliance	Grounding must be according to the applicable regulations. The metal frames and casings of the cable runs, and the remote-control stations must be bonded together and earthed to the earth bars. The grounding must not be connected to the building earth, but to the installation grounding system as provided by the customer. Armoured cables must only be earthed at the power feeding side.
2-29	Cable protection of for local conditions	The NMHS may specify additional cabling requirements to reflect local climatic/soil conditions or regulations - for example on cabling depth, or protection from humidity or vermin
2-30	Installation protection factor for equipment	Degree of protection between panels and between cable compartments and cabinets should be IP 30. When doors are opened protection should be IP 20. Degree of protection between cable compartment and main bus-bar compartment should be IP 40 after extension. For cabinets and equipment not installed in cabinets, protection should be IP 55.
2-31	Compliance of cables to local standards, regulations and norms	All cables that are used in the systems delivered by the supplier, must comply to local standards, regulations and norms. It is the responsibility of the supplier to find out what local standards, regulations and norms are applicable and that all cables are compliant with these regulations.

Table 45: Site Specification Requirements

ID	Requirement Heading	Requirement
3-01	Infrastructure	The infrastructure to house and operate the upper-air system (i.e. buildings and utilities) are not specified in this document. These details must be provided as general information in the technical specification and the vendors should be requested to confirm compatibility with the offered system and any additional infrastructure and utilities that need to be provided.
3-02	Site location(s)	The geospatial location of the site(s) must be provided in the technical specification, along with any relevant

		metadata (i.e. station identifier), and a full address for international delivery. • SEYCHELLES INTER. AIRPORT (RAWINSONDE STATION): Latitude: -4.6790 Longitude: 55.5308 • ALDABRA: Latitude: -9.4017 Longitude: 46.2061
3-03	Existing equipment	If the upper-air system is expected to be integrated with existing equipment at the site, this needs to be detailed in the technical specification and the vendor requested to confirm compatibility of their system and the provision of any additional components to allow the equipment to be integrated.
3-04	Station sounding schedule	This order is expected to provide a minimum of 60 months of operations, when meeting the minimum requirement of 2 daily soundings per month with measurements of temperature, humidity and wind to at least 30 hPa.
3-05	Delivery	The cost of DAP delivery to the address in 3-02 must be included.
3-06	Packaging	Packaging must be suitable for the international delivery.

4. Meteorological Radiosondes

Table 46 General

ID	Requirement Heading	Requirement
4-01	Radiosonde Intercomparison	The measurement performance of the offered radiosonde must be verifiable by either participation in the latest WMO radiosonde intercomparison, currently China (2010) and/or Germany (2022), or directly referenced to a radiosonde that participated, through an independent report recognized by WMO (INFCOM/Standing Committee on the Measurements, Instrumentation and Traceability (SC-MINT).

Table 47: Temperature Measurement Requirements

ID	Requirement Heading	Requirement
4-02	Temperature Range	The range of temperature capable of being sampled shall not be less than +50 °C to -100 °C.
4-03	Pressure Range	The temperature sensor shall be capable of measuring temperature from 1080 hPa to at least 3 hPa.
4-04	Resolution	The reported resolution shall be 0.1 °C or better.
4-05	Uncertainty	It shall be possible to measure temperatures during ascent with an absolute error of no more than 0.5 °C at all levels.

4-06	Reproducibility	It shall be possible to measure temperatures during the ascent to a reproducibility within: a) 1080 - 100 hPa: 0.2 °C b) 100 - 20 hPa: 0.3 °C c) 20 - 3 hPa: 0.5 °C

Table 48: Relative Humidity Measurement Requirements

ID	Requirement Heading	Requirement
4-07	Humidity Range	The range of relative humidity capable of being sampled shall not be less than 0% to 100% with respect to water.
4-08	Pressure/Temperature Range	The humidity sensor shall be capable of measuring humidity in the temperature range of +50 °C to -100 °C and the pressure range of 1080 hPa to at least 100 hPa.
4-09	Resolution	The reported resolution shall be 1% or better.
4-10	Uncertainty	It shall be possible to measure relative humidity during ascent with an absolute error of no more than 5% at all levels.

Table 49: GPS Derived Pressure Measurement Requirements

ID	Requirement Heading	Requirement
4-11	Pressure Derivation	The radiosonde shall be capable of deriving pressure from GNNS altitude. The manufacturer shall specify how the pressure measurements are calculated.
4-12	Pressure Range	The range of pressure being derived shall be at least 1080 hPa to 3 hPa.
4-13	Resolution	The derived pressure measurements shall have a resolution of at least 0.1hPa.
4-14	Uncertainty	It shall be possible to measure derived pressures during ascent with an absolute error of no more than: a) 1080 - 100 hPa: 1 hPa b) 100 - 3 hPa: 0.6 hPa
4-15	Sampling Rate	The radiosonde shall report GPS derived pressure data with a sampling rate of at least one measurement every 2 seconds.

Table 50: GPS Derived Geopotential Height Measurement Requirements

ID	Requirement Heading	Requirement
4-16	Geopotential Height Derivation	The radiosonde shall be capable of providing geopotential height measurements derived from GNNS measured geometric height. The manufacturer shall specify the method used to convert between geometric and geopotential height.
4-17	Height Range	The range of geopotential height measurements shall be at least 0 - 40 000 m.

4-18	Resolution	The geopotential height measurements shall have a resolution of at least 0.1 m.
4-19	Uncertainty	It shall be possible to measure geopotential height during ascents with an absolute error of no more than 20 m at all levels.
4-20	Sampling Rate	The radiosonde shall report geopotential height data with a sampling rate of at least one measurement every 2 seconds.

Table 51: Wind Measurement Requirements

ID	Requirement Heading	Requirement
4-21	Wind Range	The system shall measure wind by tracking the radiosonde movement using GNNS navigation signals.
4-22	Wind Speed Range	The range of wind speed that can be sensed shall be 0 to at least 120 m/s.
4-23	Wind Direction 360^0	The range of wind directions capable of being sensed shall be through the full 360 degrees of azimuth.
4-24	Height Range	Winds shall be reported starting no higher than 100 m up to at least 40 000 m.
4-25	Resolution of Wind Speed / Orthogonal Wind	Wind speed and orthogonal wind components shall be measured with a resolution of at least 0.1 m/s.
4-26	Resolution of Wind Direction	Wind direction shall be measured with a resolution of at least 1 degree.
4-27	Wind Speed Uncertainty	It shall be possible to measure wind speed with an absolute error of no more than 0.5 m/s at all levels.
4-28	Wind Direction Uncertainty	It shall be possible to measure wind direction with an absolute error of no more than 3 degrees at all levels.
4-29	Sampling Rate - Wind Data	The radiosonde shall report all wind data with a sampling rate of at least one measurement every 2 seconds.

Table 52: Physical Design and Launching Requirements

ID	Requirement Heading	Requirement
Radiosonde Design		
4-30	Weight	The radiosonde weight shall not exceed 400 grams, including battery and un- winder.
4-31	Wind Speed Capability	The radiosonde shall be sufficiently robust to withstand launching in winds gusting up to 35 m/s without damaging the radiosonde sensors.
4-32	Suspension Length	The radiosonde shall deploy to a suspension length of at least 30 m +/- 1 m beneath the balloon after launch.

ID	Requirement Heading	Requirement
4-33	Consistency of Configuration of Sensor Boom	The radiosonde shall have temperature and humidity sensors mounted externally on at least one boom, which can be consistently deployed in the same orientation.
4-34	Boom Design - Contamination Mitigation	The supplier shall supply details of the boom design, including any features designed to mitigate against the effects of contamination from moisture, exposure to solar radiation, and exposure to heat from the radiosonde body.
4-35	Shelf Life	Radiosondes supplied should be capable of being stored under recommended conditions for a minimum of 3 years.
4-36	Battery capacity	The sonde should have power capacity to maintain radiosonde operation for at least a total period of up to 30 minutes before launch and 3 hours during flight.
Pre-flight preparation		
4-37	Pre-flight Preparation	It shall be possible for a trained operator to unpack a sonde and complete all ground checks and have the sonde ready for launch within 30 minutes.
4-38	Operation via Single Operator	A system shall require no more than one operator to: prepare and launch the radiosonde, monitor and quality control the data, edit and transmit messages.
Calibration and Pre-flight		
4-39	Calibration Certification	The sonde shall be delivered calibrated, and calibration data is to be provided with each radiosonde.
4-40	Ground Check	There should be a specified ground check procedure that shall form part of the pre-flight preparation. This shall identify calibration/sensor faults and may be used to modify the calibration parameters used in subsequent data processing.

Table 53: Ground Station Requirements

ID	Requirement Heading	Requirement
4-41	Data	The ground station shall include all items necessary to; receive, process, output, archive, and display the data derived from the radiosonde.
4-42	UPS	The ground station shall be supported by an uninterruptable power supply (UPS) and this should be sufficient to operate the system for a period of 60 minutes should the mains power fail.
4-43	Pre-flight Tests	The ground system should be capable of testing the sonde systems prior to launch, ensuring temperature, relative humidity, pressure, and GPS satellite reception are functioning within specification.

ID	Requirement Heading	Requirement
4-44	Compliance	The system shall comply with ETSI standard EN 302 054-2 V1.1.1 'Electromagnetic compatibility and Radio spectrum Matters (ERM); Meteorological Aids (Met Aids); Radiosondes to be used in the 400,15 MHz to 406 MHz frequency range with power levels ranging up to 200 mW' and any other statutory requirements as necessary.
4-45	Frequency	The carrier frequency of the transmitted signal shall be operator selectable between 403 MHz and 406 MHz in 100 kHz steps.
4-46	Bandwidth	The modulation bandwidth shall not exceed 100 kHz centred on the carrier frequency.
4-47	Carrier Stability	The carrier frequency shall not drift for any reason during operation, including handling and ground effects at launch, by more than 100 kHz from the selected frequency.
4-48	Effective Radiated Power	This shall not exceed 200 mW.
4-49	Frequency – Reception	The system shall be able to receive and process transmissions within the band 403 to 406 MHz. The reception equipment will be able to sustain satisfactory operations in the presence of transmissions from any other systems in adjacent spectrum bands.
4-50	Slant Ranges / Elevation Angle	The receiving system shall be able to reliably receive data from radiosondes, at slant ranges greater than 200 km from the receiving site, from any direction and any elevation angle equal to, or greater than 5 degrees above the horizon.
4-51	Telemetry – Direction	The manufacturer shall describe the directionality of the telemetry antennae (i.e. omnidirectional, directional, mechanically steered) and the method used to achieve this directionality.
4-52	Wind Failure	Pressure, temperature, and relative humidity shall still be measured, if the wind measurements fail.
4-53	Raw Data Archive	The data stream including GPS signals as received from the radiosonde, shall be stored by the ground station in a raw data archive.
4-54	Processed Data	The fully processed data archive used to generate the upper air reports for the users, shall include as a minimum pressure, temperature, humidity, geopotential height, wind speed, and direction data.
4-55	Descent Data	The system shall continue to record the variables stated in 5-54 after balloon burst, down to the ground or until the radiosonde signal is lost.

Table 54: Data Processing Software

ID	Requirement Heading	Requirement
4-56	Algorithms & Compensation Methods	The algorithms used to generate the meteorological variables from the engineering variables shall be described fully and be available to the operator of the system at all times, including in any subsequent software updates. Any methods used to compensate for the effects of; solar radiation (temperature and relative humidity), water contamination effects on the sensors (temperature, relative humidity), and the variation in internal temperature of the radiosonde during flight (pressure sensor and sensor references), shall also be described.
4-57	Message Creation	The system shall be capable of manually or automatically creating the following message types: • FM 94 BUFR using templates 3 09 056/3 09 057 at the minimum required vertical resolution (For GBON this is 100m). • FM 94 BUFR using templates 3 09 056/3 09 057 at resolution ≤ 2 s. • FM 94 BUFR using template 3 09 056 to report descent data.
4-58	Message Update	The software to create the message must be able to be upgraded to facilitate new versions of the FM 94 BUFR coding and this must be included as part of the software support to the system.
4-59	Message transmission	It shall be possible to code and send the BUFR message at preselected times/pressures during the sounding.
4-60	Software Functionality	The system shall provide the following facilities: (a) Radiosonde Calibration Data Input - Input of radiosonde calibration data before launch (if necessary). (b) Surface Observation Input - Input of surface observation by operator (c) Launch Detection - Launch detection. Supplier shall also detail how launch is detected by the software.
4-61	Software Updates	The Supplier shall supply details of the frequency of software updates and commit to supply details of any changes to software when a new version is supplied, maintaining a change log detailing all changes, which is to be shared with the operator.

Table 55: Computer and backup power

ID	Requirement Heading	Requirement
4-62	Desktop computer	Bidder to provide a desktop PC with windows operating system and network connectivity to INAM network for each upper air sounding system.
4-63	Backup power	The upper air sounding systems and computers (PC's) must be equipped with backup power (UPS's) for running the whole system during mains power failure for a minimum period of two hours

Table 56: Site Acceptance Test and hand-over of systems for sites

ID	Requirement Heading	Requirement
5-01	Installation test	Bidder must provide all *materials required to perform testing of the system during installation / calibration.
	Written confirmation of installation	Bidder must certify in writing for each installation that the system installed has been tested and is fully operational.

Table 57: Maintenance and Support

ID	Requirement Heading	Requirement
6-01	Maintenance	Bidder to provide full maintenance of the equipment during the contract period.

Table 58: Meteorological Balloons

ID	Requirement Heading	Requirement
7-01	Provision	Provision of 800 Meteorological Balloons for Radiosonde soundings per year for period of 3 years to the following sites • SEYCHELLES INTER. AIRPORT: Lat: -4.6790, Long: 55.5308 • ALDABRA: Lat -9.4017, Long: 46.2061
7-02	Gas Type	Balloons must be suitable for both Hydrogen and Helium.
7-03	Filling Adapter	A balloon filling adapter must be provided with the delivery of first batch of balloon order
7-04	Performance (Burst Height)	Minimum burst height of 30 hPa, when flown under typical conditions, with correct handling and inflation procedures (90% tolerance). Evidence to be provided in tender documents.
7-05	Date Stamp	Date of manufacture must be included with each balloon.

7-06	Evidence of operational use	Evidence that offered product has been used operationally at WMO recognised services/institutes for a period of greater than 1 year. Please provide list of Meteorological Services and/or WIGOS Station identifiers.
7-07	Monitoring	GBON stations will be monitored regularly against the GBON minimum requirements, which include the burst height performance statistics of the balloons. If necessary, these statistics are communicated back to the station operators and/or equipment manufacturers for comment and action.

Table 59: Hydrogen Generation System (HGS)

ID	Requirement Heading	Requirement
8-01	Provision	Provision is for the supply of a hydrogen generator for meteorological applications, storage tanks (replacement or compatible with existing), water purifier (replacement or compatible with existing), UPS and other associated equipment, including the shipment to SEYCHELLES INTER. AIRPORT and ALDABRA, installation on site and training of the observing staff in the ongoing operation and maintenance of the equipment.
8-02	Site	The observation sites are located at the following coordinates: SEYCHELLES INTER. AIRPORT: Lat: -4.6790, Long: 55.5308 and ALDABRA: Lat -9.4017, Long: 46.2061 The HGS will be housed at the temperatures in all seasons range from 24 oC to 32 oC. Bidder to confirm the suitability of the proposed solution, to operate in this environment, confirming the dimensions of the equipment to be supplied, and any clearance distances or other dimensions to allow for the safe operation of the equipment and the observing staff involved (Including ATEX regulations). Please indicate pre-installation requirements in terms of site information, preparation, access, etc. The offered system is expected to install a new complete HGS at the 4 stations/sites which is detailed as follows: Hydrogen Generator Storage Tanks Water purification

8-03	Power	The Mains power supply at the site is Mains 220V AC nominal. Please confirm the proposed systems capability to run off this type of power supply. Additionally, please indicate UPS capabilities of the system proposed either as standard, or as costed options. The selected solution will as a minimum require UPS back for 10 to 20-minute outages to allow for system shutdown. The unit must include all recommended power systems necessary for the intended locations. These systems may be integral to the unit or installed externally but they must be supplied with the unit.
8-04	Water Purification	Supply and installation of a complete water purification system at each of the 4 stations/sites. To ensure the system can produce Hydrogen on an on-going basis, despite potentially varying water quality at the site, please confirm the water standard that is necessary to produce hydrogen in the volumes required (see 8-05) and for the application required. Please include in your proposal the solutions to cope with potential low water quality at the site. The unit must include all recommended water conditioning systems necessary for the intended locations. These conditioning systems may be integral to the unit or installed externally but they must be supplied with the unit.
8-05	Hydrogen Generation and Storage	One hydrogen generator for meteorological applications with capacity at least 0.5 Nm3/hr (20 SCF/hr). The Electrolytic generators to acquire must use Polymer electrolyte membrane (PEM) in the electrolysis of water, be sealed, tested, and able to operate 24/7 without interruption of service. Chemical type is not acceptable. The offered system should be compatible with the storage tanks and water purification and should allow the replacement of piping and valves and or storage tanks and water purification in future. The new storage tanks must have sufficient capacity to meet the operational need stated below. They should be made of either stainless steel or galvanized steel interconnected so that any one tank can be removed for inspection and testing without impacting the operation of the station. Provide a quote for both types of steel tanks if available. Note: Balloons currently in use are 350 gram Sounding balloons. Currently ascents are 2 per day, but allowance should be made to cover 4 ascents per day for resilience. The storage must be able to fill an additional two balloons in succession to allow for an early balloon burst.

		Please specify storage capacity (standard, options) and how long it would take to generate the required volume of hydrogen.
8-06	Storage tanks	Supply and installation of a complete storage tank with required piping and valves. The storage tanks need to be able to withstand salty atmosphere (i.e. hot galvanised or similar). They need to have an isolation capability during refilling. They should be able to be drained to enable the removal of oxygen from the system. They also need to be capable of manual handling, as there is no procedure for lifting the equipment making this impractical.
8-07	Maintenance, tools and safety	The tender documents should specify the required maintenance and servicing requirements for the offered system, including any special requirements for storage and handling. The offer should include the necessary tools for the maintenance of the system and safety equipment (i.e. special garments and hydrogen presence detecting tools).
8-08	Evidence of operational use	The operational performance of the offered system (or equivalent) must be verifiable by its use routinely as a component of at least 3 WMO Members national network for a period of more than 1 year. The contact details of the WMO Member must be included within the tender documents so WMO can seek clarification of the system use and their user experiences.

Backup Power supply (Generator and UPS specification)

Table 60: Backup Power supply (Generator and UPS specification

Technical specification	The diesel generator must be at least a 40 KVA low noise/silent diesel generator with a 200lt built-in fuel tank.	2
	The diesel generator must be enclosed in a weatherproof / low noise canopy/housing.	
	An Automatic Transfer Switch (ATS) and Automatic Mains Failure (AMF) must be installed. The controller must have an interface to allow for remote access, monitoring and control of the generator.	
	The installation to include the balancing of the load	
	Fuel tank to be double wall to cater for spillage	
	Ethernet and GSM/GPRS/LTE module/interface for remote access and monitoring	
Other non-technical requirements	- Preparation of site for the installation of the new 40KVA low noise diesel generator with a 200lt build-in fuel storage tank at SEYCHELLES INTER. AIRPORT: Lat: -4.6790, Long: 55.5308 and at ALDABRA: Lat -9.4017, Long: 46.2061 - Supply and Installation of a new 40 KVA low noise diesel generator with a 200lt build-in fuel storage tank.	

	- Provide certified diesel generator installation, operations and maintenance training to a team of SMA personnel at the office. - Perform the Diesel Generator site Commissioning and Testing, which shall include the handing over of a complete Site As-Build record. - Provide SAWS with the following upon completion of the installation: ✓ Electrical Certificate of Compliance (CoC) for electrical work conducted during the installation of the new diesel generator. ✓ Diesel Generator Compliance (Mechanical Compliance) Certificate for the mechanical system and installation conducted during the supply and installation.	

Table 61: UPS specification

No.	Description of goods	Qty
1.	Supply, Installation, commissioning and testing of a new 10kVA UPS, 55Kg **Main Features:** ➢ Wide input Voltage windows ➢ Expandable back up times ➢ Cold start ➢ Load/battery power meter display ➢ LED/LCD display ➢ Automatic charging in UPS off mode	2
	Input: ➢ Phase: single phase and ground ➢ Voltage range: 220V/230V ➢ Frequency: 45-65Hz ➢ Max current: 50A/48A	
	Output: ➢ Phase: single phase and ground ➢ Voltage: 220V/230v ➢ Waveform: ➢ Frequency: 50Hz ➢ Max Current: 50Hz ➢ THD (Linear Load): ➢ Power Factor: ≥ 0.99 ➢ Overload capacity: overload (later go to bypass, automatically resume when load becomes normal)	

	➢ Short circuit protection: current limit, turn off automatically switch	
	Protection: ➢ Surge protection: IEEEE527B ➢ Noise: FCC.A	
	Communication: ➢ RS232 ➢ Ethernet interface	
	Battery: ➢ Type: 12V/7AH ➢ Maintenance free ➢ Charge current: Standard 1.2A Long run 6A ➢ Charge time: 90% capacity after approx. 8 hours	
	Environment: ➢ Noise: maximum 55db ➢ Temperate: 0 – 40°C ➢ Humidity: 0 – 95%	
	Indication: ➢ LCD: working mode, input and output voltage, input and output frequency, battery voltage, load percentage, UPS inner temperature. ➢ LED: low battery, on-line, inverter, bypass, abnormal.	
	85% efficiency of the whole unit	
2.	Annual service/maintenance (as and when needed) of the UPS	2
3.	Issuing of an electrical Certificate of Compliance (CoC) for electrical installation performed.	2

Annexure 3
Meteorological Data Management System

Table 63:

ID	Requirement Heading	Requirement
307(a)	General purpose industrial computers and/or cloud service	The system should use a combination of general-purpose industrial computers and cloud services.
310	Office systems environment	The desktop systems (if part of the project) environment must be the latest stable version of the OS, or equivalent. [The customer should designate a time period (suggestion 5 years) for which the software will guaranteed on the offered OS.]
170	Automatic data files management	The data files or databases should be managed automatically by the system without human intervention.
234	Management of system processes	The MDMS must be able to access system components to perform system management (such as starting and stopping processes, file management, etc.).
323	Redundancy	All aspects of the MDMS should be a redundant system. The redundant systems should have a hot standby relationship. Operation should be taken over within 1 minute. It is preferred to also have a redundant LAN. Cabling should support redundant systems (no plugs have to be changed to make operation of the standby system possible).
348	Software installation from central point	The system must provide facilities for the installation, for making new versions of the software operational and for making new versions of the configurations operational, from a central point, through the MDMS.
296	Access security method	Access authorisation should be based on user identification in combination with a personal password.
169	Logging of system information	Logging of system process and error correction, as provided by the computer operating systems, must be possible. It should be possible to turn this logging on or off by a system administrator. The system administrator can select the relevant system information to be logged (when logging is switched on).
221	Alarm list	All exceptions should generate an alarm that should be presented in an “alarm list,” that should be visible for all MDMS users.
224	Notifications to user	It should be possible to configure the MDMS to send notifications to users in case exceptions, all notifications or for particular groups of notifications, occur. At least notifications per email should be possible.
971	Logging retention period	The system must retain logged data for a period of [Time period to be determined by the customer, at least 7 days is recommended]. The retention period must be configurable.
293	Data access restricted by authorisation	In order to prevent unauthorised personnel from access or damaging information it is required that authorisation take place. Access to security and privacy sensitive information must be by login

		procedure. Access authorisation is to be provided by the supplier, the customer must decide which systems must require login access.
162	Management of configuration parameters for data processing	It must be possible to configure the process of data storage, transactions and processing of the received data sets and/or data reports. Parameters that can be configurable are, for example: • Back-up location • Control data to check the supplied data (files), • Adjustment of the default-priorities • Overview of the waiting queue • Changing manually the default priority settings concerning data processing
235	Access to the MDMS for system management	The MDMS has three types of users with the following access rights: • Technician access rights The technician is responsible for monitoring the technical status of the meteorological equipment. The technician has access rights to view certain displays and to take limited actions such as described in MDMS_014. • Meteorological administrator access rights The meteorological administrator is responsible for meteorological configuration of the AWS and MDMS, the algorithms, the instruments, etc. • System administrator access rights The system administrator is responsible for the technical condition of all computer equipment, data communication equipment, and the ICT configuration of the systems (IP configuration, hardware and software configuration). The system administrator has access rights to all functions within the MDMS, but he should not change the meteorological configuration without approval from the meteorological administrator.

Software, hardware, and power supply

Software

ID	Requirement Heading	Requirement
355	Software and system configuration supported	The software and configuration of the system must be supported by the customer's-maintenance groups. Standards and requirements of the customer's-maintenance groups should prevail over any standards recommended by the suppliers of the software/hardware.
187	Notification of alarms	The AWS/Sensor should have the capability to notify the AWS Network Control if an alarm situation (defined in the AWS NC) occurs. It should be possible for the AWS/Sensor to actively initiate contact with the AWS NC to send the alarm message/info immediately when the alarm occurs. Alternatively, alarm message/info can be included in the regular data communication cycle if this cycle is based on, for example, 10-minute communication. [NMHS to determine method to silence the alarm]
1090	Software Updates/Bug Fixes in Warranty Period	Software Updates/Bug Fixes must be provided without any charge during the Warranty Period
1119	Software Support Agreement	The Contractor should supply a Software Support agreement, including pricing for a duration of [NMHS to specify time].

ID	Requirement Heading	Requirement
		[The NMHS may specify whether this is full software support, or (as simpler option) an agreed hourly rate for work by the Contractor to address software issues not covered by warranty]
1087	Software Licenses	All software licences required for operation of the system delivered by the supplier must be supplied to [Insert Customers Officer Responsible]. The supplier must be responsible for any issues regarding software licences and licensing.

IT Infrastructure

ID	Requirement Heading	Requirement
308	Spare capacity	The system should be designed so that during events of peak loads, the resources of the system (CPU, memory, external memory, network access) are not loaded for more than 50% of the total capacity.
312	Response time overviews	Response times for historic overviews/data retrievals should be 3 seconds or less.
318	System Reliability	The system should use general purpose industrial computers as the main platform component for process control. The system should be designed for a yearly 99.97% availability (MTBF, MTBR < 2 hours).
349	Installation tool	Software/configuration installation should be done by usage of a standard tool. The tool being used should be generally accepted for the applied computer system environment, or the tool should be built into the software supplied.
363	Define system users	An authorised user (system administrator) must be able to add new users to the systems, to configure permissions for users, and to remove users.
965	Environment temperature	The MDMS and display systems must be able to operate in an environment with temperatures ranging from +5C to +50C. MDMS server equipment must be placed in conditioned equipment rooms.
285	Standard internal telecommunication/ transmission network protocol	The systems should use TCP/IP as standard telecommunication/transmission network protocol for internal interfaces whenever possible. This enables systems to exchange data on the same hardware platform or via LAN/WAN. Exception: interfaces with instruments may not be able to use TCP/IP, but can use another protocol.
325	Data loss prevention during power failure	The system must be built in a way to prevent data loss at power failures. Data must be stored/saved to permanent storage as soon as it is ingested by the system and not be kept in volatile memory.

Communications and ports

ID	Requirement Heading	Requirement
53	Multiple Outputs	If the instrument is equipped with both an analogue output and a smart interface, it should be possible to connect both at the same time and collect data from both outputs without any physical damage to the instrument's electronics.
52	Output Characteristics	The physical output of the instrument should be of a standard type and format, that can be readily interfaced to equipment from other manufacturers than the supplier. The NMHS has a preference/requirement for [Required Sensor Output Protocol/format]. Outputs that require

ID	Requirement Heading	Requirement
		proprietary hardware/software are not allowed/permitted.
54	Service port	If the instrument is equipped with a (smart) service port/connection, it should be possible to connect to the service [using PC/laptop/WiFi/...] while the instrument is collecting data. Through the service connection it should be possible to perform instrument maintenance, do diagnostics, configuration, to stop/start the regular data collection mode, etc. Software tools to perform such actions should be supplied with the instruments.
178	Interfaces for instruments and other sources	The AWS must be equipped with all interfaces, physical interfaces and protocols, that are required to connect the selected instruments and other data sources to the AWS.
1113	Communication protection	Communication between all system components must be protected against unauthorized access. This especially applies to dial up connections and mobile data communications such as GPRS/4G.
173	Communication equipment for communication with MDMS	Data communication should at least be possible via fixed data communication cables (TCP/IP, serial, Ethernet), dial up connections, GPRS or the most recent versions of mobile data communication, radio modems, satellite modems, WiFi.
317	Communication equipment approval	All communication equipment used for communication via the public telephone network or fixed (hired) lines, wireless telephone or radios, must be approved by the local telecommunication authorities. If licenses are required for equipment offered, the supplier must inform the customer for approval.
334	Data communication capacity AWS	The AWS data communication equipment should be able to handle the transfer of regular data to the MDMS in less than 1/10th of the data collection interval. For example, if the data from the AWS is transferred to the MDMS at regular intervals of 10 minutes, the data transfer itself should take no longer than 1 minute. If data recovery is necessary, the remaining time can be used for that.
315	Communication costs	Communication between the AWS' and any aspect of the MDMS should take place against minimum costs. If the customer does not define what solution is to be employed, the supplier should investigate and offer the most cost-effective solution.

Annexes 4
Environmental and sustainability considerations

Material Use – Instrument

ID	Requirement Heading	Requirement
E8	Material Identification	The material of each component part of the proposed instrument must be identified by its applicable recognized recycling code.
E9	Recycled Content	The mass and percent of recycled raw material must be disclosed for each component part made of a homogenous material (coatings excluded)
E10	Biodegradability	*Biodegradable components in the proposed instrument must be identified. **Biodegradability is defined as >90% of the original material is converted into CO2, water, and minerals by biological processes within 6 months.*

Material Use – Packaging

ID	Requirement Heading	Requirement
E11	Material Selection	Where packaging material selection allows, without degradation of the instruments' performance or shelf life, only recyclable materials must be used.
E12	Material Identification	The material of each packaging element must be identified by its applicable recognized recycling code.
E13	Biodegradability	Where packaging material selection allows, without degradation of the instruments' performance or shelf life, only biodegradable* materials must be used. **Biodegradability is defined as >90% of the original material is converted into CO2, water, and minerals by biological processes within 6 months.*

Instrument Design

ID	Requirement Heading	Requirement
E14	Design for Repair	Where instrument performance requirements allow, without degradation of – for example - water intrusion or temperature range, replaceable sub-components and sub-systems of the proposed instruments must be serviceable or replaceable, without the requirement to discard the whole instrument.
E15	Efficient Packaging	Packaging for the instrument must minimize transport volume and mass wherever possible, without compromising transport durability and equipment performance following long-term storage.
E16	Recyclability	The instrument design must consider end-of-life disposal and maximize the recyclability of the assembly by facilitating efficient separation of all recyclable materials.

Operation and Maintenance

ID	Requirement Heading	Requirement
E17	Energy Performance	Where feasible, without degradation to the proposed instrument's performance under its specified operating range, the instrument's energy use must be minimized.
E18	Chemical Disclosure	All chemicals used in the operation, calibration, and maintenance of the proposed instrument must be disclosed and a Material Safety Data Sheet must be provided. Environmentally harmful chemicals must be avoided or minimized where no suitable alternative is available.
E19	Internal Batteries	Details of the battery or accumulator design, covering, cell type, voltage, capacity and any necessary safety information must be supplied for the proposed instrument if the design includes a battery or accumulator. Safety information must include instruction for the safe disposal of the battery or accumulator, consistent with local regulations, or the 2006/66/EC directive – whichever is stricter.

UPPER-AIR

Table 37: Environmental Regulatory Compliance

ID	Requirement Heading	Requirement
1-01	General Compliance	The proposed instruments must comply, at a minimum, with recognized European Environmental regulations. Applicable* regulations must apply to the instrument itself, all of its sub-systems, its packaging, and associated consumables. *'*Applicable' requires knowledge of the materials and components. Where certain materials, chemicals, and components are used – compliance to regulations controlling their use must be confirmed.*
1-02	Batteries *(example)*	Batteries and Accumulators and Waste Batteries and Accumulators Directive (2006/66EC)
1-03	Packaging *(example)*	Packaging and Packing Waste Directive (1994/62/EC)
1-04	Hazardous Substances *(example)*	RoHS 2 - Restriction of Hazardous Substances Directive (2011/65/EU)
1-05	Chemical Registration *(example)*	REACH – Registration, Evaluation, Authorization, and Restriction of Chemicals (2006/1907/EC)
1-06	Mercury *(example)*	Minamata Convention on Mercury - COP
1-07	Local Jurisdiction	Where recognized regulations, applicable in the jurisdiction where the instrument is installed, are equivalent to or stricter - the local regulation must be applied over the European regulation.

Table 38: Material Use – Instrument

ID	Requirement Heading	Requirement
1-08	Material Identification	The material of each component part of the proposed instrument must be identified by its applicable recognized recycling code.

1-09	Recycled Content	The mass and percent of recycled raw material must be disclosed for each component part made of a homogenous material (coatings excluded).
1-10	Biodegradability	Biodegradable* components in the proposed instrument must be identified. *Biodegradability is defined as >90% of the original material is converted into CO2, water, and minerals by biological processes within 6 months.

Table: 39: **Material Use – Packaging**

ID	Requirement Heading	Requirement
1-11	Material Selection	Where packaging material selection allows, without degradation of the instruments' performance or shelf life, only recyclable materials must be used.
1-12	Material Identification	The material of each packaging element must be identified by its applicable recognized recycling code.
1-13	Biodegradability	Where packaging material selection allows, without degradation of the instruments' performance or shelf life, only biodegradable* materials must be used. *Biodegradability is defined as >90% of the original material is converted into CO2, water, and minerals by biological processes within 6 months.

Table 40: Instrument design

ID	Requirement Heading	Requirement
1-14	Design for Repair	Where instrument performance requirements allow, without degradation of, for example, water intrusion or temperature range, replaceable sub-components and sub-systems of the proposed instruments must be serviceable or replaceable, without the requirement to discard the whole instrument.
1-15	Efficient Packaging	Packaging for the instrument must minimize transport volume and mass wherever possible, without compromising transport durability and equipment performance following long-term storage.
1-16	Recyclability	The instrument design must consider end-of-life disposal and maximize the recyclability of the assembly by facilitating efficient separation of all recyclable materials.

Table 41: Operations and Maintenance

ID	Requirement Heading	Requirement
1-17	Energy Performance	Where feasible, without degradation to the proposed instrument's performance under its specified operating range, the instrument's energy use must be minimized.
1-18	Chemical Disclosure	All chemicals used in the operation, calibration, and maintenance of the proposed instrument must be disclosed and a Material Safety Data Sheet must be provided. Environmentally harmful chemicals must be avoided or minimized where no suitable alternative is available.

1-19	Internal Batteries	Details of the battery or accumulator design, covering, cell type, voltage, capacity, and any necessary safety information must be supplied for the proposed instrument if the design includes a battery or accumulator. Safety information must include instructions for the safe disposal of the battery or accumulator, consistent with local regulations, or the 2006/66/EC directive – whichever is stricter.

Report completion signatures

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