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GBON National Contribution Plan of Samoa

Systematic Observations Financing Facility

Weather and climate data for resilience

GBON National Contribution Plan

Samoa

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Introduction

The Global Basic Observing Network (GBON) was agreed at the World Meteorological Congress in 2019 and came into force in January 2023. The GBON is a surface-based weather observing network designed at a global scale to support Numerical Weather Prediction. It aims to address global variability in network density and reporting frequency to improve global weather forecasting and resilience.

In recognition of the challenges for WMO members from Small Island Developing States (SIDS) and Least Developed Countries (LDCs) in meeting GBON requirements, the Systematic Observations Financing Facility (SOFF) was established alongside GBON. SOFF is a United Nationals Multi-Partner Trust Fund established by the WMO, the United Nations Environment Programme and the United Nations Development Programme. SOFF provides funding to uplift weather observations in SIDS and LDCs to meet GBON requirements.

The SOFF model is to partner each beneficiary country with a peer advisor country to provide peer support, and with an implementing entity to implement and oversee the SOFF investment. Samoa has chosen the Australian Bureau of Meteorology (Bureau) as peer advisor and the World Bank as implementing entity.

In the first phase of the SOFF project, the Readiness phase, the beneficiary and peer advisor work together to assess the existing weather networks against GBON requirements, identify gaps, and develop plans for filling these gaps. The peer advisor and beneficiary country then document these plans together in a GBON National Contribution Plan, which supports an investment proposal for the next SOFF Investment Phase.

This document provides the GBON National Contribution plan for Samoa. It has been developed together by the Samoa Meteorology Division (SMD) with the Australian Bureau of Meteorology (Bureau) as peer advisor, and the World Bank as implementing entity. It is based on review of existing documentation and engagement with SMD and other Samoa stakeholders in a country visit between 16-21 July 2023.

The document:

- outlines the current state of weather observations in Samoa, highlighting the gaps between the existing network and the GBON requirements;
- proposes the planned future state for Samoa weather networks to become GBON-compliant;
- details the recommended activities needed to reach this future state.

Module 1. National Target toward GBON compliance

Table 1. GBON National Contribution Target

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

* Although the global gap analysis identifies one station, subject to SOFF Secretariat support, Samoa will be seeking to improve two stations via SOFF, one on each major island. The second could be considered an "easy win" given Samoa effectively operates a high-density network. The possibility of including the second easy win improve station will be explored and justified in this National Contribution Plan.

1.1 Summary of Current State

Samoa's national meteorological service (SMD) comprises skilled teams of observing, technical and forecasting personnel. These teams maintain:

- 2 staffed weather stations
- 17 automatic weather stations (AWS).

There are currently no upper air stations in Samoa, with the closest upper air station located in American Samoa, 130 km to the south-east.

SMD faces major challenges in skilled and sufficient personnel, budget, logistics, sourcing of equipment and spares, maintenance and data communications, leading to quality and reliability issues. As a result, Samoa currently has no GBON-compliant surface stations and many of the AWS are not providing complete data.

There is substantial opportunity for SOFF to support Samoa to address these challenges, as outlined in the description of GBON targets below.

1.2 Principles for GBON Targets

Samoa consists of two main islands, Upolu and Savai'i, and has a relatively small exclusive economic zone (EEZ). All but one existing weather stations are located across Upolu and Savai'i.

In its global GBON gap analysis, the WMO applied the GBON marine surface and upper air station density requirements to the EEZ to develop its land-based targets for Samoa. This resulted in targets of one surface station and one upper air station. In developing targets for this Samoa GBON National Contribution Plan, the following attributes of the country were taken into account:

- Samoa consists of two main islands (Savai'i 70 x 45 km and Upolu 70 x 25 km) separated by a 20 km strait. Both islands are of volcanic origin and have elevation exceeding 1800 and 1100 m respectively. The EEZ is about 130,480 km^2. The two islands stretch about 165 km east-west.
- For upper air, the appropriate target is one station. This would align regionally with an existing upper air station in American Samoa to the ESE and other existing and potential sites to the west, south and north-east.
- As the two islands are quite compact, with an existing high-density surface network, two stations should be allocated as the GBON surface target using the high density GBON criteria. Considering the relative isolation of Samoa in all directions except the ESE (American Samoa), this is strongly recommended. The volcanic-influenced topography of the islands warrants a high-density network for national purposes.

1.3 GBON Targets

Based on the above factors, the following GBON targets for Samoa are proposed (Figure 1):

- **Surface stations**:
  - one staffed surface station with co-located AWS in/near Apia located on Upolu island (representing the central location, providing a level of redundancy),
    - Considering that SMD have two staffed stations in relatively close proximity (25 km), both with an AWS, one of these should be designated as a GBON station. Locating the GBON site at a staffed station will allow staff members to monitor equipment and undertake first level maintenance tasks to improve reliability of service The preferred location is in Apia to provide greater geographic spread.
  - one new standalone AWS to be installed on the western side of Savai'i island.
    - The preferred location would be at Ministry of Natural Resources and Environment offices at Asau on the Western end of Savai'i.
    - Staff on-site will be able to provide security and grounds maintenance (e.g. vegetation management) to ensure the site complies with WMO siting requirements.

- **Upper air station**
  - A new upper air station will need to be installed at a location where observers are present.
    - Options include Apia SMD office, Faleolo Airport or potentially near the new National Emergency Operations Centre (NEOC) in Apia. The decision will depend on any long-term planning for the potential relocation of existing Apia office, and it is recommended that an analysis be undertaken to evaluate the relative merits of each of these sites at the beginning of the procurement process.

1.4 Exemptions

With full implementation of the GBON National Contribution Plan, Samoa is anticipated to fully comply with the GBON requirements. No exemptions to the GBON requirements will therefore be required for Samoa.

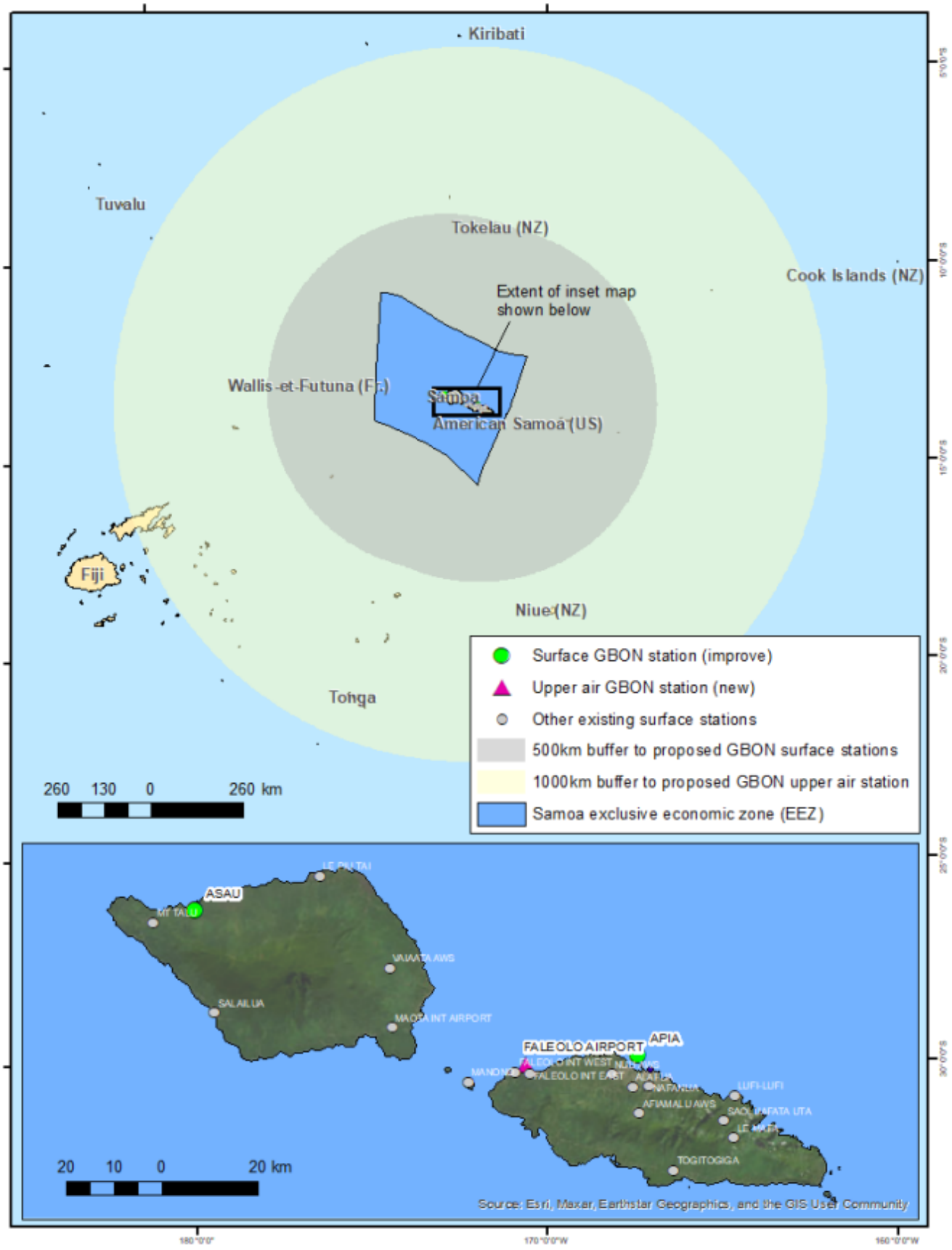

Figure 1. Map of existing and proposed surface and upper-air stations. Note: The final location for the Upper Air station will be determined through a cost benefit analysis of proposed sites at the beginning of the investment phase.

Module 2. GBON Business Model and Institutional Development

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

The Samoa Meteorology Division (SMD) is the primary organisation of relevance to the operation and maintenance of GBON stations in Samoa. As detailed below, it maintains almost all the weather stations in Samoa, manages almost all the weather data, and has a legislated mandate to do this (Figure 2).

Water resources and hydrology in the Samoa are managed by the Water Resources Division (WRD) of the Ministry of Natural Resources and Environment. The WRD undertakes river and rainfall monitoring and operates a series of hydrometric stations across both Islands to support SMD's 11 Automatic rain gauges. However, these record only one GBON variable, rainfall, and do not generally report in real-time and for this reason the WMD has not been considered to play a key role in the GBON plan for Samoa.

It should however be noted that during the SOFF mission the peer advisors witnessed strong relationships between government agencies in Samoa, particularly between the Samoa Meteorology Division, the Water Resources Division and the Disaster Management Office where data-sharing is common. For example, warning protocols allow shared responsibility via out-of-hours procedures, and recent community training in early warning systems also featured staff from these and other departments working together. Such arrangements are not reached without a high degree of trust.

Figure 2. Apia office manual and automatic weather observation site

The only other organisation presently operating weather stations in Samoa is the Samoa Airport Authority of Samoa (Ministry of Works, Transport and Infrastructure (MWTI)). It maintains two automatic weather observing systems (AWOS) at Apia Airport. The aviation AWOS do not provide data to SMD systems due to incompatible communications, however a visual weather data display is in the Observations office. As SMD does not have operational control nor ownership of these stations, it is difficult for SMD to ensure or verify the reliability and quality of these data. Consequently, this plan assumes that the GBON requirements will be met with alternative infrastructure owned and operated by SMD.

A longer-term goal for SMD is the implementation of cost-recovery from the aviation sector for the costs of providing meteorological services. This has the potential to contribute to ongoing sustainability of weather observations, particularly at airports. Further engagement with aviation stakeholders regarding cost recovery will therefore be undertaken as a key activity as part of this plan (**Activity 2.1**).

Private partnerships in Samoa are very limited and not considered an option for inclusion in the Contribution plan.

2.2. Assessment of potential GBON sub-regional collaboration

Coordination was undertaken with peer advisors for neighbouring countries during development of the National Contribution Plan. The proposed station network takes into account other regional SOFF activities and will contribute to a broader well-distributed multi-country network across a critical region for Numerical Weather Prediction (NWP) encompassing other SOFF-funded stations in nearby countries.

The National Contribution Plan has also been structured to be flexible to accommodate future regional coordination initiatives such as regionally-focused equipment calibration services, training, procurement of common equipment types, and maintenance services. These will be pursued through several forums in which SMD is an active participant (**Activity 2.2**) including:

- Regional SOFF coordination workshop in March 2024
- WMO RA V Infrastructure committee
- Pacific Meteorological Council and its committees
- South Pacific Regional Environmental Programme (SPREP)
- The Pacific Community (SPC).

During the Investment Phase, SMD and World Bank will also investigate opportunities for regional synergies for maintenance services that can be implemented during the SOFF funded Compliance Phase, such as coordinated procurement of spare parts and calibration services.

Some possible opportunities could include:

- Working with American Samoa to coordinate purchase of consumables for Upper Air and AWS equipment as well as potential sharing of resources and expertise for maintenance of equipment.
- Utilisation of the proposed Fiji Regional Instrument Centre for calibration of equipment and for advice.
- Staff training options with the Pacific International Training Desk in Hawaii.

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

The SMD annual budget averages about WST 2,105,000 (USD 763,000), around 68% of which is spent on salaries. The budget is insufficient to meet operational costs, nor can it allow for new observations equipment, vehicles, and other capital items. The shortfall is partially met from external project spending on new equipment. The budget is also not adequate for service enhancements that SMD has identified based on consultation.

In order to meet requirements of this GBON National Contribution Plan, significant additional funding resources will be required. Given the existing skill level and capacity in the NHMS, its legislated mandate (see 2.5 below), and the lack of existing private sector operators in weather and water services in Samoa, the preferred business model is the *Public model – Full State/NMHS owned and operated*. However, there is opportunity for a substantial private sector role in supporting the NHMS by including ongoing operational support in the procurement contracts for weather stations and ICT equipment (e.g. maintenance, training, calibration, advice, spare part supply, etc.).

This critical ongoing private sector role will require structuring the procurement in a manner that allows the supplier relationship to continue over the life span of the equipment. This could include procurement being done through World Bank with provisions to transfer support and maintenance contracts to SMD in the Compliance Phase, procurement for both supply and support being done via the Samoan Government as the Executing Entity supported by World Bank or potentially for elements of supply and/or support to be procured regionally through a central organisation such as SPREP or SPC.

Prior to procurement, SMD and World Bank will engage with prospective suppliers, the Ministry of Finance and regional organisations such as SPREP and SPC to undertake a review of possible procurement approaches and develop a procurement plan (**Activity 2.3**). This plan will designate the 'Executing Entity' for each element of procurement and ensure the procurement model can include supplier support for the life of the equipment.

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

While strategic planning processes are relatively immature, improvement in this area is a priority of the current SMD Director. A new Strategic Plan is under preparation, assisted by the Climate Risk and Early Warning Systems (CREWS) project. The CREWS strategic plan will recommend appropriate governance structures for national meteorological services and plans for improvements.

Active cooperation occurs with a range of international partners, including WMO, the World Bank, the CREWS project, Australia, the Japan International Cooperation Agency (JICA) and New Zealand National Institute of Water and Atmospheric Research (NIWA). SMD clearly prioritises these relationships and values the potential for improved equipment and services that result.

Existing or planned Hydromet development activities related to GBON in Samoa include:

- The World Bank Pacific Resilience Program (PREP) is funding an ICT refreshment to assist with data storage and sharing, with new systems to be procured for SMD, the Water Resources Division, and Disaster Management Office (including at the new

National Emergency Operations Centre). This project is underway and is expected to be completed by April 2024.

- Climate and Oceans Support Program in the Pacific (COSPPac). This Australian government program is, among other activities, assisting Samoa to maintain its CliDE Climate Data Management System.
- Weather Ready Pacific. This is a broader proposed regional multi-donor initiative to comprehensively strengthen the full hydro-meteorological system across the whole value chain in the Pacific region. Weather Ready Pacific can leverage the improved observations from SOFF investment as part of its broader focus on hydro-meteorological services. Weather Ready Pacific currently has seed funding and full funding is not assured.
- CREWS is working directly with countries to increase the availability of, and access to, early warning systems. As part of this project, National Strategic Plans for Meteorological Services are being developed for six Pacific SIDS, including Samoa. The project is due to be completed by December 2024.

Opportunities to leverage these initiatives have been considered in Module 3 – Infrastructure Development below. As development programs in the region are dynamic, it is recommended that at the start of the Investment phase, World Bank and SMD confirm the status of the SMD Strategic Plan, and undertake a comprehensive environment scan of planned development activities related to GBON to identify any other opportunities for leverage and to ensure the planned works will be complementary (**Activity 2.4**).

The Pacific Island Communications and Infrastructure (PICI) Panel provides advice to the Pacific Meteorological Council (PMC) on matters concerning the infrastructure supporting communications and dissemination of national and regional hydro-meteorological and tsunami (seismic and sea level) observations, forecasts, and warnings in the Pacific region. At the most recent meeting (14-16 August 2023), the Panel proposed (i) guiding principles for observations, communications and ICT infrastructure; and (ii) the development of a Regional Instrument Centre for Fiji to contribute to improved observation quality and traceability of measurements in the region.

The Pacific Community (SPC) is the principal scientific and technical organisation supporting development in the Pacific region. SPC scientific and technical capacity is well placed to support the regional approach to observations network sustainment, maintenance, renewal and standards.

Previous observations infrastructure partnerships and project investments in Samoa have not produced an integrated result or ongoing maintenance funds (for example, in their observations and forecasting systems), leaving an unsustainable outcome. Samoa is seeking to strengthen their ability to influence investment on a sustainable path by standardising equipment, integrating IT systems while maintaining safe working environment. SMD is proactive and committed to more long-term sustainable partnerships with donors and investment projects.

2.5. Review of the national legislation of relevance for GBON

The Samoa Meteorology Division (SMD), formally the Meteorology, Geoscience and Ozone Services Division, is a divisional branch of the Ministry of Natural Resources and

Environment (MNRE), Government of the Independent State of Samoa. The Ministry also includes Divisions for Disaster Management and Water Resources.

A new Meteorology, Geoscience and Ozone Services Act (2021) in Samoa provides a mandate and outlines the functional responsibilities for Samoa Meteorological Division, including Multi-Hazard Early Warning System responsibilities. The Act is strongly worded and clearly outlines the functions and accountability of SMD which include, among others, the following responsibilities relevant to GBON:

- (a) analyse and provide scientific and quality managed data and information in the areas of
    - (i) meteorology including weather, climate, and air quality
- (b) control collection, analysis and dissemination of quality managed data, information and material for the purposes of the Act;
- (c) provide meteorological services including data, information, warnings which may be provided by the Division for the benefit of the general public including but not limited to sectors such as agriculture, tourism, sports, education and cultural affairs;
- (d) provide aviation meteorological services or weather-related information or data for the purpose of aviation in accordance with NZCAA Part 174 - Annex 3 of ICAO;
- (e) allow and facilitate the exchange of meteorological, geoscience and ozone data with the Division or their counterparts from other countries, territories and in accordance with Resolution 40 of the WMO Policy and Practice (Cg-XII).

The Act therefore provides authority and responsibility for SMD to establish and operate the GBON stations and share the data internationally.

Procurement of goods and services in Samoa is regulated by the Public Finance Management Act 2001, along with Treasury Instructions Section 6: procurement and Contacting (Part K Amended 2020) and Procurement Operating Manual 2020, implemented by the Ministry of Finance.

Procurements over the value of WST $500,000 must be approved by Cabinet. Contracts are cleared through the Office of the Attorney General and may also involve approval from the Tenders Board. This process can be lengthy and can pose challenges for timely procurement by SMD of spare parts, tools, equipment, communications services, logistics and travel, and other essential components of a reliable, high-quality weather network.

As outlined in Section 2.3 above, SMD and World Bank will engage with the Ministry of Finance and other regional organisations to develop a procurement plan for weather stations and ICT equipment that allows for 'supply and support' contracts over the life of the equipment (**Activity 2.3**). The contracts will provide ongoing operational support for items such as maintenance, training, calibration, advice and spare part supply.

Funding for ongoing essential services, such as logistics, travel and communications, is also a key limitation on maintaining station reliability and can be challenging for SMD within the Samoa governmental procurement framework. During the Investment Phase the World Bank and SMD will engage with the Ministry of Finance and other potential partners such as SPREP, the Australian High Commission and the SPC, to develop robust plan for ongoing procurement of essential services to support SMD to operate and maintain the stations to a GBON standard through both Investment and Compliance phases. (**Activity 2.5**). This plan could include, for example, establishing a trust fund via one of these entities to receive SOFF compliance funds, and hold and disburse the funds for ongoing compliance activities.

Module 3. GBON Infrastructure Development

For each section of this module, the existing state of weather observations infrastructure in Samoa is outlined, followed by the target state and planned activities to achieve the target.

3.1. Surface and upper-air observing network and observational practices

Existing state

Existing weather stations in the Samoa are shown in Figure 3. These include; staffed weather stations, automatic weather stations (including both standard AWS and aviation-specific AWOS), a manual climate station and a sea level station. Currently none of these stations are GBON-compliant. Details of each station type are provided in the following sections.

Figure 3. Weather stations in Samoa

Staffed stations

SMD maintains two staffed stations on Upolu Island approximately 25 km apart, one in Apia located at the SMD office and a second at Faleolo Airport (Figure 4).

The staffed stations have a complement of manually read monitoring equipment, generally including some or all of: thermometers in Stevenson Screen (wet bulb, dry bulb, max, min); barometer; rain gauge; wind vane; anemometer; evaporation pan; and sunshine recorder.

Both stations operate 24 hours a day, with Apia staffed by one forecaster and two observers, while Faleolo Airport is staffed by one observer on shift.

Manual readings are taken 3-hourly at both stations with SYNOPS also generated every three hours and distributed internationally via email to the Melbourne Global Information

System Centre (GISC). Faleolo Airport also generates Hourly METARS (ICAO: NSFA) that are emailed to Fiji every hour and SPECIs on occurrence, with the TAFs prepared by Fiji shared internationally.

Figure 4. Manual weather station at Faleolo International Airport (outside Apia)

Automatic Weather Stations (AWS)

There are 17 AWS in Samoa that have been installed under donor projects. These include:

- Two Automatic Weather Observing Stations (AWOS), which are located at each end of the Faleolo airport runway to provide weather data to the control tower. These were installed by the Japan International Cooperation Agency (JICA) for the Samoa Aviation Services in around 2010.
- Eight additional AWS were installed by JICA with 3 on Savai'i Island and 5 on Upolu Island.
- Seven AWS were installed by New Zealand Institute of Water and Atmospheric Research (NIWA) for climate adaptation around 2016 (See Figure 6).

Both the JICA and NIWA stations use Vaisala sensors.

The condition of the AWS network is variable:

- At least seven have been identified as currently not operational due to maintenance challenges, such as lack of spare parts, including batteries. For example, the AWS located at Apia Station was reporting only wind and pressure during the in-country visit

Figure 5. AWS site at Afiamalu, Upolu Island

as the temperature/humidity sensors and rain gauge needed to be replaced but no spare parts were available.

- Maintenance is behind schedule for some stations, and some instrument calibrations have not been verified for up to 5 years.
- Additional communications and processing issues are preventing data from some operational AWS being received to the GTS. Currently, data for most JICA stations is not available possibly due to a Vodafone dish that obscures the microwave link on the hill above Apia.
- In addition, the server in the SMD office was offline at the time of the country visit due to hard disk failure.

SMD also maintains 11 Automatic Rain Gauges (ARG) throughout the country, with other rain gauges maintained by the Water Resources Department. These have not been considered in detail here as they record only one of the five GBON variables. These report rainfall in increments of 0.2 mm and 0.5 mm and are mostly functioning.

Upper Air

There are currently no upper air stations in Samoa. The closest upper air station is located in American Samoa, 130 km SE.

Marine stations

There is one sea level monitoring station located at Apia Wharf which is maintained by the Australian Bureau of Meteorology (BoM) and SPC under the Pacific Sea Level and Geodetic Monitoring project. Data is sent via BGAN satellite back to BoM servers in Australia, where it is stored and made available on the Bureau's Pacific Island monitoring webpage, however it is currently not submitted to GTS. Samoa is keen to have this data pushed to CliDE and displayed on NEON, improving access to the data.

Maintenance

SMD has no standalone maintenance section and little maintenance or technical staffing budget which leads to SMD Climate section staff performing maintenance tasks usually undertaken by technical specialists, on top of their nominal roles.

The budget constraints also limit the supply of spare parts. This has recently resulted in sensors being relocated to other sites so these can continue to operate, which is not ideal.

Figure 6. AWS at Maota Airport site showing climbing pegs and encroaching vegetation

However, even without budget restrictions, the sourcing of parts and materials is also a major challenge. With no local suppliers, all parts must be procured from overseas with lengthy delivery times and costly freight. The process of approval for overseas procurement in Samoa government is also complex and lengthy. These issues combined with budgetary

constraints within SMD, and budget cuts due to Covid, have meant that SMD rarely has a sufficient stock of spare parts, and often is unable to make repairs or fit replacement part to unserviceable equipment.

One of the spare parts issues faced currently is a shortage of replacement batteries which has led to three of the seven NIWA AWS being out of service even though the sensors are all functioning. Stevenson screens are generally in a poor condition with broken hinges, roofs and slats. Replacement of these screens should be a priority in a tropical country.

The lack of dedicated maintenance staff has also resulted in delays in calibration of equipment, with some sensors that have not been calibrated for up to five years. Being a tropical country, vegetation growth is rapid and dense, thus regular site visits (3-4 times per year) are required to maintain sites to a global standard.

A further impediment to site maintenance is the lack of a dedicated vehicle for staff to use to visit the remote sites. SMD's centralised operations model, which is efficient and appropriate for a compact country, relies on reliable 4WD vehicles able to attend remote stations, sometimes on steep topography. There have not been any recent fleet purchases, and experiences during the SOFF/CHD mission demonstrated that hire vehicles are an insufficient substitute due to inappropriate configurations and uncertain availability.

Historical donated equipment can also entrench unsafe work practices. Some of the AWS mast and communication towers (some 30 m as shown in Figure 6) do not have provision for a harness rail for attaching a personal safety harness. Staff were provided with safety training when the towers were originally installed, but safety practices have evolved since that time. Incidents of staff putting themselves at risk during major events have been reported. While this is done to ensure continuity of service, it can put lives at risk and regular refresher training should arranged if these sites are to be used in future.

Target state and recommended activities

Surface Stations

The principle is to have two GBON stations, by locating a SOFF funded AWS on each Island in close proximity to a staffed location to enable basic maintenance to be performed as required. On Upolu Island it will be located with the existing SMD staffed station, with the added benefit of the manual observations providing extra redundancy. (see note below for future location options). On Savai'i, as there are no staffed SMD offices, it is recommended that it be located near an office of the parent ministry, with staff on-site who can perform basic maintenance. The preferred location is Asau, where the Ministry of Natural Resources and Environment (MNRE) have an office.

This approach was chosen for the following reasons:

AWS located on Upolo

- Co-locating the AWS with an Upolu staffed station will enable that station to automatically provide hourly observations over 24 hours.
- Staff on-hand to perform basic maintenance is essential to ensure sufficient up-time to meet GBON standards.

- Having manual and automatic observations will provide redundancy for down-time of the AWS equipment (e.g. due to delays in shipping parts). When the AWS is down, the frequency of manual observations can be temporarily increased to hourly.

AWS located on Savai'i

- MNRE staff can provide security and grounds maintenance (e.g. vegetation and pest maintenance, servicing of sensors) to ensure the site complies with WMO siting requirements.
- They may also be able to provide trouble shooting information to staff off-site to assist with problem diagnosis and repair as required.
- This site can provide additional redundancy if major problems arise at the Apia station.
- This site will provide reliable access to data from the western side of the populated area of Samoa. This station will provide important information regarding the dominant NW/SE airstream that impacts Samoa and will be beneficial for global modelling.

Note: The options for the joint staffed station with AWS on Upolo are as follows:

- Apia SMD office – a current staffed site that is very exposed to the sea and is subject to storm surge during spring high tides. Considering the long-term impact of sea level rise, investment in new AWS and Upper Air infrastructure at the Apia office may not be worthwhile in the longer term.
- Faleolo Airport – a current staffed site that is 25 km from Apia, and is somewhat exposed to the sea, but located on higher ground less likely to be impacted by storm surge. Suitability considerations would include access to the existing airport AWS, and sufficient space to locate an Upper Air station at the site, depending on lease availability.
- Apia near the new National Emergency Operations Centre (NEOC) – this is a recently opened site that will be jointly used by the Samoa Disaster Management, the Water Resources Divisions and SMD, with the possibility of the SMD office potentially relocating to this location in the future.

Suitability of each site and availability of land for AWS and Upper Air infrastructure will be assessed as part of the analysis of sites at the start of the investment phase.

SMD proposes to use SOFF funding to upgrade the manual observing equipment at a staffed station in Apia/Faleolo to GBON standards and to upgrade structures, facilities, power and communications to support these services; as well as to establish a standalone AWS at Asau and upgrade structures, facilities, power and communications for this site.

The surface station and AWS site to be upgraded as part of this plan are listed in Table 2. The proposed instruments, facilities and observing systems for these stations are summarised in Table 3. Selection and installation of instruments will be compliant with *WMO-No. 8 Guide to Instruments and Methods of Observation*.

Table 2. Planned GBON surface stations

Station name	Island	Existing station status	Planned GBON configuration
Apia/Falelo SMD Office	Upolu	Existing staffed station	Co-located staffed and AWS All 5 GBON variables

Asau	Savai'i	Existing ARG at MNRE office site	Standalone AWS at MNRE office site All 5 GBON variables

Table 3. Instruments and observing systems for planned GBON surface stations

Manual synoptic sites:	Automated synoptic sites:
Instruments	Instruments
• Electronic temperature and humidity sensors with digital readout @1.25 – 2m. • Wind vane (estimated values) or wind sensors (measured value) @10m. • Standard 8 inch (203mm) or 5 inch (127mm) manual rain-gauge. • Other manual instruments (evaporation, sunshine, soil temperatures) as required. • Any electronic instruments required to supplement manual observations (digital barometer)	• Resistance Temperature Device (RTD) dry bulb probe and relative humidity probe @1.25m – 2m. • Wind speed and direction sensors @10m. • Standard 8 inch (203mm) tipping bucket rain-gauge. • Barometer • Other automated instruments (evaporation, solar radiation, soil temperatures) as required. • AWS processor to collate data (preferably with a 7-30 day buffer) and send messages at the required intervals.
Structures	Structures
• Instrument shelter (Stevenson style), gloss white and double louvered, with stand to achieve bulb/sensor height of 1.25-2m. • Tilting counterweighted 10 m mast. • Post to 0.3 m to support rain gauge -where required. • Fencing, adequate for the required security of the site.	• Instrument shelter (Stevenson style), gloss white and double louvered, with stand to achieve sensor height of 1.25-2m. • Tilting counterweighted 10 m mast. • Post to 0.3 m (staffed) or 0.7 m (unstaffed) to support rain gauge • Fencing, adequate for the required security of the site. • Housing for the AWS processor, barometer and power supply separate from other sensors.
Facilities	Facilities
• An observations enclosure sufficient to ensure exclusion of obstacles impacting on readings (Outer 25 x 25m, inner enclosure 18 x 18m). • A nearby building to house observing consumables, cleaning materials, station records and stationery, and a workstation (with PC and monitor/s) for the manual observer. • A local display for any electronic data (T/RH/WS/WD) recorded on site. • A power supply to enable communication of coded messages. • An uninterruptable power supply to ensure message transmission. • Supply of clean water for cleaning and wet bulb readings.	• An observations enclosure sufficient to ensure exclusion of obstacles impacting on readings (Outer 25 x 25m, inner fenced enclosure 18 x 18m). • Mains and/or solar power supply to site. • Batteries to support solar, and/or to act as UPS for message transmission. • Signage to inform or deter the public.

Communications	Communications
• Robust cellular to ensure regular, timely message transmission. • Backup HF or other common communication method.	• Robust cellular data communications to ensure regular, timely message transmission. • Redundant communications system where feasible. • Optional: local display of automated observations

To improve these stations to meet GBON requirements, the following activities will be undertaken:

- **Activity 3.1**: Determine optimal site for Apia staffed station by assessing relative merits of: the existing site at SMD office location in Apia; the possibility of co-locating at the National Emergency Management Office site (where SMD may also locate to in the future); and the Faleolo Airport site. Secure land at chosen location.
- **Activity 3.2:** Undertake audit of existing manual equipment and facilities at staffed station, and at the Asau AWS site, to identify all items that require procurement.
- **Activity 3.3:** As required, procure 1 x uplifted manual observing equipment, and 2 x new AWS for the two sites under 'build and support' contracts, including site works, structures, facilities, power and communications infrastructure.

Upper air station

A new upper air (UA) station will need to be installed at a location where observers are present. This will be at the site selected for the GBON staffed station at either Apia or Faleolo as mentioned above.

As there is no existing UA infrastructure, this will need to be designed and built from scratch.

The upper air station will be manual to minimise equipment complexity and maintenance challenges (Table 4). The equipment will be operated by the SMD observing staff rostered on shift at the station. A hydrogen generator will be required due to the logistical challenges of sourcing and delivering hydrogen in the remote island environments. A remote balloon launcher is recommended to reduce staff handling of hydrogen filled balloons.

The proposed instruments and observing systems for the station are summarised in Table 4. Selection and installation of instruments will be compliant with *WMO-No. 8 Guide to Instruments and Methods of Observation*.

Table 4. Instruments and observing systems for planned GBON upper air stations

Manual balloon release system
Instruments/consumables
• Radiosondes (environmentally sustainable model) • Balloons (environmentally sustainable model) • 'Met' string (environmentally sustainable model) • Parachutes (as required) • Personal Protective Equipment (PPE) suitable for dealing with explosive environments.

Structures
• Balloon shed or remote balloon launcher where manually constructed balloon trains can be safely inflated and released. • Separate (or partitioned) Hydrogen generation shed (or storage shed if bottled H2 is available). • Fencing, adequate for the required security of the site. • Exclusion zones (painted lines), beacons/lighting and paths within the site.
Facilities
• An enclosure sufficient to ensure exclusion of the public and obstacles that may impact or be impacted by balloon releases. • A nearby building to house upper air consumables, cleaning materials, various computer and communications systems supporting the upper air observations, and a workstation for the manual observer to assemble balloon trains. • A local display for the radiosonde profile and access to sensors for ground check data (T/RH/WS/WD/press). • A power and water supply to enable H2 generation and monitoring, constant communication with the radiosonde and the transmission of coded messages. • A hydrogen generation system (HOGEN) and H2 storage facility to ensure adequate supply for the anticipated upper air program. • An uninterruptable power supply to ensure the above. • Supply of clean water for hydrogen generation.
Communications
• Communications systems for the upper air program (normally supplied with the Upper Air system). • Robust cellular or satellite communications to ensure regular, timely message transmission.

To establish the upper air station to meet GBON requirements, the following activities will be undertaken:

- **Activity 3.4**: Secure land access for upper air station at agreed location for the staffed surface station.
- **Activity 3.5:** Procure 1 x upper air station equipment under 'build and support' contract, including site works and all ancillary infrastructure.

Other 'Easy Wins'

SMD will seek SOFF support for an "easy win" to audit its existing AWS, identify those that are serviceable or repairable, and uplift their communications and IT systems to ensure these stations report internationally via the new Meteorological Data Management System described below (**Activity 3.6**). This will include ensuring that any serviceable JICA AWS are fitted with a cellular communications system to replace the existing microwave communications systems.

As another "easy win", the Bureau is also prepared to upgrade the data transmission algorithms and systems for the existing sea level stations such that they report internationally to the GTS. (**Activity 3.7**). This can be done concurrently with the SOFF investment. These stations can be designated marine GBON stations for the variable sea level pressure. This will require endorsement by the Samoa WMO PR.

Maintenance

The ongoing operation of the observing equipment requires both preventative and corrective maintenance. This is important to maintain routine operations, address faults as they arise and ensure the safety of the staff. Examples of maintenance tasks are shown in Table 5.

The SOFF investigation highlighted that maintenance is the largest challenge for meeting GBON requirements. Maintenance is therefore a critical focus of the contribution plan. The planned approach is for the procurement contracts for upper air, AWS and manual weather station equipment to be "Supply & Support" contracts for the lifespan of the equipment (refer Section 2.3 and **Activity 2.3**). The contracts will include:

- Supply and installation (where relevant) of all required equipment, including all required calibration equipment (e.g. transfer standards).
- Training, including
    - Ongoing, regular training in detailed maintenance and calibration methods for the SMD technical team (when established).
    - Ongoing training in basic equipment maintenance for the SMD field observers so they can make basic repairs on-site without needing a costly trip by a technician.
    - Ongoing training for field staff in operation of upper air equipment.
- Ongoing on-demand advice service via phone or teleconference to support SMD staff when problems arise ('call-a-friend').
- Continuous supply of spares to be held in-country. Supply to be proactive based on estimated replacement frequencies.
- All other required calibration and maintenance services that are not done by SMD personnel.
- Opportunity for contract renewal when equipment reaches end-of-life.

Funding for ongoing essential services such as logistics, travel and communications during the Compliance Phase is also a key limitation on maintaining station reliability. As outlined in Module 2, during the Investment Phase the World Bank and SMD will engage with the Ministry of Finance and other potential partners such as SPREP, the Australian High Commission and the SPC, to develop a plan for ongoing procurement of essential ongoing services to support SMD to operate and maintain the stations to a GBON standard through both Investment and Compliance phases. This plan could include establishing a trust fund to receive, hold and disburse maintenance funding (refer Section 2.5 and **Activity 2.5**).

This funding mechanism will need to support freight and travel costs to ensure SMD technicians can visit sites for the regular proactive maintenance and for reactive repairs when required, station communication costs (e.g. satellite or cellular provider), and all other ongoing travel (road and ferry), communications, logistics and other costs required to ensure GBON compliance.

It is proposed that a Pacific regional solution be identified for (i) level 3 maintenance and repair (see Table 5), (ii) instrument calibration and (iii) train-the-trainer services. Due to the small number of staff at most Pacific Island NMHS, regionally based teams that can support multiple Pacific Island Countries will be both effective and sustainable.

Table 5. Example maintenance tasks for GBON stations

Level	Description	Surface tasks (examples)	Upper Air tasks (examples)

1	Basic tasks requiring few consumables or parts carried out by local personnel Local staff or contractors Basic instruction *And at sites with an upper air program:* In-country observations staff Moderately complex tasks carried out by staff following standard operating procedures (SOPs). Tools, parts and consumables will be required. Specific instruction on hydrogen safety.	• Clean Stevenson screen • Change wet-bulb wick • Cut grass/ vegetation	• Attach sondes and launch balloons • Change over hydrogen cylinders
2	Tasks carried out by staff following simple procedures. Tools, parts and consumables may be required. In-country observations staff Basic meteorological technician training	• Collect station metadata • Replace sensors and modules • Verify performance of sensors	
3	Specialised maintenance actions carried out by trained staff. Procedures are complex and fault-is a required skill. Pacific Region maintenance resources Advanced meteorological technician training	• Replace infrastructure • Set up and configure new equipment and sensors • Advanced fault-finding	• Annual maintenance of UA system • Advanced fault-finding • Set up and configure new equipment and sensors • Install data communications system
4	Specialised repair or replacement by manufacturer or agent	• Return to agent/ manufacturer of component	• Return to agent/manufacturer of component

3.2. ICT infrastructure and services & 3.3. Data management system

Existing state

Data collection and transmission

Observations from the staffed stations are currently recorded by the observers in logbooks (Figure 8) and transcribed into METAR/SPECI and SYNOP messages on a desktop computer (Figure 9). Messages from the Faleolo station are then emailed to Apia station. The Apia observers then forward the METAR/SPECI messages on to Fiji every hour. The Fiji Meteorological Service (FMS) generate TAFs for Samoa and for international distribution. SMD staff email the SYNOPs every 3 hours to the Melbourne GISC for international distribution via the GTS.

They also convert the SYNOP messages to weather reports and publish these four times daily on the SMD webpage. (5.30am 11.30am, 5.30pm. 12.00am)

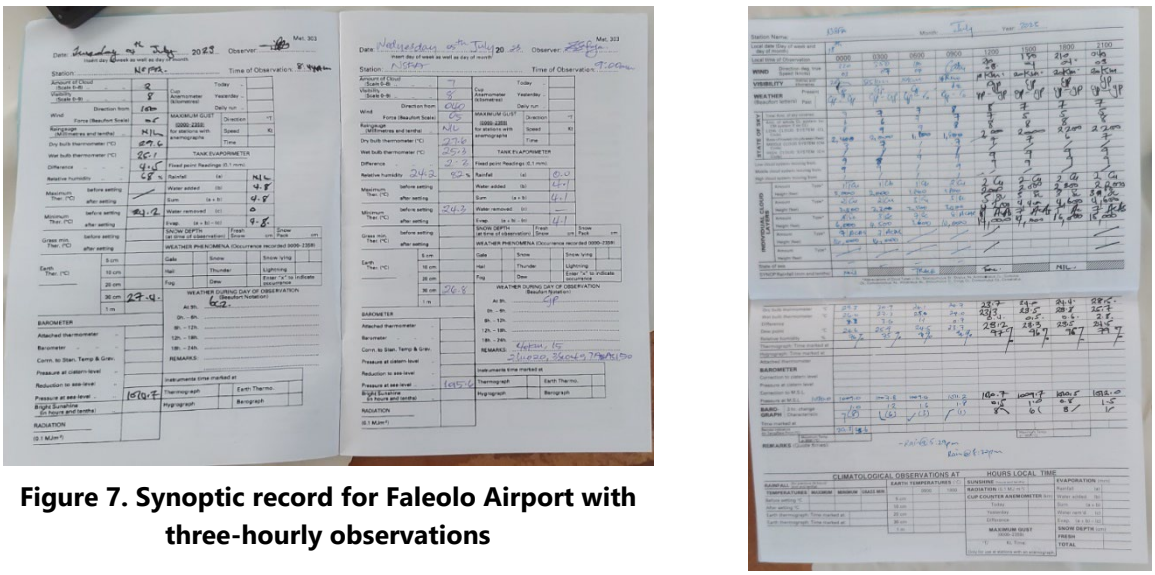

Figure 7. Synoptic record for Faleolo Airport with three-hourly observations

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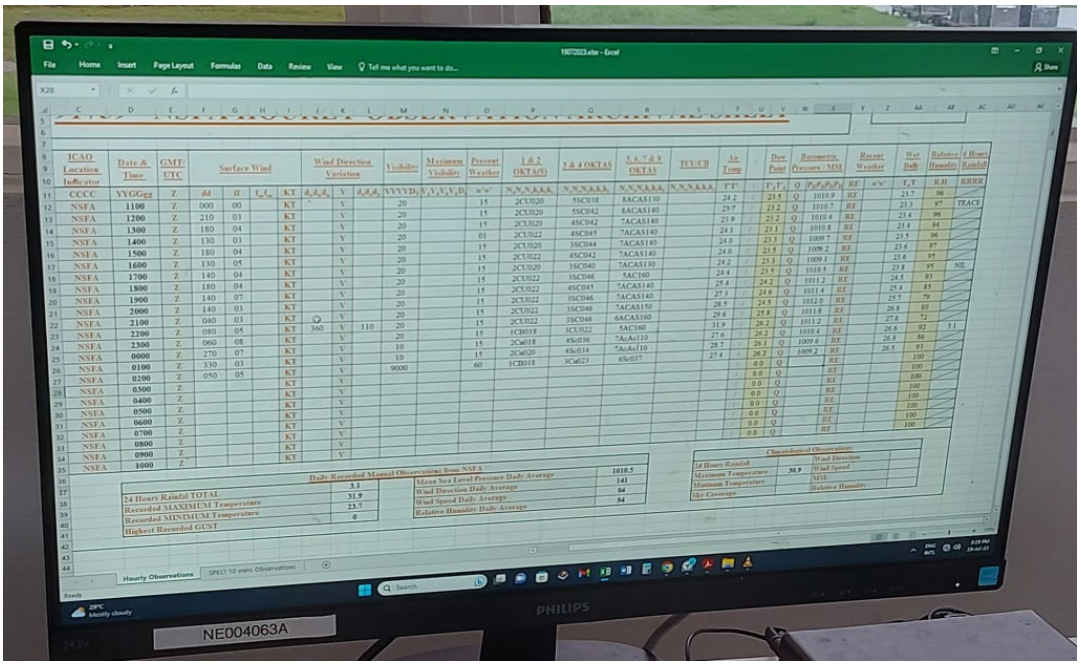

Figure 8. METAR/SPECI display at Faleolo Airport

The SMD office complex consists of a number of older buildings located at the picturesque coastal point of Apia. The Meteorology forecasting operations building/room is quite small which is further restricted internally due to IT equipment dedicated for data collection, forecasting servers, networking and storage infrastructure spread across desks and equipment racks creating a noisy environment.

The equipment, racks and the room Itself are reliant on the same split system air-conditioning unit. Equipment temperatures would rise very quickly if air-conditioning were to fail. A mixed environment like this is not ideal for staff or ICT equipment. This will be addressed during the audit of requirements for the new Meteorological Data Management

System and WIS 2.0 implementation proposed in Activity 3.8 and Activity 3.10 detailed below.

Figure 9. Faleolo observations office display of the two JICA AWSs located at each end of the runway. A second display is available in the Air Traffic Control Tower.

Transmission of AWS data depends on the AWS type:

- NIWA AWS send data at 10-minute intervals via 3G/GPRS to NIWA servers in New Zealand. NIWA servers then forward the data on to the SMD CliDE database on a server in the SMD Apia office. This data does not go directly to the forecasters as it is not distributed via the GTS, but is available on a separate webpage via NIWA's NEON web tool.
- JICA AWS send data at 5-minute intervals via microwave to a JICA server in the Apia office. This data is then converted to BUFR. At present (July 2023) the system is only partly functional due to microwave transmission issues and server HDD failure. The components still functional are the two runway AWOS systems at Faleolo Airport (Figure 10). However, the data is not distributed beyond the air traffic control tower and the airport observations office.
- Forecasters are unable to view data from all AWS systems on the same screen as systems are not integrated. The data from the JICA AWSs at the airport are not available to forecasters in Apia.

Current issues impacting transmission include:

- Blocking of microwave signals – Data from JICA AWS located at Faleolo Airport and to the west are not being received due to the microwave signals being blocked by a telecommunications antenna installed in 2019 on Mt Vaea that appears to be interfering with the signal. This problem is being discussed with the Office of the Regulator to instigate a resolution. An alternate, and preferable option being considered, is to use a GPRS for all JICA stations.

- BUFR conversion system - There is also a problem with BUFR conversion system; however a JICA volunteer will be in Samoa in July/August 2023 to look at this problem.
- Server Hard drives and software – The Hard Drives of the JICA server have failed (end of life) and the software in use is no longer supported. New software and hard drives are required to resolve this issue and it is anticipated that the 2023-24 SMD budget will facilitate these purchases. The licensing of the CentOS and ibl Moving Weather software is uncertain.
- As at July 2023 no AWS or AWOS data reaches the GTS due to data communication issues and lack of data processing and integration tools.

Climate Data Management System

SMD currently hosts three locations where data is stored.

i) CliDE local database

SMD maintains a local version of the Climate Data for the Environment (CliDE) database on a server at the SMD office in Apia (Figure 11). It can only be accessed by climate and other managerial SMD staff based at that location.

CliDE is a database management system developed by the Bureau under the International Climate Change Adaptation Initiative. It provides storage, basic visualisation and extraction tools for weather and climate data. It can process data in near-real-time. Its function has expanded over the years to the level that it can operate as a meteorological data management system.

The SMD version is hosted on servers at the SMD office. Weekly updates are made to the Cloud/remote version of CliDE which is located in Australia. Data sources include:

- NIWA have provided some additional tools and all equipment installed by NIWA is able to report to CliDE via NEON.
- Data from the staffed stations is manually entered into CliDE from the SYNOP messages emailed by field observers.
- Data from some of the manual weather stations and rain gauges which is collected from sites during maintenance visits and entered into CLIDE at a later date.

ii) JICA local database

Data from JICA stations is not currently entered into CLIDE. Historical data is stored on a server in the forecasting office which is currently offline due to an equipment issue.

iii) NIWA NEON

Data are pushed to NEON from the NIWA AWS/ARG. The frequency is set by NEON and is typically either 10 minutes or hourly.

The NEON server is hosted by NIWA in NZ. From NEON the data are pushed to CliDE in Australia, usually update on a 10 min interval. CliDE data is backed up daily to BoM servers in Australia.

Data can be viewed both on a NEON dashboard or via the CliDE web portal (Figure 10). The NEON dashboard is quite limited but the CliDE outputs are tailored to the different users. This tool is used by the forecasters to see some recent observations. Forecasters also have access to the raw coded e-mail messages from the staffed field stations.

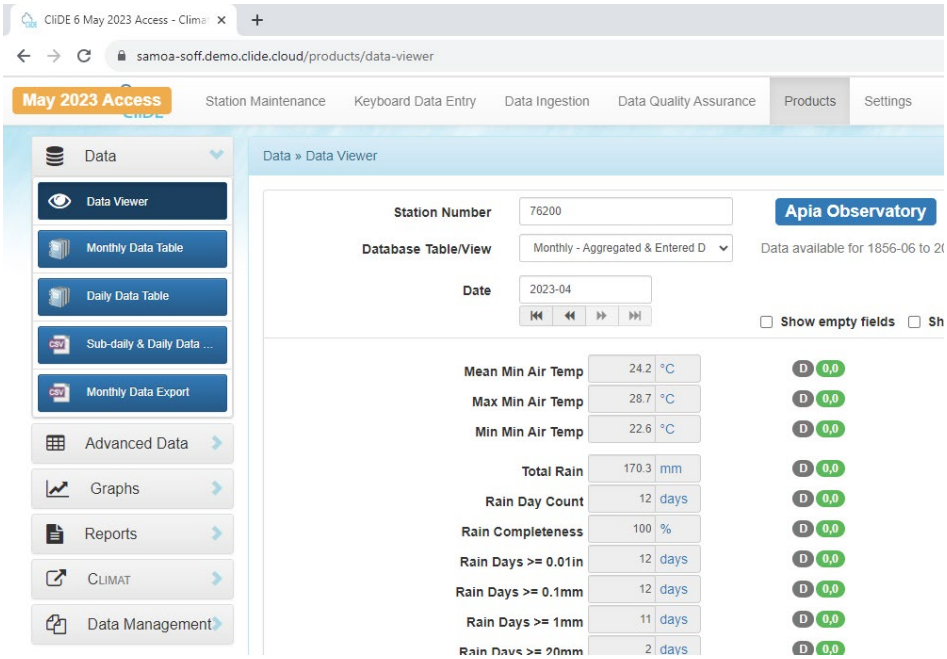

Figure 10. CliDE climate data management interface

Other than the four times daily weather reports on the SMD webpage, the observations from SMD AWS or field stations are not accessible to other stakeholders or the public.

Target state and activities

Achieving sustainable, reliable reporting to WIS at hourly frequencies from the proposed GBON surface stations will require a significant upgrade to SMD's ICT and data management systems including implementing a new Meteorological Data Management System (MDMS).

At the start of the investment phase, an audit of existing power supply, ICT equipment and data flows will be undertaken to establish the detailed architecture of a Meteorological Data Management System (MDMS) compliant with WIS 2.0. The audit will also include consideration of requirements for the physical location of related equipment in the SMD office, including noise levels and cooling needs etc, that may necessitate separation of equipment from the staff working environment.

The MDMS must not be a single point of failure. This must be avoided with redundancy of the MDMS hardware, network connections and processing workflows or by deploying the MDMS on cloud-based services with the required level of resilience.

Key anticipated elements of the data system are described at conceptual level below.

- ***Observing station data collection***
  As part of the upgrade of the manual and automatic weather stations, both stations will be equipped with robust cellular (preferred) or satellite communications to ensure regular, timely message transmission. Redundant data communications (cellular & satellite) from all sites is recommended.

AWS will be configured to send data to the MDMS via a suitable data transfer protocol (e.g. MQTT or SFTP). The MDMS should have the ability for observers to supply manual observations via e-mail in the existing SYNOP or METAR/SPEC format, as well as through more modern methods such as a web or mobile-accessible interface.

- ***Data transmission to WIS 2.0***
  The MDMS will have the capability to undertake basic real-time automated QC, then convert the data received from both automatic and manual stations to BUFR format before making the data available to WIS 2.0 through an HTTP service provided as part of the initial MDMS configuration and hosted by SMD.

- ***Data services***
  The MDMS will also provide data services (e.g. APIs, shared filesystem, publication/ subscription service) to enable SMD to access the data, use it operationally and make it available to stakeholders.

- ***Climate data management***
  A Climate Data Management System (CDMS) will access data from the MDMS. The CDMS could be an updated and potentially cloud-based version of CliDE, or another suitable system selected in the procurement process. The CDMS should be compliant with *WMO No. 1131 Climate Data Management Systems*. The CDMS will be used to store, view and extract all climate data and metadata collected by SMD. Appropriate processing to produce quality-controlled data and statistics for climate purposes will be performed in the CDMS.

Webpage

The SMD public facing webpage will also be reviewed to identify improvements for the dissemination of key meteorological and climate data to other Samoa stakeholders and the public. Provision of real-time data for all stations would be beneficial to all stakeholders. Enhancing the sharing of the data under the SMD banner will increase public and government support for the important work done by SMD to collect and steward these data, supported by SOFF.

Through the entire value chain of data collection, transmission, processing, storage and distribution, SMD will retain total control and custodianship over their data.

Activities to uplift data systems as described above are:

- **Activity 3.8:** Procure expert audit of power supply, ICT equipment and data flows at start of Investment Phase, to develop detailed architecture, including physical location requirements for related equipment, for the Meteorological Data Management System and WIS 2.0 implementation.

- **Activity 3.9**: Procure, install and commission a Meteorological Data Management System (including WIS 2.0 capability) through a 'supply and support' contracting approach, owned and operated by SMD, and including ongoing training and maintenance support. This should include user and administrator training and update training.

- **Activity 3.10**: Installation of the MDMS to include recommended upgrades to the SMD office to ensure acceptable working environment for staff and separation from ICT equipment.

- **Activity 3.11**: Procure, install and commission upgraded Climate Data Management System components through a 'supply and support' contracting approach.
- **Activity 3.12**: Develop/support upgrades to existing SMD web presence to provide weather data products to stakeholders and the public.

3.4. Environmental and sustainability considerations

Environmental and sustainability considerations will be included in the procurement process, as a selection criterion for suppliers. This will enable World Bank and SMD to consider opportunities for reusable instruments or biodegradable materials such as:

- Biodegradable string (e.g. biotwine) for radiosondes;
- biodegradable balloons and parachutes (coloured blue or green to reduce ingestion by turtles and marine birds);
- reduction in size of radiosondes, incorporating biodegradable materials where feasible;
- environmentally sustainable packaging such as cardboard and paper;
- ensuring instruments do not contain mercury;
- careful use of batteries to reduce toxic waste.

In addition, prior to site works for upgrading stations or installing new stations, an environmental management plan will be prepared (**Activity 3.13**) considering local conditions and approaches to minimise the environmental impact of construction activities such as:

- use of solar and/or wind power at sites;
- sustainable materials used for construction, including reduction in site footprint;
- sites should be maintainable with basic tools (i.e. use of ladders and climbing harnesses should be avoided);
- plan for safe removal of waste at end of construction.

Module 4. GBON Human Capacity Development Module

4.1. Assessment of human capacity gaps

The Samoa Meteorology Division (SMD) currently has 42 staff (Table 6). Two teams are critical to the sustainability and quality of observations at SMD:

- The Weather and Forecasting section comprise 6 forecasters and 8 observers covering 24-hour shifts at both Apia and Faleolo Airport sites.
- Climate services with five staff members

The Climate services staff take daily readings from two Climate stations, collect data from manual stations supported by community volunteers and upload this to the CLIDE database. There are also no dedicated technicians within SMD and maintenance of stations and equipment is generally undertaken by staff from the Climate section on top of their other duties.

There are currently no dedicated ICT specialists within SMD with ICT support provided by volunteers from within Forecasting and Climate Services who are predominantly self-trained.

Table 6. Staff profile as of November 2023 (courtesy SMD)

Branch	Doctorate/ MSc/	Bachelor	Other	Total	Meteorological training
Administration	1		6	**7**	
Forecasters/observers		5	9	**14**	2 BIP-M 3 BIP-MT
Climate		3	2	**5**	
Geoscience		5	8	**13**	
Ozone		1	1	**2**	
Projects	1			**1**	
Total	6	9	24	**42**	5

Staff resources in SMD are limited and will be stretched further as more projects come in that require engagement and support from SMD, while maintaining day-to-day operations of SMD services (Table 6).

Currently only two of the forecasters had been formally trained at institutions that provide BIP-M credentials – Bureau of Meteorology Training Centre and PAGASA in the Philippines. Other forecasters have joined the introduction to forecasting with the Pacific Training Desk in Hawaii (NOAA). All forecasters are internally trained for about 5 years.

Much of the observational training is done within Samoa and with the Fiji Met Service – the 6-month BIP-MT course. Three staff have completed the BIP-MT course and are designated as Meteorology Technician (Observations).

In the Geoscience Section, 5 of the 13 staff have BSc level qualifications, while the remaining staff have certificate level training. In the Climate Service Department, 3 of the 5 staff have BSC qualifications.

SMD has a poor gender balance with currently only 6 females in the team of 42, and only 1 in the Forecasters/observers section, however previously there had been 5 females in this group.

Initiatives to attract and maintain female staff should be promoted within the entire SW-Pacific region, and directly tied to the success of the SOFF program (Activity 4.13).

Figure 11. SMD Assistant CEO and staff with the SOFF team from the Bureau – July 2023

Key gaps in human capacity necessary to ensure GBON compliance of observations are:

- Only two of the observing personnel currently have BIP-MT qualifications which are considered essential to ensuring the sustainability and quality of observations.
- The SMD personnel have no formal training in cellular and satellite communications which are critical to transmission of real-time data for GBON compliance.
- Key staff co-located with the GBON stations require basic weather station maintenance skills to address equipment problems at stations in a timely manner to ensure reliability of observations. .
- SMD has no specific ICT personnel. To successfully implement a new Meteorological Data Management System (MDMS) compliant with WIS2.0, further ICT expertise will be required in data and communications systems including HTTP, MQTT, APIs and WIS2.0 data exchange systems. This should include enabling access enhanced forecasting data from ECMWF for the forecasting team.
- SMD has no technical officer roles in their organisation chart, and no staff currently trained in technical support. In order to ensure continuity of service for station equipment a permanent technical officer role should be created, with additional SMD staff trained to support this role to ensure back up is available.
- SMD do not have staff designated for quality management systems and equipment/sensor verification.

In order for SMD to adequately service the requirements for the new and rehabilitated GBON stations, SMD will need operational and financial support, as well as training as outlined in Activities 4.1 to 4.11 listed below.

4.2. Capacity development activities for technical staff

The following capacity development activities are proposed to address the gaps identified above:

- **Activity 4.1**: Provide training in basic automatic and manual weather station verification and maintenance at the start of the Investment Phase for all SMD observers and nominated MNRE staff on Savai'i, with ongoing training through the Compliance Phase. The training should be specific to the equipment types that will be installed. This would ideally be included in a 'supply and support' contract as part of the equipment procurement.
- **Activity 4.2**: SMD to be supported by SOFF to recruit one Technician Officer during the Investment Phase. This position will be responsible for completing and recording preventative and corrective maintenance at SMD sites. Support will be required both during Investment and Compliance phase. This role would manage a store of spare parts.
- **Activity 4.3:** Provide comprehensive training in weather station maintenance and metadata collection for the new technical officer and one to three staff members to provide back up support, both at the start of Investment Phase and ongoing through Compliance Phase. This would ideally similarly be structured into 'supply and support' contract.
- **Activity 4.4**: Provide training in cellular and satellite communications and router configuration during the Investment Phase to the new technical personnel and existing staff supporting this role. Similarly, this training could be included in a 'supply and support' contract as part of equipment procurement.
- **Activity 4.5**: Offer training leading to BIP-MT qualifications to all of SMD's observing personnel not currently qualified. This could be organised through the Bureau of Meteorology, NZ Met Service or Fiji Met Service.
- **Activity 4.6**: Provide training in OSCAR/Surface and WDQMS operation to selected members of the Observations and Technical teams.
- **Activity 4.7**: SMD to be supported by SOFF to recruit one ICT professional, skilled in network, database and communications technology critical to WIS2.0, MDMS and CDMS. Support will be required both during Investment and Compliance phase. Training in WIS2.0, MDMS and CDMS may also be required.
- **Activity 4.8**: SMD to be supported by SOFF to train an existing staff member as a back-up ICT officer to support the ICT professional employed through Activity 4.7
- **Activity 4.9**: Arrangements to train a number of existing SMD in quality management systems, including field sensor verification, observations metadata management and maintaining quality records.

4.3. Capacity development activities for senior management

The following capacity development activities are recommended to address the gaps identified above:

- **Activity 4.10**: Recruitment of a SOFF-funded program/project manager to oversee equipment procurement, installation and commissioning during the Investment phase, with the position to ideally continue for the life of the equipment during the Compliance phase funded with SOFF compliance funding.
- **Activity 4.11**: Training in finances, staff management and strategic planning for the SMD senior management team.

4.4. Gender and CSOs considerations

The following capacity development activities are recommended to address the gaps identified above:

- **Activity 4.12**: Organise stakeholder engagement consultations with civil society organisations (CSOs) focused on women's empowerment. This could include:
    - Direct contact with NGOs working with women and girls in Samoa to promote employment opportunities in SMD (e.g Coalition for Women in the Pacific).
    - Presentations at Community meetings.
    - Presentations to school groups.
    - Working with the Samoa National university and international agencies to secure funding to develop a scholarship or bond program to encourage women to enrol in the mathematics and science programs required for entry into Meteorology courses.
- **Activity 4.13:** Develop a Gender Gap Analysis and Gender Action Plan during the Investment Phase to guide the mainstreaming of gender and social inclusion initiatives into SOFF investments. The Gender Action plan could include the following:
    - Targets for female participation in the role areas associated with SOFF Investment and Compliance phases in Samoa.
    - Inclusion of gender targets in procurement documents where human resources are part of the procurement,
    - Annual reporting of achievement of the above targets.
    - Development of ongoing campaign in schools and communities to promote female participation in roles linked to SMD.

Module 5. Risk Management Framework

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

As part of the development of the National Contribution Plan, a high-level risk assessment has been undertaken (Table 7), focusing on risks that were identified during the Readiness phase, with planned mitigation measures. The mitigation measures will be implemented during the Investment Phase (**Activity 5.1**).

Table 7. Risk analysis

Identified Risk	Mitigation Measures	Monitoring and Evaluation
Lack of equipment maintenance due to lack of spare parts leads to equipment malfunction	Procurement of equipment under 'supply and support' contract including continuous supply of spare parts. Maintain a local store of key spare parts.	Monthly spare parts inventory reporting
Lack of equipment maintenance due to lack of funding for travel and logistics	Establishment of logistics fund to cover travel costs, vehicle maintenance or rental, daily subsistence allowance (DSA) over the life of equipment.	Monthly reporting on logistics needs and activities. Regular quality audits
Lack of equipment maintenance due to lack of dedicated technical staff member	Recruitment of dedicated technical officer with continued support for this position through investment and compliance phases	Quarterly reporting on maintenance visits
Loss of data due to long lead-times for repairs due to travel distance, complicated logistics	Co-locate the Savai'i automatic weather station near the office of a parent ministry. Manual observers or other staff to provide basic maintenance and redundancy	Monthly review of WDQMS and GBON compliance
Poor data quality or lack of data from standalone AWS due to degradation of site conditions, vandalism or theft	Locate standalone AWS at Ministry of Natural Resources and Environment office site Proactive maintenance by SMD staff funded through establishment of 'logistics fund' Review of data that fails automated quality checks	Monthly review of WDQMS and GBON compliance Weekly review of quality flagged data
Poor internet connections lead to	Equip all stations with redundant cellular and/or satellite communications	Monthly review of WDQMS and GBON compliance

data transmission delays		
Key observations are not traceable to a known standard	Develop a routine program and record keeping of field sensor verification and regular calibration of field transfer standards	Annual reporting of quality statistics
Unreliable power leads to communications outage and data delay	Equip all stations with batteries, uninterruptible power supply and solar/wind power generators	Monthly review of WDQMS and GBON compliance
Unsuitable accommodation for equipment leads to degradation of condition	Include building accommodation audit and upgrade if required in procurement for staffed station uplift. Equipment status audit.	Annual quality audit by SMD quality manager
Insufficient human resources or technical skills to install or maintain stations and ICT system	SOFF to provide support for training of technical and observing staff during Investment and Compliance phase SOFF to fund recruitment of additional skilled staff during both Investment and Compliance Phase as outlined in Module 4 Build public and government support for SMD to ensure its budget is supported by: • Improved visibility of observations through stakeholder dissemination via uplifted data management systems and webpage • Improved weather services through access to modelling centre products during compliance phase Workforce planning to address attrition	Annual human resources audit by SMD

Module 6. Transition to SOFF investment phase

The activities outlined in this National Contribution Plan will provide the basis for developing the Investment Proposal for Samoa's National GBON Network. The Investment Proposal will be developed by World Bank and SMD, with input from the Bureau (**Activity 6.1**).

Summary of GBON National Contribution Plan

Provide summary of GBON National Contribution Plan by filling this table

Table 8. Summary of GBON Contribution plan for Samoa

Components	Recommended activities
Module 2. GBON business model and institutional development	1. Engagement with aviation stakeholders to develop plans for aviation cost recovery to support ongoing funding for SMD.
	2. Engage in regional forums to pursue opportunities for regional coordination in Investment Phase and Compliance Phase elements such as calibration, training, common equipment types and maintenance services.
	3. Develop procurement plan that allows for the procurement of equipment to include private sector ongoing support (e.g. maintenance, training, advice, spare parts, etc.) for the life of the equipment through Investment and Compliance phases.
	4. Confirm the status of the SMD Strategic Plan, and undertake a comprehensive environment scan at start of Investment Phase of planned development activities related to GBON to identify opportunities for leverage and to ensure works are complementary.
	5. Engage with the Ministry of Finance and other potential partners, to develop a robust plan for ongoing procurement of essential services, to support SME to operate and maintain the stations to a GBON standard during Investment and Compliance phases.
Module 3. GBON infrastructure development	1. Determine optimal site for Apia staffed station by assessing relative merits of: the existing site at SMD office location in Apia; the possibility of co-locating at the National Emergency Management Office site (where SMD may also locate to in the future); and the Faleolo Airport site. Secure land at chosen location.
	2. Undertake audit of existing manual equipment and facilities at staffed station, and at the Asau AWS site, to identify all items that require procurement.
	3. As required, procure 1 x uplifted manual observing equipment, and 2 x new AWS for the two sites under 'build and support' contracts, including site works, structures, facilities, power and communications infrastructure
	4. Secure land access for upper air station at agreed location for the staffed surface station
	5. Procure 1 x upper air station equipment under 'build and support' contract, including site works and all ancillary infrastructure.
	6. Audit existing AWS, identify those that are serviceable or repairable and uplift their communications and IT systems to enable them to report internationally via the new MDMS
	7. Update data transmission systems for the existing sea level station to enable reporting to WIS (Bureau).

	8. Procure expert audit of power supply, ICT equipment and data flows at start of Investment Phase, to develop detailed architecture, including physical location requirements for related equipment, for the Meteorological Data Management System and WIS 2.0 implementation.
	9. Procure, install and commission a Meteorological Data Management System (including WIS 2.0 Capability) through a 'supply and support' contracting approach, including ongoing training and maintenance support. This should include user and administrator training and update training.
	10. Installation of the MDMS to include recommended upgrades to the SMD office to ensure optimal working environment for staff and equipment.
	11. Procure, install and commission upgraded Climate Data Management System (CDMS) components through a 'supply and support' contracting approach.
	12. Develop/support upgrades to the existing SMD web presence to provide weather data products to stakeholders and the public.
	13. Develop an environmental management plan for investment activities prior to the commencement of site works.
Module 4. GBON human capacity development	1. Provide training in basic automatic and manual weather station verification and maintenance at the start of the Investment Phase for all SMD observers, and nominated staff on Savai'i, with ongoing training through the Compliance Phase. The training should be specific to the equipment types that will be installed. This would ideally be included in a 'supply and support' contract as part of the equipment procurement.
	2. SMD to be supported by SOFF to recruit one Technician Officer during the Investment Phase. This position will be responsible for completing and recording preventative and corrective maintenance at SMD sites. This role would manage a store of spare parts.
	3. Provide comprehensive training in weather station maintenance and metadata collection for the new technical officer and one to three staff members to provide back up support, both at the start of Investment Phase and ongoing through Compliance Phase. This would ideally similarly be structured into 'supply and support' contract.
	4. Provide training in cellular and satellite communications and router configuration during the Investment Phase to the new technical personnel and staff supporting this role. Similarly, this training could be included in a 'supply and support' contract as part of equipment procurement.
	5. Offer training leading to BIP-MT qualifications to all of SMD's observing personnel not currently qualified. This could be organised through the Bureau of Meteorology, NZ Met Service or Fiji Met Service.
	6. Provide training in OSCAR/Surface and WDQMS operation to selected members of the Observations and Technical teams.

	7. SMD to be supported by SOFF to recruit one ICT professional, skilled in network, database and communications technology critical to WIS2.0, MDMS and CDMS. Support will be required both during Investment and Compliance phase. Training in WIS2.0, MDMS and CDMS may also be required.
	8. SMD to be supported by SOFF to train an existing staff member as a back-up ICT officer to support the ICT professional employed through Activity 4.7.
	9: Arrangements to train a number of existing SMD in quality management systems, including field sensor verification, observations metadata management and maintaining quality records.
	10. Recruitment of a SOFF-funded program/project manager to oversee equipment procurement, installation and commissioning during the Investment phase, with the position to ideally continue for the life of the equipment during the Compliance phase funded with SOFF compliance funding.
	11. Training in finances, staff management and strategic planning for the SMD senior management team
	12. Organise stakeholder engagement consultations with civil society organisations (CSOs) focused on women's empowerment.
	13. Develop a Gender Gap Analysis and Gender Action Plan during the Investment Phase to guide the mainstreaming of gender and social inclusion initiatives into SOFF investments.
Module 5. Risk Management	1. Implement measures outlined in the NCP risk management framework.
Module 6. Transition to SOFF investment phase	1. Develop investment proposal, incorporating activities from this GBON National Contribution Plan (UNDP, SIMS, with support from Bureau).

Report completion signatures

Peer Advisor signature Andrew Jones, General Manager International Development Australian Bureau of Meteorology
Beneficiary Country signature Ms Peseta Noumea Simi. CEO Ministry of Foreign Affairs and Trade -
WMO Technical Authority signature