24 September, 2024 update

GBON National Contribution Plan

São Tomé and Príncipe

Systematic Observation Financing Facility

Weather and climate data for resilience

GBON National Contribution Plan

Republic of São Tomé and Príncipe

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Module 1 National Target toward GBON compliance

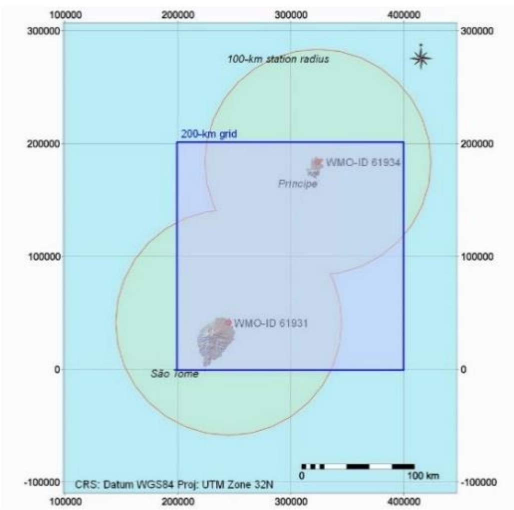
1. Summary of the GBON National Gap Analysis

The GBON Gap Analysis study focusing on the current spatial and temporal resolution of the STP surface and upper air weather observation network, including data communication issues, revealed the following GBON gaps:

1.1.1 Surface Observations

1.1.1.1 Spatial Resolution

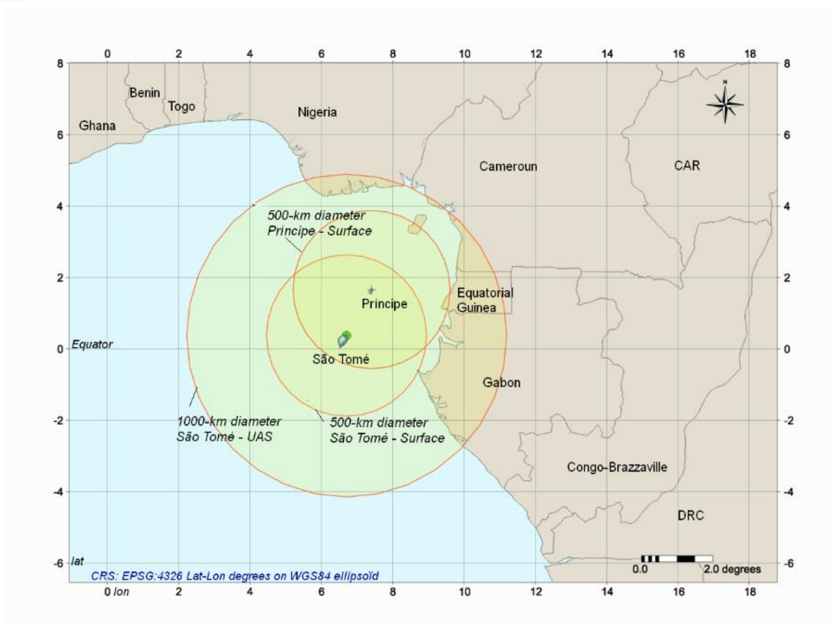
Figure 1a illustrates the STP archipelago, projected in a UTM (Universal Transverse Mercator) coordinate system and illustrating the two (2) proposed GBON target Surface AWS on respectively São Tomé and Príncipe Islands. Both stations also have WMO-IDs as shown, and are located at the respective Island airports.



In the past (<1980), STP had one Upper Air Sounding facility near São Tomé int'l airport, located at the current INM Head Quarters. This old UAS site was assessed as totally obsolete by the INM and peer-advisor SOFF team. A GBON UAS - Upper Air Sounding facility was also indicated by WMO in their initial Gap analysis communication.

Figures 1a & 1 b: Locations of the GBON target Surface AWS (2) and UAS (1) of São Tomé and Príncipe (incl. 500/1000-km diameters for Surface/UAS, as used for SIDS)

A fully new UAS facility is required and set as a GBON target by the INM STP (see Fig.1b), and recommended by the INM and peer-advisor. This sounding facility will play an important role for weather prediction and analysis in the Gulf of Guinea. Indicative 500-, and 1000-km diameters (for SIDS) are also shown (Fig.1b) for the UAS, to be located near São Tomé int'l airport.



1.1.1.2 Temporal Resolution

The current earmarked GBON AWS of STP do not comply with the hourly data communication standard (for the 6 weather variables), required by GBON. We refer to the Gap Analysis report for more details. At this moment (Feb-Mar, 2024), irregular time series of SYNOP messages are communicated by the two synoptic stations (WMO_IDs 61931 and 61934) to the Congo – Brazzaville WMO - RTH[i] and used for aeronautical purposes. Data are currently transferred to the WMO GTS/WIS via the Congo Brazzaville RTH, using a manual messaging protocol and the MESSIR software.

2. National Target toward GBON Compliance

Table 1 below summarizes the National GBON Contribution Target (# stations), set by the INM of São Tomé and Príncipe.

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	1	0	1	0	2[1]	0
Upper-air	1	0	0	1	0	1
Marine	*when applicable					

Table 1: GBON National Contribution Target of São Tomé and Príncipe

INM and peer-advisor recommend to also improve a second and existing AWS at the airport of Príncipe Island to GBON compliance. The rationale for this is the specific geographical location (i.e., 170-km apart), different climatological and weather conditions of São Tomé on one hand and Príncipe on the other hand. GBON observations also form the basis of the data chain for EW4All. Both islands have important resident populations and economies. It is therefore important to have observations on both islands to support and timely inform local communities. Occurrence of extreme weather (e.g. large convection, severe tropical thunderstorms) on São Tomé Island not necessarily means alert warning on Príncipe Island and vice versa.

In order to meet GBON compliance, STP requires to lift the GBON gaps, mentioned above. The NMS has therefore set and recommends the following **national GBON targets**:

[1] São Tomé & Príncipe will seek a Target of (two) 2 Surface AWS and (one) 1 UAS, as compared to the original (WMO June 2023) GBON global gap analysis. See the short rationale described in paragraph below the table.

- ***Spatial Coverage of Surface Observations:*** improve and upgrade the two (2) current WMO-ID Surface AWS to GBON compliance status. These two Surface AWS are located near São Tomé Int'l Airport and on Príncipe Island (at domestic airport). With these two GBON Surface stations, INM and São Tomé and Príncipe as beneficiary country will entirely meet the spatial GBON surface coverage requirement (global 200-km grid), as can be seen from Figure 1a.
- ***Data Communication:*** Install a full WIS2.0 communication node to send data to WMO via the new WMO-WIS2.0 data communication system, using FOSS[2] based data protocols;
- ***Temporal Data Requirement of Surface Observations:*** link the two GBON earmarked and current WMO-ID reporting stations to the WIS2.0 system, and also meet the near real time hourly GBON temporal data requirement for the six reporting variables;
- ***Upper Air Soundings & Observations:*** Renew the Upper Air Sounding facility near São Tomé int'l airport and retake the sounding practices (twice daily) to meet the GBON requirement.

A phased approach is proposed to meet the GBON targets, as next to infrastructure deployment, important human resources (personnel) capacity and institutional development will also be required. In the next modules, the different aspects on how to implement the GBON targets are further discussed.

Module 2 GBON business model and institutional development

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

In STP, the National Meteorological Service is by legal Decree nº 10 of May 21 2012[3], currently the only operator and authorized government institution, acquiring meteorological observations with potential to support GBON. It collaborates closely with the ENASA[4] for providing aeronautical meteorological services. There are no private sector operators providing meteorological observations or data services in São Tomé and Príncipe.

The INA (National Water Agency) of the DGNRE[5], operates a network of 12[6] hydrometrical flood monitoring stations. These stations are also equipped with AWS. Data are shared with the INM through GSM/GPRS. Due to the very close hydrometeorological connection, cooperation (incl. agreements and protocols) between INM and INA is of high relevance.

[2] FOSS: Free and Open-Source Software based standards and protocols
[3] "Diário da República", May 21 , 2012. STP Gvt. Decree #10. Approval of legal statute of INM. Also, on https://faolex.fao.org/docs/pdf/sao118129.pdf (webpage visited Feb 20, 2024) (in Portuguese).
[4] ENASA : National Company for Airports & Air Traffic & Navigation Safety – STP
[5] DGNRE: Directorate General of Natural Resources and Energy
[6] Hydrometric stations were installed by the UNDP implemented "SAP" or "Sistema de Alerte Precoce" project (~2015/16) with 11 monitoring stations on São Tomé and 1 hydrometry station on Príncipe Island

At this stage, only a few private sector operators and Co which do meteorological observations were identified. For example, an oil palm estate in the South of São Tomé Island (AgriPalma C°), operates its own AWS for own local weather monitoring purposes.

Several government or related organizations are relevant and show keen interest in meteorological observations and data. The CONPREC or National Council for Natural Disaster Preparedness and Response is currently the main governmental stakeholder, which at the national level, is the main coordinating body for disaster management activities. It has a formal cooperation agreement with INM for disseminating daily weather forecasts, generated by INM, for early warning purposes. We refer to the Country Hydromet Diagnostic report - Annex 2: Stakeholder consultations, for more information and parties interested a/o involved.

In view of current growth in socio-economic sectors i.e., tourism, agriculture, small industry, ship operators, e.g., cargo and passenger transports, fisheries, we can map several private entities and governmental parties interested in weather information a/o collaborative weather observations with the INM. Most stakeholders highlighted the need for more tailored and near real time weather services and products to fit their needs. Discussions with INM showed that potential opportunities exist to work more closely and partner with the water, agriculture and health authorities, but also the private sector (tourism, agriculture).

In terms of research, INM currently does not undertake significant research endeavours, due to its reliance on budget funding and skilled e.g., academic staff. We noted that most senior meteorologists are or have reached retirement age and left the organization for a variety of reasons. They were (or are) not replaced mainly due to financial constraints.

However, this finding does not preclude new opportunities for INM to engage in research. It could further look in developing collaboration and built partnerships with national and international institutions and interested partners.

We therefore recommend and request support to engage with private a/o government stakeholders and built partnerships, using e.g., public-private or other business model, working in the overall socio-economic, political and technical context of STP as a SIDS. INM proposes to organize a stakeholder engagement workshop, to which public and private sector potential partners will be invited to discuss and elaborate on business models, 3P[7] and opportunities in the SIDS relatively small country setting of STP. The Table 2.1 below shows the investment requirement for this business development and institutional development action (workshop costs).

Table 2.1: Investment proposal for stakeholder and private partner engagement

Item #	Item/Activity	Location (suggested)	Cost estimate (USD)
1	Stakeholder and private sector engagement workshop	São Tomé & Príncipe	

[7] 3P: Public – Private - Partnerships

Total	See IFR [8]

INM is also requesting further support from SOFF, peer-advisor and IE in this aspect. We refer further to paragraph 2.4 for the national observation network strategy development.

2.2 Assessment of potential GBON sub-regional collaboration

São Tomé and Príncipe are through the DAAC or Directorate for Environment & Climate Action, involved in several regional environment and climate related projects and actions. STP is part of the large WACA program (West African Coastal Adaptation program (led by the World Bank / GFDRR), a multi sector investment plan, aiming at increasing resilience and adaptation to climate change in the coastal zones of over ten (10) West African countries. The INM is also involved (2022-onwards) as recipient of (>10) new WACA weather observation (AWS) station infrastructure, incl. coastal e.g., tidal monitoring (see Fig.1). INM will establish cooperation agreements with national private (i.e., ENASA) and Government partners (DGAAC, DGNRE) in relation to operation & maintenance and life cycle management of AWS infrastructure and investments by int'l partners and SOFF. Cooperation with private Co in the agricultural sector (e.g., oil palm, cacao industries) and deploying privately-owned AWS, will be further explored.

Further, INM has currently (2023-24) no immediate direct cooperation in joint meteorological observations with the NMS of neighbouring countries i.e., Gabon, Equatorial Guinea, Cameroun, Nigeria, other countries. No cross-border (bilateral or multilateral) cooperation agreements for exchanges of weather information and warnings with neighbouring countries seem to exist.

Figure 1: New (in operation since Aug, 2023) WACA project AWS - Automated Weather Station at Porto das Neves harbour, North West São Tomé Island. Equipped with additional tidal gauge and present weather sensor PWS for harbour monitoring (picture cm; Feb 02, 2024)

It is recommended to investigate cooperation opportunities in the field of collaborative weather maritime observations with neighbouring countries e.g., with adjoining EEZ (Extended Economic Marine Zones) with support of international knowledge partners.

[8] For budget estimates, we refer to the SOFF Investment Phase Funding Request or IFR (elaborated jointly by the IE, peer-advisor and beneficiary)

As potential collaboration with direct neighbouring countries, INM considers a marine observation network as important to explore further in a regional context. **We recommend that reinforcement of regional collaboration is included in the (new) INM strategy.**

For increasing engagement and fostering regional collaboration, related to GBON and SOFF, INM requests some mobility funds for participation or organizing e.g., regional meetings, partner study visits (e.g., locations and countries, to be decided, e.g., Gabon, Cameroun, a/o Palop[9] countries: Angola, Brazil, Mozambique, Cabo Verde, Guinee Bissau) or other. Table 2.2 summarizes the investment requirement for these activities.

Table 2.2: Investment proposal for engagement (mobility) in regional collaboration

Item #	Item/Activity	Locations	Cost estimate (USD)
1	Mobility fund (5-yr) for participation and exchange in SOFF, GBON regional a/o other activities	Various	See IFR[4]

2.3 Assessment of the most effective business model to support network operations

Until present, INM has large difficulties in securing the operation and maintenance (O&M) of its meteorological observation network. Figure 2 for illustrates the current AWS network and function in STP. The INM oversees around 20 AWS and two MWS stations on the islands.

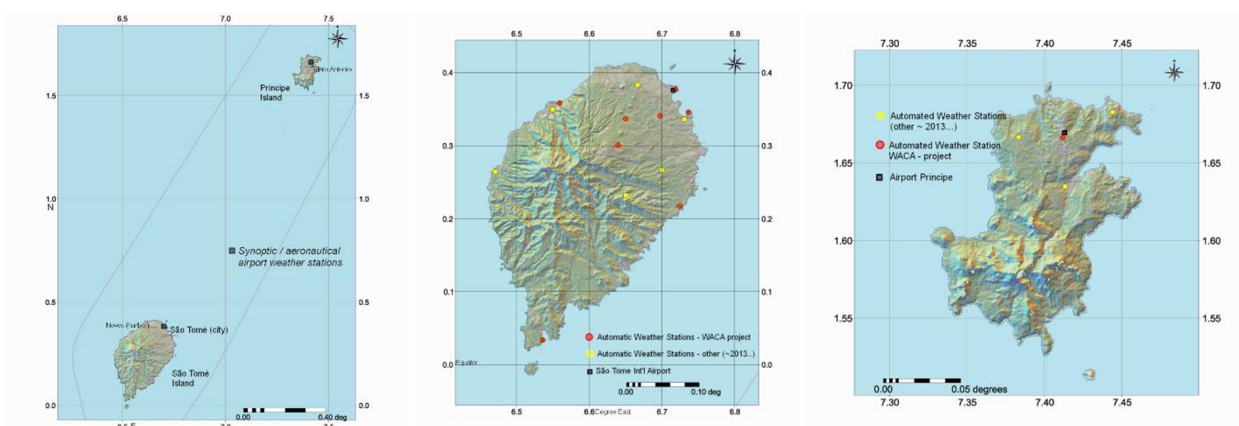


Figure 2: Weather station (AWS) infrastructure of São Tomé and Príncipe (Jan, 2024)

Although, important int'l development assistance and donor support has been materialized for setting up new or rehabilitating meteorological AWS and hydrometrical stations (ref. SAP by UNDP in period 2013-16, WACA project by WB, from 2022 to present), these investment projects in

9 "Païses (Africanos) de Lingua Oficial Portuguesa"

general, do not (or poorly) foresee in funding operation and maintenance (O&M) costs, incl. personnel requirements to perform preventive maintenance and control of this new observation infrastructure. This leads in most cases to a rapid degradation of the observation infrastructure, especially in very humid tropical equatorial conditions as in STP. It can be noted that the O&M cost of a surface AWS for e.g., a 10-year projected lifetime, will almost exceed the installation and instrument cost of an AWS. This oversight by many projects can be considered one of the root causes of failure of observation networks in several developing countries (ref. World Bank, 2022)[10].

Next to this external and int'l development collaboration funding aspect, the financial status and annual budget of INM (in 2023) amounts to a 3,151,176. STN (Dobra), and equivalent to 128,619.0 EUR (€). The ENASA provides 83.4% of this budget, for hiring INM personnel to deliver the aeronautical weather monitoring and forecasting services. The STP governmental (ministry) funding (16.6%) is used for administrative support staff, maintenance of offices and limited mobility. 5.3% of the budget is generated by INM and can be used for e.g., O&M. Although, the annual budget trend is stable, it can be seen easily that this amount does not permit to support any ambition level of the INM.

STP being a relatively small SIDS and country, INM has a relatively small personnel contingent of 28 staff (20 Male : 8 Female) from which 20 have a meteorological education (various levels, from basic BIP-MT to academic meteorologist). There is only one ICT staff and 7 are administrative and support personnel.

Most (~>15) of the meteorological technicians and staff of the INM are affected to ENASA and the aeronautical 24/7 weather services for the two main airports (São Tomé Int'l and Príncipe domestic airports).

There are only a few technicians available for maintenance and replacement of equipment, observation network and data communication (ICT) management.

Based on the discussions (with INM), it became clear that there is no real or direct possibility to outsource (preventive a/o malfunction) maintenance and station ICT issues (except hiring of station security guards). The UAS (Upper Air Sounding) facility has since long disappeared, and a totally new UAS infrastructure set-up is required including hiring of new personnel with appropriate UAS competences for this work. This will require human capacity development (ref. Module 4).

It is therefore recommended that new technicians and staff will be hired to the INM to fill the human resources and personnel gaps in operation of the national meteorological service. More details on this will be given in Module 4 (Human Capacity Development).

There are in first instance gaps in O&M technicians, ICT and also data quality control and weather and climate database development and management. These activities will also require more annual operational core funding, through int'l engagement (e.g., O&M and capacity development

[10] World Bank, 2022. ***Charting a Course for Sustainable Hydrological and Meteorological Networks in Developing Countries.*** Washington, DC: World Bank

funding by observation infrastructure development projects) but also from governmental sources in the first place.

In the area of public-private sector collaboration with the INM, there are currently no formal agreements with the private sector. Only, an agreement with the national company ENASA for the civil aviation sector exists.

The SOFF Operational Manual defines 4 different types of business models i.e., fully state-owned, with or without private operator, etc. Our discussions indicated that the INM is not yet accustomed with these management possibilities, processes and models.

It is therefore recommended to support the INM, in a screening and evaluation process of possible institutional and business models for the institute, applicable in the national context of STP. Issues are i.e., availability of potential partners and private sector operators, required qualifications, responsibility and liabilities, type of business model, legal aspects, terms of reference, financial and funding issues, risk management, etc.

This business model development process is closely linked to the assessment and evaluation of the national strategies for developing and improving observation networks (see paragraph below).

2.4 Assessment of existing national strategies and projects for developing and improving observing networks

Currently no strategic plan and institutional documents exist which describe an existing national strategy for operating and improving meteorological observation networks and services. We refer also the STP - Country Hydromet Diagnostic report for additional information.

The proposed GBON network requires to be fully compliant with WMO rules and regulations at the end of the 5-year SOFF investment faze. It should also fit the current and planned national investments with respect to meteorological observations. Only the marine meteorological observations are currently not included in this stage of the SOFF process.

Adaptation of the current institute's organizational framework, including development and use of strategic multi-year planning for operations and management can be considered essential. This will be required in order to absorb the potential significant SOFF investment, and be able to implement the SOFF investment faze activities e.g., Surface AWS improvement, set-up a new UAS facility, human resources capacity development for O&M, int'l data communication (WIS2.0) and dissemination, project management and more.

We therefore recommend the IE, with support from the peer-advisor and other expertise partners, to organize support for the INM with the elaboration of a strategic plans, including a national strategy for improving the meteorological observation network and services.

<u>Sustainable</u> observation network operation and maintenance (O&M), incl. human resources development and management, data communication (incl. secure data storage, quality control,

analysis) and wider dissemination will be a very important aspect of this development activity. Also engaging in regional and int'l collaborative actions (new technologies, research, etc.) is an important aspect.

We note that this national strategy development process through SOFF, will be closely linked to other int'l weather and climate related development assistance and investment projects i.e., WACA (by IE/World Bank), SAP (IE/UNDP) and more.

Table 2.3 summarizes the investment requirement for national strategy development activities to improve the institutional capacity in relation to GBON and the meteorological observation network of STP.

Table 2.3: Investment proposal for national strategy development - for operation and management of the GBON Surface (2) and UAS stations and the meteorological observation network of STP

Item #	Item/Activity	Locations	Cost estimate (USD)
1	Inventory of current and potential cooperation partners (incl. visits, contacts) Review of legal documents (related to Meteorological observations & aviation)	São Tomé and Príncipe Islands (2)	See IFR[4]
2	Conduct a workshop with main stakeholders on GBON AWS and UAS infrastructure (full operational chain)	São Tomé	
3	Draft and publish a Meteorological Observations Strategic Plan (with support of peer-advisor a/o other expertise)		

2.5 Review of the national legislation of relevance for GBON

The INM is now under the supervision of the Ministry of Infrastructure and Natural Resources (MIRNA). INM's legal statute was approved by Law Decree No. 10/2012[11], and its main attributions are: to maintain and develop the national meteorological, seismological and air quality information and surveillance systems, issuing severe weather warnings to public and private entities; ensure the provision of services in the fields of meteorology, seismology and air quality to the different national and international socio-economic agents, promote and ensure study and training at national and international level in the fields of meteorology, seismology and air quality. INM has currently the unique mandate for the above-mentioned monitoring services.

[11] To add decree reference

The current national legislation and regulations on meteorological observations are not entirely adequate with respect of implementing GBON, also with respect to compliance and operations. INM remains the prime national authority in meteorology.

Another government Decree (No. 12/2018)[12] was published in 2018 regarding the legal status of the INM employees. This Decree has not been realized yet. It is recommended that INM pursues implementation of this legal act.

The NMS is allowed (by law) to contract external services from private sector a/o other entities to support the observation process chain (e.g., for station maintenance or another work process).

There are no special legal requirements or customs constraints related to importing meteorological instruments and related equipment's. It is however recommended that the INM includes eventual taxes and custom costs in their project proposals and budget, to avoid any issues related to procurement of equipment's and services.

[12] Reference to decree

Module 3: Infrastructure Development

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

The aim of the SOFF investment phase project is to improve and maximize the impact of surface and Upper air weather observations on global numerical weather prediction (NWP). This will be achieved in STP by:

- Improving two (2) currently WMO-ID Surface AWS to comply with GBON standards;
- Installing and operating a new Upper Air Sounding (UAS) station facility;
- Acquiring and managing adequate IT hardware components to store data and permit communication and sharing with the WIS2.0;
- Developing Human Capacity to maintain the observation infrastructure, including O&M, ICT, data and information management, sharing and dissemination processes;
- Engage in partnerships with the int'l climate research and weather forecasting community;
- Engage with CSO's (civil society organizations), government agencies and the private sector in meteorological information use and service building;

Two (2) improved GBON Surface AWS

The NGA of STP indicated that two (2) synoptic AWS need to be improved to become GBON status Surface AWS (see Fig.1a/b). The second GBON Surface AWS (on Príncipe Island) was approved by SOFF in relation to early warning purposes, as a significant number of people reside on the Island (see map in Figure 2), and the region is prone to tropical extreme weather (thunderstorms, large convection, etc.).

Table 3.1: List of current WMO - WIGOS registered Surface airport weather stations

Station Name	WIGOS_ID	ICAO	Owner	Type	Lat	Lon
São Tomé Int'l RWY29	61931	FPST	INM	AWOS[13]	0.337593N	6.718714E
Príncipe airport RWY18	61934	FPPR	INM	AWOS	1.666357N	7.411577E

The two (2) current synoptic and earmarked GBON weather stations are in operational condition, serving aviation weather purposes and air safety. However, they are not compliant with GBON due to a gap in data transmission frequency (required hourly) and automated data delivery to the new WMO WIS2.0 system. Also, renewal or (urgent) replacement of malfunctioning instruments is very problematic, as INM does not have budget or receives any (government or ENASA client) funding

[13] AWOS: Airport Weather Observing System incl. additional aeronautical instruments (ceilometer, PWS, etc.), next to the standard weather variable monitoring instruments (wind mast, temp, pressure, humidity, rainfall).

for this important O&M process. The required hardware investment in the SOFF programme will include new observation sensors (related to GBON variables), and appropriate data loggers for WIS2.0 communication. Additional hardware (spare parts) e.g., wind mast, cables, protection fences, etc. will also be foreseen.

Operation and more preventive maintenance of the two earmarked GBON Surface AWS (also on two islands) will also require more human resources as currently available within the INM, and capacity development in O&M, ICT and data quality control (re. Module 4).

Based on the NGA and the previous description and analysis section, the SOFF beneficiary and peer-advisor team, is recommending the following initial infrastructure investments for the INM to produce GBON compliant observations. The recommendations for equipment requirements follow the WMO TT-GBON 6.1 and 6.2 Deliverable reports on Tender Specifications for AWS and Upper-Air Stations.[14]

Table 3.2: Equipment requirement for the AWS (stations) to meet GBON compliance

Required AWS components	GBON station Locations		Spare
Instrument/equipment	São Tomé Int'l RWY29	Príncipe airport RWY18	
Air Temp / Humidity sensor	✓	✓	✓
Radiation shield	✓	✓	✓
Wind speed - direction sensor	✓	✓	✓
Pressure sensor	✓	✓	✓
Precipitation sensor	✓	✓	✓
Wind mast & stands	✓	✓	✓
Solar power supply	✓	✓	✓
Power regulator/multiplexer	✓	✓	✓
Data logger	✓	✓	✓
Data comm. modem, antenna	✓	✓	✓
Lighting protection	✓	✓	✓
AWS cabinet; junctions,	✓	✓	✓
Cables, wiring, connectors	✓	✓	✓
Protective fencing	✓	✓	-

We considered a quantity of 2 instruments plus one additional spare (as normally one invests in 130% on instrument networks). We included one spare of each instrument for the 2 locations. Verification (Feb, 2024) of the GBON earmarked stations and locations leads to the following investment requirement for the surface AWS (2) rehabilitation:

[14] TT-GBON-Deliverable 6.1 - GBON-Tender-Specifications-for-AWSs-V1.1.pdf and TT-GBON-Deliverable 6.2 - Requirement document to be used as input to tender specifications for radiosonde-related procurements-.pdf

Table 3.3: AWS sites (improve/upgrade) investment proposal and required actions

Activity #	Action required	Quantity	Cost estimate (USD)
1	Rehabilitate or upgrade data loggers to meet MTQQ & SFTP transfer protocol requirement	2	[15] See IFR
2.	Upgrade air temp/humidity sensors incl. radiation shields (not meeting requirement measurement range)	2	
3.	Upgrade precipitation sensors (not meeting requirement measurement range)	2	
4.	Upgrade wind speed & direction sensors (not meeting requirement measurement range)	2	
5.	Verify a/o upgrade atmospheric pressure sensors (not meeting requirement measurement range)	2	
6.	Replace solar panels, batteries, power regulator, multiplexer, and security materials	2	
7.	Verify / replace lightning protection unit and cables/earth	2	
8.	Upgrade communication at all sites (modem, antenna, sim cards,)	2	
9.	AWS cabinet and mountings	2	
10.	Cables, wires, junctions, terminal boxes…	2	
11.	Labour, transportation (flights), Dsa for external support, where required	2	
12.	Field installation cost (incl. inter-island travel, etc.)	2	
13.	Int’l Transport (air freight) of equipment goods	2	
14.	Import duties, customs clearance cost	2	
15.	Operation & Maintenance of GBON AWS (2) Estimate: 6,000. $ p.a. * 5-years * 2 AWS	2	
	Total		[7] see IFR

Please note that SOFF investment funds need to be used for the essential GBON weather variables (air temperature, humidity, wind speed/direction, atmospheric surface pressure, precipitation rate).

One new Upper Air Sounding (UAS) station

Monitoring the vertical profile of the atmosphere using essential state weather variables (temperature, humidity, pressure, and horizontal wind) is critically important when initializing weather forecast models and for air navigation. Upper-air radio sounding has proven to produce observations in good quality. A requirement of spatial resolution for upper-air sounding is 1000 km (in marine areas, applied for SIDS) with sufficient temporal resolution for observation per location being 2 soundings in 24 h (GBON rule).

[15] For budget estimates, we refer to the SOFF Investment Phase Funding Request or IFR (elaborated by the IE, with the peer-advisor and beneficiary)

Two types of upper-air radio sounding systems are available: semi-automatic with manual launching and fully automatic. Both types of systems use the same sonde models (manufacturer specific), and thus, produce equally accurate observations. Daily operation with manual launching is somewhat more laborious, and thus, salary costs can be a burden with semi-automatic sounding system. The fully automatic system does not require daily attention from technical staff, but it requires expensive annual (or better quarterly) preventive maintenance which, due to need for advanced level capacity, is to be made by manufacturer (high operational cost implication). Corrective maintenance may also require (ad hoc and expensive) remote and/or on-site support from the technical team of manufacturer. When the system ages care must be taken to avoid long data gaps.

We verified some budget posts for investment and operation of an UAS. The following were included:

- initial investment cost (semi vs. fully automatic station);
- civil infrastructure work (rehabilitation) cost;
- cost of consumables (sounder, balloon, rope, and winder);
- operating cost the sounding system (daily human work for semi-automated, preventive maintenance, relevant spare parts; corrective maintenance);
- human capacity gains for the beneficiary country (meteorological expertise);

The initial investment cost of fully automatic sounding system is significantly higher compared to semi-automatic system. However, the difference in investment costs is temporary compensated for the automated station in operational costs (i.e., salary costs). This assumption is especially valid in developed countries (high personnel salary costs) and when operating UAS stations in remote regions (extra transportation and e.g., local residence costs).

This compensation or gain is considered to be comparatively small in STP as the observation station is located at the INM Headquarters near São Tomé airport and the site is already 24/7 staffed. The human resource personnel cost to operate an UAS is relatively low. In case a fully automated UAS is chosen, the INM will have to bear the expensive preventive and corrective maintenance costs of the fully automated UAS system (usually done exclusively by the int'l manufacturer), after the SOFF investment phase.

Apart from the operating personnel need of a semi-automated UAS system, it offers some more flexibility in operation (e.g., supporting additional sounding campaigns for research org., etc.). The SOFF investment permits to hire and capacitate human resources of beneficiary countries in UAS operation and data analysis. This can be considered important human resources and "brain gain" for a country, incl. job creation.

After due consideration, the best operational model and way to ensure fulfilling GBON requirements for UAS stations in the short-, medium- and long-term is to operate semi-automatic upper-air sounding system in STP.

Based on joint recommendation by the peer-advisor and beneficiary, the current defunct UAS site at the INM Headquarters will be fully rehabilitated and made operational. Semi-automated UAS requires human resource manpower (balloon launching and monitoring twice daily), but also permits São Tomé and Príncipe to further develop its human resource capacity in meteorology.
Renovation and construction work on the current UAS site will also be required, including implementation of safety measures (gas storage etc.), related to UAS operation.
The technical and local assessment (Feb, 2024) of the Upper-air site, indicated that nothing is left over of the old UAS site. The plan therefore envisages the total renewal and rehabilitation of the balloon room and building, procurement of a H_2 generator, a ground monitoring system and consumables, including application of safety measures. Also, additional UAS staff recruitment and training will be included (ref. Module 4).

Table 3.4: Investment requirement for the UAS rehabilitation – São Tomé (INM HQs)

UAS station	Balloon building rehabilitation	Hydrogen generator	Ground system hard-/software	Consumables
São Tomé Int'l INM HQs	✓	✓	✓	✓

The start-up investment and activities needed for the rehabilitation of the UAS site are:

- Rehabilitation works of the balloon room/building in accordance with int'l standards and code of practice (incl. Safety regulations)
- H_2 (hydrogen) generator and storage; Helium (He) gas cylinders (for back-up)
- Ground system hardware/software
- Consumables (radiosondes, balloons, strings, etc.)

Table 3.5 gives the investment requirement and an indicative cost estimate of the UAS upgrade

#	Item/activity	Quantity	Unit price	Cost estimate (USD)
1	Rehabilitation works UAS building	1	--	
2	H_2 hydrogen generator & storage	1		
3	H_2 hydrogen storage tank, piping, valves,	1		
4	Ground monitoring system hard-/software - Upper-air Ground System - UPS and Desktop PC	1		
5	Ground System lease contract for 5-years	1 (5-yr)		
6	Consumables: Balloons	400 p.a. for 5-yrs		
7	Consumables (radiosondes)	400 p.a. for 5-yrs		
7	Helium gas cylinder (backup)	1 per yr.		
8	Shipping and transportation (to Sal)	Per shipment		
9	Import duties, customs clearance	Per import		

		Total	See IFR [16]

- **Observational practices defined per network & SOP**

The performance of the surface observation network depends on the skills, and competencies of the staff responsible for the installation and operation of the station instruments and communication systems. The operation of the GBON AWS and sounding station requires a robust process of observation, including preventive a/o corrective maintenance and SOPs (Standard Operation Procedures). The beneficiary has already a long history in making weather observations for the aviation (aeronautical) sector. The airport stations are 24/7 manned stations (ref. SYNOP code). For the GBON stations, the INM will invest in preparing a new special SOP protocols (for Surface AWS and UAS), including data transmission (to WIS2.0) processes.

The peer-advisor will further support in developing Standard Operation Procedures (SOP) for the observing systems, related to GBON. This includes the new data communication and WIS2.0 transfer protocols now in use by WMO. The latter also supported by regional training from WMO (preferably in Portuguese). For operating the renewed upper-air sounding facility, a support training program will be defined and developed, and new UAS operations staff to be recruited.

- **Preliminary maintenance plan for existing and improved/new stations, including calibration practices**

INM plans to use a preventive maintenance schedule of 90 days for GBON earmarked stations, as is done now for the current airport weather station network undergoing a 90-day interval full inspection. Corrective maintenance activities should be performed to fix technical or communication failures. It is anticipated (due to the close locations of the GBON AWS to the main INM offices) to attend system breakdowns within 24/48-hours for the 2 GBON AWS. Current maintenance activities are done by the technical staff located at São Tomé INM Head Office. The operation of the GBON Surface AWS on Príncipe Island may require special attention and additional personnel. Corrective maintenance may also require and include field re-calibration of instruments.

Calibration

The INM staff should engage also in executing field calibration of instruments when anomalies a/o mal-functioning is detected of the future GBON Surface AWS. When required, instruments can be sent for inspection and (re-)calibration at one of the RA-1 WMO RIC or Regional Instrument Centres e.g., Gaborone (Botswana), Nairobi (Kenya), Casablanca (Morocco) or e.g., IPMA (Portugal). For language issues a/o eventual trainings in this respect, the Portuguese national weather service could be useful. The equipment manufacturers will also be involved in designing an equipment maintenance and (re) calibration programs. We also recommend to cooperate closely with the peer-advisor on maintenance and calibration aspects where needed. INM and peer-advisor recommend to invest in the following small field calibration equipment, required for improving local operations and maintenance of weather field instruments.

[16] See Investment Phase Funding Request (IFR)

Table 3.6: Field calibration equipment requirement

#	Field Calibration Test equipment	Sensors	Quantity
1	Temp/humidity sensor with rad. shield	Temp/humidity	1
2	Barometric Pres. Transfer standard	Atmospheric pressure	1
3	Rain gauge calibration device	Precipitation calibration	1
4	Prop. Torque etc.	Wind verification	1

3.2 Design of the ICT infrastructure and services

For developing a successful ICT infrastructure, increasing the value chain of an automatic weather observation network, we highly recommend to begin with building required human capacity and resources. Enough staff is required to ensure resilience and should be tasked and trained in skills and knowledge relevant to IT in meteorological observation. The organization is recommended to gain knowledge and skills in meteorological data, data processing principles and tools, data formats (e.g., NetCDFv4, BUFR, GRIB), system architecting, software developing, database, API, network management, as well as web developing.

The ICT infrastructure of the INM should be able to support a principle of automatic data collection from station and data delivery to international and stakeholder distribution as well as to operational forecasters through a database including an automatic Quality Control (QC) of observation. In the following considerations for the specific technical ICT development needs in the INM of STP are considered.

a. Description of the ICT infrastructure and services design

The INM Head Quarters accommodates the national meteorological data infrastructure (main server) for storing and dissemination weather and climate data of São Tomé and Príncipe.



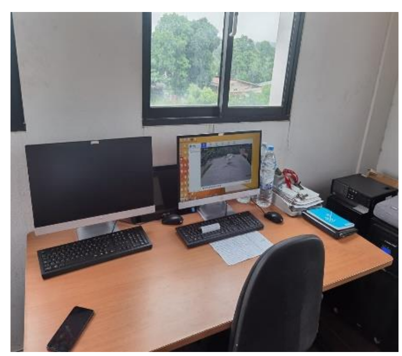


Figure 3: Main data Computer at the INM main office

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

The int'l airport aviation weather services use a separate network and system for providing weather forecasts and air navigation information to pilots including message handling i.e., the ICAO AMHS. Data communication from airport AWS is currently through VHF. The other INM-AWS data transmission is currently achieved using GSM/GPRS technology via a national telecom provider. The AWS use typically own data loggers (e.g., Campbell CR1000X or other and modems).

Incoming station data (10' or longer time intervals) are centrally stored (Fujitsu computer) and managed using the AmbiDS[17] software. This permits to monitor station functioning, data reception and also to do initial quality checks (anomalies). Recently and in the framework of development assistance equipment supply projects (e.g., SAP and WACA projects), AmbiDS[17], a cloud-based environmental (incl. weather) data collection and monitoring system, based on remote cloud-based ftp-server storage, was also installed for the new i.e., SAP and WACA AWS station (sub)networks.

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

Currently, the INM (aviation weather forecast unit at the airport) is using a Corobor[18] MESSIR message handling system to report weather data to the Cong-Brazzaville RTH. Airport weather observation staff (São Tomé Int'l airport and main node) perform this process manually to transfer the standard SYNOP messages to the WMO-GTS/WIS. The software is accommodated to communicate to the new WMO WIS.

However, except from sending SYNOP or other messages using MESSIR-COM/WIS, there is no staff capacity for operating a stand-alone WIS2.0 Node and the WIS2.0-in-the box FOSS free and

[17] AmbiDS: Web-based environmental data management application (©AmbiMetric, Pt)

[18] Corobor, a (former) French Company, distributing e.g. MESSIR systems and software, is currently embedded in Campbell Scientific (USA) and now is operating as: Campbell Scientific France.

open software system and tailoring this to their own needs and compliance requirements of WMO GBON. We further refer to Module 4 on Human Capacity Development in this respect.

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

Meteorological data acquisition (sub-hourly) is achieved in STP at several station locations. Aviation weather services use the ICAO's AMHS (Automated Message Handling System for data communication. Synoptic aviation weather station data and messages from the two airports) are also communicated to the WMO – GTS/WIS.

As measures of resilience in data continuity, the INM recommends to upgrade the main data storage facility including software updates and a full-fledged installation of the WIS2.0 node at the INM HQs main office (or airport forecast unit, manned by INM staff).

A capacity development (training) program needs to be set-up and conducted to roll-out the use of WIS2.0-in-the-box and integrate this in the current data flow and weather and climate data management systems of INM. It is recommended to use a bi-lingual (English/Portuguese) training as enrolled by WMO for other regions. It can also be envisaged to also have regional a/o Atlantic SIDS training events (in the various countries; locations to be decided).

3.3 Design of the Database Management System

In addition to automatic and/or manual meteorological observations on site and transfer, a modern, functional Climate Data Management System (CDMS) is a key element in the value chain of observation from measurement station to the end-user. The following specifies general key elements to consider in technical and budgetary perspectives.

Data management system is recommended to use open-source technologies and open protocols (e.g., Open CDMS) to ensure sustainable and redundant operation, maintenance, and development throughout their lifecycles and beyond. DMS can be built cloud-based or on premises-based depending on national legislation and regulation, staff capacity as well as a decision of the organization. The CDMS must be able to ingest and store multiple different types of weather observation data formats.

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

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

The system must be able to store relevant metadata regarding stations, station networks and observations. Automatic updates to the WMO/OSCAR system are preferred. The delivery of GBON hourly observations should be reported by WMO guidance (no. 306) and GBON practices.

a. Short-term data storage and access through the services and protocols required by applications for national and international operational activities

The INM is currently storing its incoming station data on a small main data server. Data are now made disponible to some INM staff through AmbiDS[19], a cloud-based data storage and back-up solution. Current data storage (managed by ICT staff) and access is currently INM staff dependent, and not generalized in the service.

b. Acquisition of data to and from WIS/GTS, WIS 2.0 and other national or international sources required for operational activities

INM is sending standard synoptic data of São Tomé Int'l airport station to the WMO-GTS/WIS by the MESSIR-COM/WIS Message Handling System. There is currently a capacity gap to acquire or supply other data to WIS2.0 system (see also Module 4).

c. Data delivery to the national CDMS

INM stores incoming weather station data on its mainframe computer at INM Headquarters. Data can be queried by some INM staff using the AmbiDS cloud-based data storage and access system. It is envisaged that once the GBON compliance phase has been reached, the CDMS should be able to ingest and store multiple different types of weather observation data and formats:

- Surface weather observations
- Upper-air radio sounding observations
- Aviation weather observations
- Lightning observations
- Marine (e.g. tidal observations) / optional

These will be available via the WIS2.0 node for further use, applying the WMO resolution #40 on (re-)use of weather station data by third parties.

d. Discovery and descriptive metadata management

INM will seek technical support and advice to set-up the climate database system (CDMS), but also a data dissemination system (web-based data platform). This will permit registered users to access weather and climate information and also foster national and int'l exchange in weather and climate data use and applications. For the process of metadata production and management (e.g., in netCDF, BUFR, GRIB2 and other data formats), training of staff is further required (see Module 4). The Tables 3.8 and 3.9 contains the INM and peer-advisor recommendation for hard- and software computer upgrade (improvements required for meeting future GBON compliant data

[19] AmbiDS: cloud-based data storage and hosting application and system (ref. Ambimetric.com/Pt)

communication. It is also advised to hire consultant service with respect to data management, networks, CDMS and set-up of the data dissemination platform.

e. CDMS and Climate Data Rescue

One note on historical weather and climate data. Important historical weather **data rescue** efforts are required in São Tomé and Príncipe, to safeguard important historical analogue (paper) meteorological data for use in climate change research and climate-service building initiatives. This requires however more staff capacity and hiring of personnel. It can be recommended to initiate climate data rescue initiatives using e.g., CLIMSoft v.4 (or other tools), for digitally archiving the numerous (long-term) analogue weather and climate data, still all in old paper archives (see Fig.). The peer-advisor (KNMI) is also involved in large global climate data rescue efforts with WMO (e.g. IDARE[20]). This CDMS aspect will also require some manpower (and scanning, OCR-type) reproduction tools.

Figure 4: Manual weather data archiving at INM-STP

Table 3.7: Requirement for advisory service for ICT and data management

#	Advisory service (short term consultant)	Activities	Cost estimate (USD)
1	Hard-, software, network engineering; incl. Free & Open-Source Software solutions	Review of current practices, recommendation; including FOSS use; multiple missions e.g. total 30-days input (travel, Dsa, fee)	
		Total	See IFR [21]

Table 3.8: Computer hardware investment requirement (example)

#	Computer & communication (ICT) Equipment	Quantity	Description / specifications	Cost estimate (USD)
1	e.g., Dell PowerEdge Rack Server, HP or similar types,…	1		
2	Router e.g. CISCO ER 4331 or similar	1		
3	Network access point e.g. Cisco	1		
4	Network switch e.g. Cisco	1		
5	PC (e.g. Dell OptiPlex, HP or other..)	6		

[20] IDARE: https://www.idare-portal.org/ WMO-GFCS Int'l Data Rescue Portal, managed by KNMI peer-advisor

[21] See Investment Phase Funding Request

6	Monitor e.g. EIZO EV2556 24" Full HD	6		
7	Tablets (field data collection)	6		
8	NAS storage (Synology or) 24 TB	1		
9	Smart UPS 3kVA	1		
10	UPS 700VA	6		
11	Cables, wiring,	-		
12	WLAN-USB e.g., TpLink	6		
13	Scanner e.g. Epson Perfection V550 Photo	1		
14	Printer e.g. HP ColorLaserjet CP5525dn	1		
15	Multifunctional A3-A4 printer (for data rescue)	1		
16	HP color cartridges	3x4		
17	Int'l transport (e.g., air freight)	-		
18	Customs clearing, import duties,	-		
			Total	See IFR [22]

Table 3.9: Software upgrade/improvement investment requirements

#	Software	Use/location	Location	Coast estimate (USD)
1	tbd	Central incoming station data monitor ()	INM HQs	
2	UAS Ground System	Upper-Air Sounding	INM HQs	
3	MS Windows OS 6-pack	Generic new PCs	INM HQs	
4	Linux (Ubuntu)	Generic for new PCs	INM HQs	
5	Miscellaneous i.e., malware scanners, etc.	--	--	
6	Other (tbd)			
			Total	See IFR [23]

3.4 Environmental sustainability considerations

The INM will strive to minimizing the environmental impact of observing technologies as they also strive towards GBON compliance. The surface observing networks will be designed, implemented, and operated with the aim of having a sustainable weather and climate observing systems. The upper-air consumables will meet environmental regulatory compliance for batteries, packaging and hazardous substances with the consideration of biodegradable packaging to be used where possible.

INM will also consider 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 to develop a SOP that will guide the re-use of instruments and the elimination of single use plastics or all-in-

[22] See Investment Phase Funding Request
[23] See Investment Phase Funding Request

one sensors. Technologists will also be trained on instrument repair and advance fault diagnostics in support of this initiative. Further sustainability specific considerations include at least:

Upper-air sounding station: The GBON compliant sounding system (despite of being fully or semi-automatic) is recommended to be located at a site where permanent staff works daily. This is the case in São Tomé and Príncipe (at INM Headquarters, near São Tomé Int'l airport). There will be no staff displacements and burdening financial implications. Regular (i.e., quasi permanent) attention can be assured. The tender process will also emphasize quality criteria related to composability in material selection where applicable. The investment in sounding system is made for 20-30 years, and thus, care must be taken to ensure that annual maintenance is ensured throughout its lifecycle. This has high financial cost implication for the operation, especially in the case of fully automatic sounding systems. Generation of hydrogen, needed by balloons, locally at the station will make the operation more environmentally sustainable. Proton-Exchange-Membrane technology i.e., a PEM based Hydrogen (H_2) electrolysis and production system will be employed[24]). INM can opt to develop a plan to fully supply power to the UAS facility using solar technology.

AWS: The GBON compliant AWS is recommended to improve (where needed) existing AWS with civil infrastructure (e.g., electricity, wind mast, etc.) that is reusable or has environment friendly maintenance. With scheduled preventive maintenance and calibration, the lifecycle of sensors will be lengthened as long as appropriate. Solar renewable energy will be used (and in several cases is already used for AWS power supply in STP as appropriate.

[24] PEM-based H_2 electrolysis equipment for UAS balloon filling

Module 4: Human Capacity Development

4.1 Assessment of human capacity gaps

The INM human resources base consists of a total of 28 employees[25] (January, 2024). The gender ratio of staff is 8 women to 20 men (see Table 4.1 below).

	# of Staff	Category	Training
	4	Meteorologist	Higher level in Meteorology
	16	Meteorological Technician / Observer	Various levels (classes) of meteorological training
	1	ICT Technician – Station Operation & Maintenance	Average level of meteorology and informatics
	2	Administrative assistant*	---
	1	Driver	---
	4	Cleaning**	---
	Total: 28		

(*) one in São Tomé main office and one in Príncipe Island (Autonomous Region); (**) 2 in ST; 2 in RAP

Table 4.1: Human resources of the INM – STP (Jan, 2024)

In the broader context of economic and social development of São Tomé and Príncipe in the last decades, current global climate change issues and also the potential future ingestion of SOFF investments for setting-up the GBON infrastructure of the country, the INM is aiming at a human capacity growth scenario, for developing and delivering more weather and climate services to both the public and private sector (e.g., early warning, agriculture, tourism, water, health, environment, maritime). Table 4.2 shows the desired situation and future needs for human resources related to the weather and climate sector and science.

Table 4.2: Desired human resource capacity (by INM-STP)

Staff functions	Actual #	Recommended	Desired
Meteorology	4	+ 2	6
Hydrology/oceanography	0	+ 1	1
Climate Services / Air quality	0	+ 2	2
Agro-hydrometeorology	0	+ 2	2
ICT specialists	1	+ 3	4
Weather Observer / Meteorological Technician	16	+ 4	20
Geophysics	0	+ 1	1
Administrative/support	7	+1	8
Totals	28	+14	44

[25] Source: INM, 2024.

The current (or recently retired) meteorologists followed higher level or academic degree training abroad in various countries and universities. This ranges from countries in Eastern and Western Europe and Latin America (e.g., Brazil) to Asia (P.R.China). Several INM staff also followed short trainings in African Centres such as EAMAC, AGRHYMET (Niamey) and ACMAD application centres and WMO RTC's. Aviation meteorologists also follow ICAO linked trainings in regional centres and/or training from Portugal (IPMA).

Current Weather Observers, now called Meteorological Technicians, are trained locally according WMO Class IV and Class III syllabi. It is highly recommended that those technicians involved in the GBON stations receive updated training, especially because the WMO updated Basic Instruction Package (BIP-MT 2022) sets higher standards for the training requirements for Weather Observers. For São Tomé and Príncipe and SIDS in general, Marine Meteorological Observers should also be trained amongst others. These specializations are included in the recent BIP-MT 2022.
Furthermore, attention should be given ToT (Training of Trainers) issues, and regular updating and refreshing of current trainer staff. The WMO Regional Training Centres (RTC) e.g., INAMET (Angola), SAWS (South Africa) or EAMAC (Niger) for meteorology and AGRHYMET (for agro-hydrometeorology) in Niamey, can play an important role here. A recent capacity gap for many INM staff is the management of the newly introduced WIS2.0 by WMO (2021). The new information system uses FOSS (Free and Open-Source Software) tools and the upper-level computing language (Python v.3). Where the use of Linux (e.g., Ubuntu) Operation Systems is very common by meteorologists, using a/o adapting python code used by the WIS2Box requires dedicated training in use of OS-ware as for example the Github and new IoT communication tools such as MQTT, based on very low power consumption (Loran) technology. The WIS2.0-Box is the Reference implementation of the WMO-WIS2 Node.

Although SOFF cannot support the full personnel (HR) growth scenario of the INM, a number of new staff, closely linked the SOFF implementation process is needed, for the INM (together with the IE/UNDP) to be able to successfully carry out the SOFF Investment project. We therefore also recommend and include SOFF dedicated personnel requirements in this NCP report.

4.2 Capacity Development activities for technical staff

- **Recommendation on training activities and recruitment for technical staff in:**

a. Instrument, calibration and station maintenance

For the training of technical personnel directly related to the GBON surface stations, the training requirements can be summarized as follows in Table 4.2

Table 4.2: Training and competence requirements for technical staff (O&M Surface stations)

Performance component: Install instruments and communication systems	
1.	Assemble and test instruments before transport to site
2.	Transport and install instruments and communication systems
3.	Coach observer staff in O&M of new instruments incl. use of SOPs

4.	Test performance, prior to operationalization
5.	Complete site classification for observed variables,
6.	Prepare metadata submission to WIGOS via OSCAR (and PoC)
Performance component: Maintain and control system performance	
7.	Schedule and conduct preventive maintenance; ensure spare parts; check inventory
8.	Monitor data availability and communication
9.	Verify correct instrument functioning
10.	Provide guidance to Observers and conduct refresher training
11.	Record maintenance checks, on-site events, calibrations, replacements in station log
Performance component: Diagnose Faults	
12.	Detect abnormalities in data acquisition
13.	Check cabling, wiring, power supply,…
14.	Record faults in maintenance log
Performance component: Repair faulty instruments and comm.systems	
15.	Requisite spare parts
16.	Repair according SOPs and processes
17.	Perform tests after repair to ensure compliance with performance requirements
18.	Record repair actions

b. Upper-air station capacity development training needs

For the Upper-Air Station operations and maintenance, the training requirements are summarized in Table 4.3.

Table 4.3: Training and competence requirements for UAS O&M

Performance chain components	
1.	Prepare and deploy balloon and payload - Carry out Balloon room safety check - Prepare and fill balloon - Instrument ground check - Release balloon
2.	Track balloon flight - Compute and record; upper-air pressure, temp, humidity, wind speed & direction - Carry other (special) observations as required (e.g. Ozone)
3.	Encode and transmit upper-air observation data using prescribed codes and protocols
Knowledge and skills requirement	
4.	H_2 (hydrogen gas) safety and generation
5.	Understanding of basic meteorology (ref. WMO BIP-MT) and Upper-Air meteorological sounding obs.
6.	SOPs and prescribed practice of Upper-air radio sounding observations
7.	On-site instrument care and use of tracking software

For manning the Upper-air Sounding facility, recruitment of a meteorologist and two meteorological technicians and capacity development is a requirement for successful future operation of the site. This presents also a long-term personnel investment.

- **c. ICT and Data Communication capacity development requirements**

The ICT and the data communication technology component plays an important role in O&M (operation and maintenance) of the GBON surface and UA soundings. New WIS2.0 communication technology will be applied and training is required for improved understanding and use of this FOSS-based data communication. The WIS2Box communication (via HTTP/MQTT) differs from the traditional MHS (Message Handling Systems) to the WMO-GTS. Tables 4.4 and 4.5 summarize the training and competence requirement for data communication. It can be seen as essential that the ICT lead personnel of INM (managing data communication and transmissions) obtains skills and training in the use of Python computing language. This open source upper-level language is relatively easy to understand but basic training in running and adapting python code in a Linux Ubuntu environment is essential. Beside WIS2.0, use of upper-level OS computing languages (Python, R) was and is becoming more standard practice in data analysis and processing (incl. meteorological data and data management systems). Below in Table 4.4, training requirements are shown:

Table 4.4: Training and competence requirement for ICT and Data Communication (Python OS computing language training)

Competence component: basic Python computing	
1.	Installing Python v3.10 or higher (use of virtual environment versus hard paths)
2.	Updating and checking packages and libraries (e.g., main libs and site-packages)
3.	Running Python from command line; via IDLE interface; calling python
4.	Basic Python: Creating and running small python code
5.	Basic Python: variables, strings, numbers and math; functions, loops;
6.	Basic Python: Debugging code; ..

In the Table 4.5 below, the training requirements for use and set-up of a WIS2.0-Node are summarized. This training requirements applies to ICT personnel and senior meteorologists requiring full understanding of the data communication setup and protocols of the WOM WIS2.0. This can apply to the weather and climate database related staff of INM and researchers. Technical Observer staff can be trained only for e.g., WIS2.0 data inputs (using e.g., the MINIO widget interface) in case needed for manual data transmission (in case needed). The WIS2.0-Node is to be configured for automated data ingestion (due to the hourly GBON data communication requirement). These options can be set by Python trained ICT staff.

Table 4.5: WIS2-in-the-Box training requirements (for ICT staff a/o dedicated meteorologists e.g., database managers)

Competence component: install and operate WIS2-in-the-Box (WIS2.0 Node)	
1.	Acquire knowledge of WIS2box @ WMO https://docs.wis2box.wis.wmo.int/en/1.0b5/
2.	Acquire knowledge in use of GitHub FOSS repository
3.	Installing (and updating) the WIS2box components (requires Python knowledge)
4.	Configuration and administration; authentication and access building

5.	Data ingestion setup
6.	Public service setup
7.	Downloading data from WIS2

- d**. Climate Database Management System training requirements**

The INM staff is currently not using much database concepts (e.g., MySQL, PostgreSQL) to query and organize its current weather and climate data. It is recommended to initiate and support CDMS efforts using capacity development in this field. This database activities will be streamlined with the WMO WIS2.0 data exchanges, after full operationalization of the WIS2.0-Node, and once the staff is capacitated in the WIS2.0. The training requirement on databases can be geared towards two training packages. The first is geared in getting support and capacity in managing and working with an open source geospatial CDMS (station time series data) using relational database concepts and statistical tools.

Table 4.6: Training requirements for Climate Database Management & Development (1)

Competence component: concepts of web-based geospatial and relational databases	
1.	Geospatial aspects of meteorological data; coordinate reference systems, map projections and datums; accuracy assessment; issues with use of small mapping software's;
2.	Meteorological data formats: grib2, bufr4, netCDF, geojson, csv, geotiff and others
2.	Open-Source basic GIS geospatial mapping concepts (data applied to São Tomé and Príncipe)
3.	Setting up a geospatial – temporal (AWS station) data base
4.	Relational database querying (using PostgreSQL, MySQL)
5.	Data communication with WMO-WIS2.0

As mentioned in Module 3 (CDMS Data Management System infrastructure), the open source-based climate database program CLIMSoft[26] v4., also supported by WMO, can be used to initiate data rescue efforts (digitalization of historical analogue data). For rapid-pace development of its data rescue efforts (digitalization of historical analogue data), INM also requires training and support in ClimSoft v4. and obtain knowledge in relational database and web-based technologies. We note that R-coding (language) training is required to fully use the functionality of ClimSoft for data analysis. We therefore recommend the following items for capacity development in this respect:

Table 4.7: Training requirements for Climate Database Management and Development (2)

Competence component: ClimSoft training for historical data rescue and climate data analysis	
1.	Install/setup Climsoft_v4+; user assign;
2.	Ingestion of historical (analogue) climate records
3.	Management of current AWS data
4.	Message encoding/handling and comm. with WMO-WIS2
5.	Basic R-code (language) introduction (e.g., RStudio)
6.	Climate data analysis procedures (using R-instat)

[26] CLIMSOFT v4.x see https://climsoft.org/

7.	Building Climate Services from data services

Capacity Development requirements for meteorological technicians (AWS/UAS), ICT data communication & information technology and data management

In summary, we summarized the capacity development training programs and estimated the financial implications in the summary Table below. The trainings may be organized as face-2-face events and locations to be decided. The trainings can be in any other country of choice (local, Portugal, Netherlands, Niger, others) or can also be conducted in São Tomé and Príncipe or any other selected place. It is generally assumed that trainings are conducted in a hybrid mode, with e.g., a face-2-face component and also an on-line follow-up using an e-learning platform and adequate knowledge exchange model and process.

Table 4.8: Summary of Capacity Development activities for Meteorological Technician, ICT and Climate Data Management Systems (CDMS)

#	Capacity Development Activities	Short Description	Mode face-2-face on-line; hybrid;	Cost estimate (USD)
1	Meteo Technician Station O&M Training program	Number: 4 trainings Trainer org.: WMO RTC Locations: 2 in STP ; 2 trainings abroad; #staff: 6 in STP; abroad?	tbd	
2	Upper-Air Sounding Station Training Program	Number: (2) Years (tbd)[27] Trainer org.: KNMI, IPMA?... Location: tbd Duration: 1-wk; tbd # staff: 3 to 5	tbd	
3	ToT competence training (from WMO-RTC)	Number: (2) Years (tbd) Trainer org.: WMO-RTC Location: INAMET, SAWS,.. Duration: tbd # staff: 3	tbs	
4	ICT & Data Communication Training (1) Basic Python	Number: (2) Years 2,3 (tbd) Trainer org.: NL (ITC) or any other; tbd Location: on-site Duration : 1-wk ; # staff: 10	Face-to-face with on-line follow-up	

[27] The execution of the training program will depend on the new Strategic Plan and recruitments of new staff. The training courses will be planned in the Years (e.g., 2 to 5), pending readiness of personnel, equipment's, etc.

5	ICT & Data Communication Training (2) WMO - WIS2.0 Box	Number: (2) Years 2,3 (tbd) Trainer org.: NL (ITC/KNMI in collaboration with IPMA) a/o with WMO affiliated; tbd; Location : STP on-site Duration : 1-wk # staff: 10 (tbd)	Face-to-face with on-line follow-up	
6	CDMS Concepts of Geospatial & relational Databases	Number: (2) Years 2,3 (tbd) Trainer org.: NL (ITC); tbd Location: STP Duration: 1-wk # staff: 10 (tbd)	Face-to-face with on-line follow-up	
7	CDMS ClimSoft v.4 Data Rescue and Climate Data analysis	Number: (2) Years 2,3 (tbd) Trainer org.: NL (ITC) with KNMI, Climsoft network Location: STP Duration: 1-wk # staff: 10	Face-to-face with on-line follow-up	
			Total	See IFR [28]

Personnel investment requirements to set-up the GBON infrastructure and attain GBON compliance

We stated earlier that new personnel and technical assistance will be required in order to be able to successfully implement SOFF in São Tomé and Príncipe. Below in Tables 4.9 to 4.11, we included personnel requirements for the different (sub)tasks related to SOFF and GBON. Because of the limited number of stations, certain duties (e.g. O&M, should be combined e.g., UAS and AWS maintenance, data communication, etc.).

For the re-activation of the UAS site in STP, there is also an investment requirement for human resources capacity (Upper-air sounding qualified technical assistance). We added the investment requirement for human capacity in Upper-air sounding qualified personnel in the Table 4.9.

Table 4.9: Investment Requirement for (new) Upper-Air Sounding technical assistance & O&M

Technical assistance (personnel) Investment cost for UAS & AWS O&M operations (5-yr)				
Item #	Qualification	# staff	Annual cost (USD)	5-yr cost (USD)*
1.	technical assistance UAS supervisor: Higher education level in meteorology & UAS	1	*See Investment Funding Request*	''''
2.	Meteorological Technician (UAS qualified) and also O&M (AWS)	2	""	''''
			Total	See IFR [29]

[28] See Investment Phase Funding Request
[29] See Investment Phase Funding Request

(* annual cost increases, incl. inflation, etc. over 5-year period)

The annual (up to 5-year) operational costs for the UAS station should also be estimated based on established guidelines and country specific conditions. This includes e.g., technicians local transport to/from site. We observe that INM personnel is currently 24/7 present at São Tomé Int'l airport (aviation weather forecast section) and at very close distance (~200m) of the INM HQs and UAS facility (to be renewed). The Meteorological Technicians (2) should also take care of the GBON AWS O&M.

Also, for the data communication, storage and dissemination (currently one only at INM), a new recruitment and investment is required to support SOFF and meet the GBON requirements, as shown in Table 4.10. Also e.g., int'l technical assistance should be foreseen to support setting-up a FOSS-based data storage, management and dissemination infrastructure.

Table 4.10: Investment requirement for ICT and CDMS staff personnel

New technical Human resource Capacity requirements		# staff	Cost estimate (USD)
1	One (1) ICT or higher-level trained technician for ICT data communication and SOFF data management	1	
	Total	1	See IFR [30]

4.3 Design capacity development activities for senior management

- **Recommendation on training activities and recruitment for management in**

    a. Strategic and financial planning;

INM proposes a number of work visits of senior management staff to advanced NMS (e.g., KNMI, IPMA and others), for exploring further personnel and knowledge exchanges and elaboration of other cooperation activities.

    b. Project & data management

For daily management of the SOFF / GBON project, INM and peer-advisor recommend to recruit one (local) project management staff. Taken into account the limited number of GBON stations, the person should combine this project management task with the data management and dissemination at INM. Next to managing and the daily operations and data of the SOFF project, and overseeing the regular reporting to IE/UNDP (3-months for expenditures and 6-month for progress), the SOFF project manager should also engage actively with stakeholders, CSOs,

[30] See Investment Phase Funding Request

potential cooperation partners and the government, along the SOFF lines set out in the SOFF Readiness phase reports (ref. see also CHD-STP report key recommendations).

Related to project management and dissemination of weather information, communication and presentation skills (of e.g. extreme event early warnings and weather information) short trainings are also requested. This leads to the following Investment requirement for project management and Senior Staff CD.

Table 4.11: Investment requirement estimate for SOFF-GBON project and senior staff Capacity Development

Capacity Development in NWP		# staff	Cost estimate (USD)
1	One (1) SOFF project mgt. staff (salary component…)	1	
2	Senior mgt. staff CD and mobility	-	
	Total		See IFR [31]

4.4 Gender and CSOs considerations

Gender issues

Climate change and extreme weather events are not gender neutral, but they affect women, girls, men, and boys differently[32],[33]. This is due to socioeconomic circumstances, cultural beliefs or traditions that can all contribute to inequality, resulting in women being put in situations of disadvantage when disasters strike. Therefore, it is important that in the pre-disaster context, those who likely will be the most affected by crisis, are also included in the preparedness process. This includes having equal access on political, social, and economic levels as well as being able to participate in decision making. Not only is it fair, that population is equally engaged in climate change adaptation and resilience building, but there is also substantial evidence that shows that women are often the most resilient members of society and the powerful agents of change in the event of a disaster. They also have historic coping mechanisms that can be of use when designing and tailoring local grass-root level early warning systems or other climate change adaptation services and activities.

Inclusion and participation of women in work processes at all levels at INM (and STP in general) is average compared to the world. It approaches a 30-70 F:M gender ratio. To improve, the INM will further implement the WMO guidelines[34] and follow its Gender Action Plan in this respect.

[31] See Investment Phase Funding Request

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

[33] https://wmo.int/site/wmo-and-early-warnings-all-initiative

[34] WMO Gender Action Plan

INM recommends the following gender-related actions to further promote and empower women in weather observations, climate services and the SOFF process. In all foreseen and recommended capacity development actions (this Module 4), participation of female personnel and gender equality will be actively pursued. This includes women participation in international exchanges, training and study visits e.g. at WMO-RIC, peer-advisor a/o other centres.

In its recruitment process for services and personnel, INM will actively see to attract women, and aim towards increasing its current gender 30:70 ratio towards a 40:60 and ideally a 50:50 balance. Women's participation will also be promoted (e.g., using where needed local sensibilization mini-workshops) in the work area of "improving observing networks" (see sections 2.3 and 2.4). Here INM is relying on local (island resident) governmental or private partners, for service agreements or contracts. INM also foresees and will further pursue empowerment of women from CSO's in the participatory 'Triple Sensor' observation approach and information gathering chain (see next section: CSO participation and inclusion).

CSO participation and inclusion

Concerning CSO participation and inclusion in weather and climate monitoring, several choices exist to more engage CSOs in weather monitoring and climate. One possible option is to engage CSOs using a Triple Sensor collocation approach. The idea of this approach was born in the framework of an EU-FP7 project AfriAlliance. We refer to a small demo on *http://afrialliance.itc.utwente.nl/triplesensor/* and reference[35] for more information and short explanation below:

" In Triple sensor collocation, we gather, collocate and compare information gathered by different observers or sensors i.e., in this case 1> citizens (i.e., local urban or rural communities, CSOs), 2> data from the NMS AWS network and 3> data from satellites or NWP models, to get the most reliable information on the weather variables (for example rainfall, or temperatures, humidity, etc.) for the location. An advanced statistical Triple collocation algorithm is used for the evaluation.

A selected number (e.g., 30 or more conform funding obtained) of citizens (CSOs e.g., to be selected e.g., local health posts, rural communities, local schools, urban..) will be supplied with low-cost meteorological automated AWS and encouraged (trained) to observe, operate and maintain and report. This information will be compared with the official national AWS network and also NWP model a/o satellite data. In the end we can evaluate who is the most reliable and also derive the best (combined collocated or merged estimate), and organize CSO inclusion events related to weather and climate observations". Statistical triple collocation of observations is used as statistical evaluation method. Such initiatives increase the awareness of CSOs for meteorological observations and their direct potential societal benefits.

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[35] Project literature reference: Mannaerts, C. M., Maathuis, B., Wehn, U. , Gerrets, T. , Riedstra, H. , & Becht, R. and L. R. (2018). *Constraints and opportunities for Water Resources Monitoring and Forecasting using the Triple Sensor approach WATER-SC: Large Scale EO Exploitation Activities in Support of International development Initiatives View project*. https://doi.org/10.13140/RG.2.2.21395.53288

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The recommendation (feasibility to be further discussed and elaborated) is to cooperate closely with Ministry of Health and the Directorate of Environment and Climate Action, due to the increased attention of health and heat waves and related weather phenomena in STP. The local "health posts", distributed across the islands could e.g., be used as citizen observation sites, among others (e.g., local schools or other CSO willing to cooperate). We propose to monitor both surface temperature, humidity and rainfall.

In order to further develop the strategy and upscale CSO inclusion, we propose and recommend an investment for stakeholder consultation and mobilization for developing this original weather monitoring strategy with partners. The investment includes a workshop where different CSO's and other stakeholders will be invited.

Table 4.12: Investment requirement estimate for Gender Actions and CSO engagement

Activity #	CD activity Description Short courses	Location	Cost estimate (USD)
1	Table 4.12a: Gender Plan action consultations and workshops (2)	STP;	
2	Consultations and inclusion of CSOs in weather & climate observations, using e.g., feasibility Triple Sensing collocation or other actions	STP; CSOs, stakeholders, various locs.	
3	(Stakeholder) Workshop on CSO inclusion in weather and climate	STP	
		Total	See IFR [36]

[36] See Investment Phase Funding Request

Module 5: Risk Management

WMO recommends its members to establish a Quality Management System (QMS) to ensure that customer and end-user requirements are met (WMO n°. 1100). INM is currently not involved in any ISO9001:2015 or other ISO-type certification projects for implementing a Quality Management System process in its aeronautical and other weather services.

The main finding and recommendation of the beneficiary and peer-advisor is to further develop and adopt risk-based thinking within the organization for the various work processes, ranging from station observations, operations & maintenance to data processing, communication (ICT) and database management. It also recommends INM to give additional attention to risks related to the operation of its other AWS networks (i.e., maritime, agrometeorology, research, environment) next to the aeronautical, and in the near future also 3rd party operators. Their role in the value chain of observation will most probably become more important, but should be monitored using appropriate QMS by INM. Risk management should also be applied to the upper-air radio sounding station operations, as this activity was discontinued (since long).

Recommendations for risk management during the SOFF Investment period and operational period

As stated in the SOFF Operations Manual 21, the risk mitigation procedures of the IE will be relied upon for SOFF implementation during the Investment phase. The Operational phase is supported by the risk mitigation procedures of the beneficiary. The following Table 5.1 summarizes overarching key risks for investment and operation phase to be carefully considered and handled by IE, beneficiary and peer adviser. We distinguished among the following risk categories:

- Contextual: risks related to conflicts, safety, political stability, regional weather, jeopardizing the delivery of the Readiness and Investment phase outputs
- Institutional: risks related to the beneficiary country's institutions participation in the Readiness and Investment phases
- Programmatic: risks related to the country ownership of the Readiness phase outputs and transition to investment and operations.

Table 5.1: Risk management framework for SOFF – São Tomé and Príncipe.

Risk category / description	Probability	Mitigation action	Monitoring & evaluation
Contextual - Geography (insecure areas)	Low Low	No GBON site is considered insecure; No action required	NMS to monitor conceptual risks; with special attention on station /

- Site Accessibility issues - Weather Extremes: thunderstorms, large convections - Power supply and safety	 Medium Low	The 2 GBON AWS & UAS (at INM main and regional offices; airports); regular AWS control, maintenance required; GBON Surface infrastructure will be located on guarded airport grounds, with adequate power supply and back-up	instrument operation & maintenance
Institutional - National Strategy for Weather & Climate Observations - Staff availability for implementation (AWS, UAS, ICT, DB) - Inadequate Human Capacity - Slow procurement of equipment a/o technical capacity issues - Slow implementation of installation - Slow implementation of training & CD activities - Retaining of staff & competences	High High High Medium Medium Medium/high High Medium - High	Develop a National Strategy and use Strategic Planning for operations Recruit staff for O&M, ICT, CDMS, etc. Conduct Staff training and use HR development plan; for young professionals…. Support/advice required for certain equipment's e.g., hpc, uas,… Train a/o hire additional workforces to support station installation; and data production chain;… Develop fast-track process, especially for ICT, WIS2, DB trainings; Implement staff policy, and NMS to take corrective actions; NMS to implement staff development policy;	INM management to take urgent action and measures to develop a strategy (incl. planning processes) IE, peer-advisor, beneficiary country jointly monitor progress Idem; IE, peer-advisor and NMS jointly monitor progress Country beneficiary (NMS) takes NMS to monitor and take appropriate action

- Slow implementation of data sharing and dissemination		Develop fast-track capacity development for ICT & databases	
Programmatic - Decrease in funding support for operations - Lack of support from other Government agencies, incl. central	Medium/High Medium/High	IE and NMS management are responsible for taking actions to secure (nat./int'l) funds NMS uses sufficient communication to persuade gvt. And others; STP gvt. has weather and climate in agenda;	IE and NMS management are responsible for monitoring NMS with support of IE monitors gvt. and partners interests,

Continuation and extending the QMS insurance and certification processes (currently done for the aeronautical station infrastructure, is recommended. We therefore also propose to invest in this important QA/QC process. Again, we propose international exchange (incl. expertise and knowledge) and continued engagement of INM staff in this process. Table 5.2 summarizes the investment requirement for QMS

Table 5.2: Investment requirement for Quality Management Systems engagement

Activity #	CD activity Description Short courses	Location	Cost estimate (U$)
1	Workshop (expertise exchange)	São Tomé	
2	Staff study visits, participation and collaboration with int'l, countries, QMS expertise centres or private C°	Tbd (in 5-year period)	
		Total	See IFR [37]

[37] See Investment Phase Funding Request

Module 6. Transition to SOFF investment phase

The transition to SOFF investment phase is recommended to carry out by following the Gap Analysis and National Contribution plan (this document). The peer adviser, IE and beneficiary have together filled in funding request for SOFF implementation phase. This supports the best coordination in the transition phase.

Summary of the GBON National Contribution Plan

Components		Recommended activities
Module 1: GBON National Target	1.	One original Target GBON AWS at São Tomé int'l airport and an additional (second) GBON compliant Surface AWS on Príncipe Island, and one (1) UAS at the end of the SOFF Investment phase;
	2.	An operational "from observation to data dissemination" chain, including sustained data communication and information management.
Module 2: GBON Business development, private sector engagement and institutional development	3.	INM will develop a national strategy for weather and climate observations. This will include a strategic plan, presenting the necessary institutional framework to support GBON implementation. Next to GBON station data communication, the observation strategy will include improved early warning for civil protection and be inclusive for the other socio-economic sectors of STP i.e., agriculture, water, energy, environment, tourism and maritime sectors.
		It will interact with stakeholders and analyse business models and opportunities for public-private partnerships. The organization is now only active in partnering with ENASA (airports, aviation) and CONPREC (dissemination of weather bulletins for early warning).
		The financial status of INM to carry out GBON compliant operations consists currently of very limited governmental funding and the foreseen financial investment support from WMO SOFF, through UNDP (IE) for GBON infrastructure deployment and CD. Service agreements with public or private sector operators can be seen as possible vehicles for co-funding and sustaining meteorological operations and services.
Module 3: GBON Infrastructure development		Following WMO and SOFF guidance, INM will improve current its earmarked AWS, set-up a GBON compliant observation infrastructure including a new UAS, and use WIS2.0 data communication. Through engagement with SOFF, peer-advisor, other country NMHS and regional partners, it aims to set-up a monitoring and evaluation chain, starting from station operations, calibration, maintenance, communication and data QA/QC (Quality Assessment and Control).

Module 4: GBON Capacity Development		The INM, focusing currently mostly on the aeronautical sector (aviation weather), has a HR capacity gap for implementing and building a full "from meteorological observation to information dissemination chain", to the different sectors, stakeholders and public in general. The gap in capacity in INM is in specific job or task related fields, ranging from instrument calibration and station maintenance, automated data transfer and handling using the newer WIS2.0 FOSS, ICT and climate data management and dissemination. Also rescue of important long-term historical climate data including quality control requires more human capacity and solutions. INM also will develop its institutional HR planning to avoid e.g., staff turnover and loss of competences.
Module 5: Risk Management		The key risks indicate that there is currently a substantial institutional risk for implementing SOFF. With support from the IE and peer-advisor, the INM will proceed first with developing a strategic planning instrument, including a "sustainable operation chain" for its GBON stations and observation network. This will require recruitment of a significant number of human resources and embedding them in the INM structure (new organigram) and institutional framework. Temporary employment of int'l expertise to support SOFF the process in STP, is among the options (e.g., UN junior professional or analogue schemes). Mitigation measures are also given. Following WMO advice[38], INM will seek support for introducing QMS i.e., ISO9001:2015 standards in its operational observation chains. Extending this quality insurance to its other monitoring operations and staff development in QMS is also recommended.
Module 6: Transition to GBON Investment phase		The transition to the Investment phase is recommended to carry out the NGA and NCP (this document). The peer-advisor, IE and beneficiary have together prepared the funding request for the investment phase.

[38] WMO Publication n° 1100.

Annex 1: List of abbreviations and acronyms

AMN-CP	National Maritime Agency and Port Authorities
ANP-STP	National Petroleum Agency of STP
AWOS	Automated Weather Observing Systems
AWS	Automated Weather Station
STP	São Tomé and Príncipe
CONPREC	National Council for Disaster Preparedness and Emergency Response
CSO	Civil Society Organization
DGA	Directorate General of Environment
DGAAC	Directorate General of Environment and Climate Action
DGNRE	Directorate General of Natural Resources & Energy
DPA	Directorate of Fisheries & Aquaculture
DRM	Disaster Risk Management a/o Risk Reduction (DRR)
ENASA	National Enterprise for Airports & Air traffic Safety
ECMWF	European Centre for Midterm Weather Forecasting
EU	European Union
EUMETSAT	European Meteorological Satellite Agency
FAO	Food & Agricultural Organization (UN)
FOSS	Free and Open-Source Software
GBON	Global Basic Observation Network – WMO
GFS	Global Forecasting System (US/NOAA)
GSOD	Global Summary of Day meteorological database (WMO Res.41)
ICAO	International Civil Aviation Organization
IMAP	Maritime and Harbor Institute
INAC	National Institute of Civil Aviation
INA	National Water Institute
INM	National Institute of Meteorology
INSP	National Institute for Public Health
KNMI	Royal Netherlands Meteorological Institute
MAPDR	Ministry of Agriculture, Fisheries and Rural Development
METAR	Meteorological Airport Reports (used for aviation)
MHEWS	Multi Hazard Early Warning Systems
NHS	National Hydrological Service
NMS	National Meteorological Service
NOAA	National Oceanic and Atmospheric Administration (USA)
NWP	Numerical Weather Prediction
NGO	Non-Governmental Organization
OSCAR	Observing Systems Capability Analysis Reviewing Tool - WMO
SIDS	Small Island Development States
SNPCB	National Service for Civil Protection and Fire Brigades
SOFF	Systematic Observations Financing Facility
SYNOP	Synoptic coded weather station messages
UN	United Nations
UNDP/PNUD	United Nations Development Program
UNICEF	United Nations Children's Fund
WIGOS	WMO Integrated Global Observing System
WIS2.0	WMO Information System 2.0
WMO	World Meteorological Organization

Report Completion Signatures

Report Completion Signatures

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