Systematic Observations Financing Facility

18 December 2023

GBON National Contribution Plan of Malawi

Systematic Observations
Financing Facility

Weather
and climate
data for
resilience

GBON National Contribution Plan
Malawi

SOFF Beneficiary country focal point and institution	Amos Mtonya , Department of Climate Change and Meteorological Services (DCCMS)
SOFF Peer advisor focal point and institution	Teferi Demissie, Norwegian Meteorological Institute

Table of contents

Module 1. National Target toward GBON compliance

Table1. GBON National Contribution Target

Type of station	Baseline (Results of the GBON National Gap Analysis)				GBON National Contribution Target	
	Target (# of stations)[1]	GBON-compliant stations (#)	Gap		To improve	New
			New	To improve		
Surface	3	10	0	4	4	0
Upper-air	1	0	1	0	0	1
Marine	*when applicable					

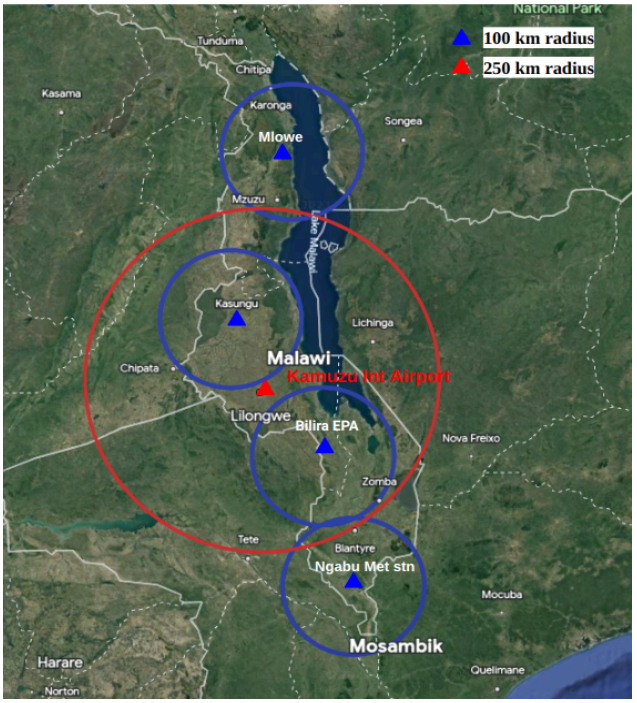


Figure 1. Map of Malawi with locations of surface stations to be improved (blue circle) and new upper air stations to be installed (red circle)

[1] For SIDS, for the WMO GBON Global Gap Analysis in January 2022, the EEZ area has been added to the total surface area which is the basis for the target number of stations. The standard density requirements for SIDS have been calculated with 500 km for surface stations and 1000 km for upper-air stations.

Table 2: Malawi's National Target toward GBON compliance

Requirements	SOFF progressive threshold	National target toward GBON compliance and timeline	Vision for long-term target toward full GBON compliance
Horizontal resolution			
Surface-based	4 of stations	4 stations by 2025	
Upper-air	1 of stations	1 station by 2025	
Reporting cycle			
Surface-based	80% of daily reports exchanged	80% of daily reports exchanged by 2025	80% of daily reports exchanged
Upper-air	80%of daily reports exchanged	80% of daily reports exchanged by 2025	80% of daily reports exchanged
Procurement process can be complete within 2024			

Module 2. GBON Business Model and Institutional Development

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

The Department of Climate Change and Meteorological Services (DCCMS) is a governmental department in Malawi under the Ministry of Natural Resources and Climate Change (MoNRCC). With regards to GBON implementation, DCCMS has the sole responsibility for meteorological services provision including management of station and data. The current activities at DCCMs is therefore considered as a fully public business model (Government owned, government operated). Relevant to the private sector collaboration for the operation and maintenance of GBON, DCCMS partners with some ministries in Malawi who host some DCCMS owned weather monitoring stations. The management of these stations and data is the sole mandate of DCCMS. Partnerships, and relationships with other government agencies in Malawi , although mostly informal include:-

- Ministry of Agriculture - Some of DCCMS weather stations are hosted at the Ministry of Agriculture premise. DCCMS also shares climatic data and services with the ministry (agrometeorological bulletin). There are future plans to provide access to observations in real time through a link or interface;
- Ministry of Education- some observations stations are hosted in schools;
- Lilongwe Water Board (LWB) - hosts weather stations, a lightning detection sensor, and also offers basic maintenance around the weather station. ‘
- The management of station and data is however a sole responsibility of DCCMS
- Department of Disaster Management Affairs (DoDMA) - Main recipient of information of extreme weather events
- Ministry of Transport and Public Works including Department of Civil Aviation - Mainly on provision of aviation services.
- National Water Resources Authority (NWRA)
- Department of Fisheries (DoF) - Co-hosting of buoys in Lake Malawi with DCCMS

Private agencies that have had collaborations with DCCMS and of relevance for the operation and maintenance of GBON include:-

- UNDP - Partnership with DCCMS. They have offered support in infrastructural development and system maintenance services through projects, also procurements of observing systems under the M-CLIMES project[2]
- There is a formal agreement with Trans-African Hydro-Meteorological Observatory (TAHMO)[3] on cooperation on observation data

Following consultation with DCCMS and other stakeholders during the SOFF readiness phase, potential new partners and recommendations of their roles are provided below. They include both governmental and private organisations that could provide support towards GBON compliance strategy:-

- Telecommunication providers - DCCMS is currently under discussion with Telecom Network Malawi (TNM), a mobile service provider.Formal agreement with telecommunication providers can be beneficial for reliable communication for real time data transfer.
- Academia - DCCMS collaborates with some academic and research institutions in Malawi including Malawi University of Science and Technology (MUST), Lilongwe University of Agriculture and Natural Resources Malawi (LUANAR) and the University of Malawi. DCCMS mainly provides meteorological courses and advice on syllabus to these institutes. There are no formal agreements however. These relationships can be strengthened with formal agreements and arrangements for collaboration on key

[2] Procurement Notice. Terms of Reference for Expansion of flood forecasting functionality of the Operation Decision Support System (ODSS) to selected river basin catchments in the central region of Malawi. M-CLIMES
[3] TAHMO

areas of science and advancement of weather and climate services in Malawi. A focus on meteorological infrastructure and observations as an essential element for successful application of weather and climate services in Malawi can be established. The research collaborations can be instrumental in determining meteorological infrastructure and observations as a priority for future funding.

- Media - Media has a significant role in shaping the weather and climate policy. DCCMS has a MoU with the Farm Radio Trust (FRT) on agromet services, including dissemination and communication. Meaningful partnership with other media houses in Malawi can be beneficial for DCCMS and enable them to have input on how issues related to weather and climate services are framed and reported. Positive public feedback on services provided by DCCMS can be key for funding opportunities.
- Energy generation and supply companies (Electricity Generation Company Limited (EGENCO) and Electricity Supply Corporation of Malawi Limited (ESCOM)) - The energy sector has different requirements for meteorological services. Meteorological conditions affect production of energy and partnerships with these companies can be beneficial to both parties. DCCMS has had meetings with the EGENCO but no formal MoU has been drafted. Formal partnerships with the Energy generation and supply companies can be established.
- Civil Aviation Authority - DCCMS provides aviation meteorological services (observers, forecasters, and technicians) to 2 international and 2 national airports in Malawi. There is however no clear regulation with DCCMS regarding aviation meteorological services cost recovery. DCCMS and relevant partners should re-evaluate cost-recovery funding arrangements with ICAO, including co-funding of human capacity, QMS implementation and ICT systems. This funding should be allocated to DCCMS and should be adjusted accordingly to match the full cost of the aviation services provided by DCCMS.
- Department of Fisheries has plans to buy, install and own weather stations - DCCMS should establish meaningful partnership such that data are provided under GBON quality regulation under DCCMS expert guidance hence increasing the overall data availability in Malawi
- Department of Water Resources (DWR) and Water Boards - There currently exists informal partnership between DCCMS and DWR especially on climate service co-production on mainly flood management systems. These services can be extended to include data provision in line with GBON requirements.
- Department of Geological Services - There is an emerging interest to engage more with the department considering that land-slides have emerged to be more hazardous, contributing to much of the loss and damage during cyclone Freddy in March 2023. The department would be a relevant partner in land-slide monitoring.

Possible private providers can be:

- National Parks (Lengwe, Kasungu, Liwonde) - considering their role to safely host weather monitoring stations
- Sugar producing companies - One such company, Illovo, has a long experience in managing its own manual and automatic weather stations. There is potential to share data and engage in the co-production of services
- UNDP has partnered with DCCMS since 2014 (They have offered infrastructural development, maintenance of systems etc.) Other projects have been mostly short-lived.
- WMO has also partnered well with DCCMS.

2.2. Assessment of potential GBON sub-regional collaboration

Neighbouring countries to Malawi include Mozambique, Zambia and Tanzania. All of which are beneficiaries to the SOFF support; Mozambique (SOFF 1st batch), Tanzania (SOFF 1st batch) and Zambia (SOFF 2nd batch). Considerations for resource optimization during procurement of stations

and maintenance plans in the investment phase should be explored as all the neighbouring countries are recipients of the SOFF support. Sub-regional dialogues and co-ordinations should be established to facilitate best practices for procurement, network maintenance plans and human capacity development.

With regards to regional collaborations, DCCMS participates in two Regional Climate Outlook Forums (RCOFs)s; Southern African Region COF (SARCOF) annually and South-west Indian Ocean COF (SWIOCOF) on invitation. These are mainly active during the approach of rainfall season: SARCOF is for the Southern African Development Community (SADC) countries; SWIOCOF is for Indian Ocean (IO) islands (Comoros, Madagascar, Mauritius, Reunion, Seychelles) and IO west coast countries (Mozambique and Tanzania).

Regionally, NHMS in the SADC are linked through the SADC Climate Services Centre (located in Botswana). Its coordination capability is not very strong and has so far dealt with weather/ seasonal forecasting issues and network expansion and management. Additionally the forums do not include formal arrangements for data sharing, human capacity building relevant for GBON. DCCMS participates in:

- Climate Experts group of SADC;
- SARCOF- Southern African Regional Climate Outlook Forum
- SWIOCOF[4]- South-Western Indian Ocean Climate Outlook Forum
- Southern African severe weather forecasting demonstration project (SWFDP)[5]
- Southern Africa Regional Flash-Flood Guidance System (SARFFG)[6]

Currently, there are no observation-data sharing practices in Malawi with neighbouring countries. This can be possible in future especially through regionally coordinated projects that are coordinated by UNDP, African Union and other development partners. Additionally, DCCMS's meteorological data policy (2017)[7] which includes 11 guiding principles regarding data classification and data sharing, provides in its third principle consideration for sub-regionals and international data exchange. The principle states that "Meteorological data and products should be made available free of charge to the National Meteorological Services of other countries in accordance with WMO Resolution 40[8] on free and unrestricted exchange between WMO member states."

Strengthening the institutional capability of the SADC climate service centre has potential for optimization of FOFF operations and building the SADC sub-regional collaboration

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

DCCMS operates on a *government owned, government operated financial model* for the operations of its observation networks. Therefore 100% **funding sources** come from the Other Recurrent Transactions (ORT) from the Government of Malawi budget. Development partners (e.g Green Climate Fund (M-Climes) (UNDP) support mostly on initial capital investments e.g procurement of AWS. The current annual expenditure for the operations of the observation networks at DCCMS is US$235,224 on salaries and US$40,180 on operations and maintenance of the observation network. This does not guarantee the sustainability of the observation network in Malawi.

Current funding sources:

1. ORT (Other recurrent transactions from the GoM budget)
2. Donor funded project e.g Green Climate Fund (M-Climes) (UNDP)

In Malawi, DCCMS has the sole mandate for meteorological services including management of stations and sharing of meteorological data locally and internationally. There currently does not exist a

[4] South West Indian Ocean Climate Outlook Forum
[5] South African severe weather forecasting demonstration project (SWFDP)
[6] Southern Africa Region Flash Flood Guidance System
[7] Meteorological Data Policy In Malawi
[8] WMO Resolution 40

legal framework to support privately ownership and management of stations hence a fully public business model in Malawi. However for sustainability of observations network at DCCMS, the following are possible future funding sources;

- Government funding (increased and consistent)
- Cost recovery basis - DCCMS should re-evaluate its cost-recovery business plan and strategise for its effective implementation. This is needed, especially with regards to aviation weather services and other climatological services to generate income to manage its station network and infrastructure. DCCMS can establish this through consultation including implementation of provisions in Annex 1 of the meteorological data policy (2017).
- SOFF Implementing phase -Proposal for funding in the next 10 yrs
- Public–private partnership (PPP) to work hand in hand with the current business model in Malawi
- DCCMS can also investigate how to develop the cooperation with the possible private partners described in 2.1 into a type 2, 3 or 4 business model,[9] and with a direct contract with the DCCMS where data are provided under GBON quality criteria to DCCMS for a fixed amount, thereby increasing the overall data availability (a long-term plan given the current position of DCCMS)

In collaboration with the peer advisors, DCCMS has developed a financial plan[10] for operating the modernised infrastructure, including considerations on the total cost of ownership. The estimates are based on a world bank report[11] on Charting a Course for Sustainable Hydrological and Meteorological Observation Networks in Developing Countries (Grimes et al. 2022). The estimates will be used in the SOFF investment funding request for Malawi.

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

DCCMS is currently reviewing its five year (2017-2022) Strategic plan. A draft of the next 5-year strategic plan is under implementation and needs more input and to be better aligned with other relevant national and international initiatives and projects.

The Strategy Plan (2017-2022)[12] has 6 main outcomes

1. Improved weather and climate monitoring and prediction.
2. Strengthened environment for climate change and meteorological services delivery
3. Improved infrastructure and human capacity in climate change and meteorological services
4. Improved communication and dissemination of climate change and meteorological information to sector specific stakeholders and the general public
5. Improved provision of aviation weather services
6. Effective and efficient climate, climate change and research services provided

The following outputs description expected to achieve “Improved weather and climate monitoring and prediction”, have relevance to GBON for the improvement of observing networks in Malawi:-

1. Improved weather and climate monitoring and prediction.
    1.1. 90% of weather and climate monitoring and prediction systems automated by 2021
        1.1.1. Existing monitoring systems assessed quarterly and reports produced through to 2021
        1.1.2. 70 meteorological observers and technicians trained in assessment and basic maintenance of conventional and automated monitoring systems

[9] See chapter 4 of the Operational Guidance Handbook on SOFF private sector archetypal business models
[10] SOFF Expenditure Estimate for Malawi.pdf
[11] Charting a Course for Sustainable Hydrological and Meteorological Observation Networks in Developing Countries
[12] DCCMS Strategic Plan 2017–2022 Main Document.Pdf

1.1.3. Six Attachments to South Africa, Tanzania, Kenya, USA and United Kingdom and Japan conducted by six officers and reports produced by June, 2021
1.1.4. Procurement of equipment (MeteoFactory and SynergyWeb, Weather RADAR) based on internal assessment conducted by June 2018
1.1.5. Training conducted to Engineers, Technicians and operators by June, 2021

1.2. Expand weather and climate monitoring network by 75% by 2021
1.2.1. 40 Automatic Weather Stations(AWS) procured and installed by 2021
1.2.2. 5 new conventional meteorological stations established by 2021
1.2.3. 3 Radio Sonde equipment procured and installed by 2021
1.2.4. Technical Stationery, Science consumables, and Spare parts for Conventional Meteorological equipment procured through to 2021
1.2.5. Back-up power for AWSs and electrical resistance thermometers installed through to 2021
1.2.6. Maintain and calibrate conventional meteorological instruments and equipment and upper air observation equipment

1.3. Improved weather and climate prediction skills by 2021
1.3.1. Capacity in weather and climate prediction enhanced
1.3.2. Meteorological data transmission and information communication for 21 stations and DCCMS Hq enhanced to 90% by 2021
1.3.3. Weather and climate prediction and seasonal forecasting enhanced through to 2021

Based on the Strategy Plan (2017-2022), there has been progress and some of the targets were achieved. There however have been challenges in implementing some tasks/activities due to lack of funding and human resources. The implementation of these tasks can be facilitated through SOFF.

One specific output on observation network expansion was '40 AWS procured and installed by 2022, which was achieved through the M-CLIMES project (33+), SADC (5) and TAHMO (30)

That makes the Green Climate Fund funded M-CLIMES Project as an existing development project that has supported the observation network expansion and maintenance of the network. AWSs acquired under the project are the ones that are used in WIS2BOX pilot for WMO, and the ones being targeted for GBON

Future Plan:
DCCMS currently has a draft of the next 5-year Strategic Plan that requires more input and alignment with updated policies and initiatives. Plans also include a complete review of the 2017-2022 strategic plan and a new Strategic Plan in 2024.

There is also World Bank support to undertake systems upgrade, i.e., integrate old AWSs with Campbell-scientific loggers to revive their operations using their old sensors. The IE with support from the peer advisors can be included in this operation. This should be complimented in SOFF especially with a focus on establishing sustainable observation systems in the long-run.

2.5. Review of the national legislation of relevance for GBON

There is currently no legislative act at DCCMS[13] describing the legal mandate and scope of DCCMS. However DCCMS is governed by the National Climate Change Management Policy (2016)[14] and the National Meteorological Policy(NMP) (2019)[15] . The NMP with a timeframe of 2019-2023 has seven priority areas including:-

1. Monitoring and Prediction of Weather and Climate;
2. Management of meteorological data and information;

[13] Department of Climate Change and Meteorological Services
[14] Government Of Malawi National Climate Change Management Policy
[15] Government Of Malawi National Meteorological Policy

3. Meteorological engineering, communication and information technology (IT);
4. Meteorological Research Services;
5. Capacity building and Awareness;
6. Financing the climate change and meteorological sector and
7. Cross cutting issues

The first three priority areas provide development plans and strategies relevant to GBON. However successful implementation of most of the well laid out strategic outputs were based on availability of funding and expertise assumption. The current policy documents need to be updated. A draft Meteorological Act for meteorological services is currently under review by the Ministry of Justice in Malawi. The outcomes could be relevant for improvement of weather observations. The priority areas relevant to GBON should be well mapped out and the IE should ensure that SOFF related activities are included in the Funding Request.

Public Procurement and Disposal of Assets (PPDA) is a government organ that regulates all procurements for government agencies in Malawi. DCCMS gets a tax waiver on procurement of Meteorological instruments that are to be used for public good.

IEs have their own procurement systems (both local and international). DCCMS is in a position to benefit from procurement systems for both government and IEs. UNDP has partnered with DCCMS in the procurements[16] of observing systems (M-CLIMES project) in the past and continued partnership will be very beneficial. Would be nice if SOFF would support such frameworks

There will be no constraints to the implementation of GBON as DCCMS's meteorological data policy (2017) provides for data sharing in line with GBON requirements i.e., Meteorological data and products should be made available free of charge to the National Meteorological Services of other countries in accordance with WMO Resolution 40 on free and unrestricted exchange between WMO member states. The proposed updated policy should also provide for free and unrestricted exchange between WMO member states.

[16] Government Of Malawi And UNDP Individual Consultant Procurement Notice

Module 3. GBON Infrastructure Development

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

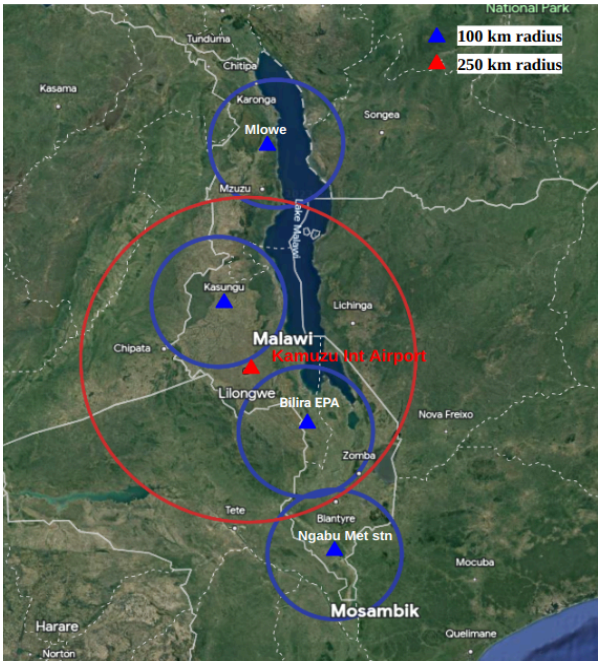


Figure 1. Map of Malawi with locations of surface stations to be improved (blue circle) and new upper air stations to be installed (red circle)

A list of observation instruments and systems per site per the proposed GBON Surface Land station in Malawi is provided[17]. Estimates for the investments needed for the installation of new stations and the improvement of existing stations is provided in the Financial plan[18] . General activities relevant for network design and planning in Malawi may include but are not limited to:-

- Enhance sites' suitability (fencing, community awareness for ownership and safety);
- Acquire AWSs and spare parts (sensors, power accessories) for improvement;
- Acquire Upper air station and recommended spare parts;
- Acquire upper air operations accessories (gas and cylinders, power backup, balloons and radiosondes)
- Acquire calibration tools or unit for all sensors;
- Provide training (factory training and/or local) in stations' operations and maintenance, and calibration;
- Acquire workshop tools and equipment;
- Install stations and parts;
- Upgrading CLIMSOFT database management system (improve to integrate AWS data or acquire another CDMS)
- Acquire rugged laptops for field use in servicing and maintenance;
- Acquire a vehicle for field use in servicing and management;
- Acquire desktop computers for monitoring and data processing;
- Develop a stations operations and status monitoring unit;
- Develop SOPs for all stations' operations and maintenance;
- Undertake institutional capacity building (ICT infrastructure, servers room enhancement, CDMS improvement, local network improvement; OSCAR and WDQMS);

[17] Proposed GBON surface stations
[18] SOFF Expenditure Estimate for Malawi.pdf

- Undertake human capacity building (ICT/ electronics, NWP analyses and applications, CDMS improvement, WIS2Box, GIS, etc);
- Lobby for CSO/ Private sectors partnering in stations operations and other climate services

Based on the DCCMS GBON Gap Analysis, emphasis should be placed during network design and planning, including laying the foundation for capacity development for the upper air station. Radiosonde has not been operated in a while in Malawi therefore DCCMS lacks capacity on the operation and maintenance of the upper air system. With this regard, DCCMS prefers the automatic Meteorological Balloon Launching System that has been shown to have technical performance similar to that achieved with the traditional manual launch radiosonde and requires less operation cost in addition to reduced challenges in performing manual radiosounding launches. Investment requirement for upper installation provided in this report is based on estimates provided in a world bank report, Charting a Course for Sustainable Hydrological and Meteorological Observation Networks in Developing Countries (Grimes et al. 2022)[19]. The procurement of upper-air system, lead by the IE (UNDP), DCCMS with support from the peer-advisors will therefore further explore the provided budget based on GBON technical specifications for Upper-air Stations (radiosonde)[20]. Possibilities of sub-regional collaborations with the neighbouring SOFF countries to try to achieve best value for money in the procurement and maintenance plans or radiosondes should also be considered.

Observational practices defined per network

Upper air Station;

- target balloon launch 2 times a day;
- automate data transmission fo global data exchange;
- continuous monitoring of station status and operations;
- provide and monitor LAN for servers communication and data integration;

Automated Weather Stations:

- target hourly observations reporting;
- automate data transmission for global data exchange via GTS/ WIS2Box;
- continuous monitoring of station status and operations;
- provide and monitor mobile network status for data communication;
- provide and monitor LAN for servers communication and data integration;

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

- Pre-calibration of sensors;
- Orientation on basic cleaning of less sensitive but key part by hosts;
- Quarterly routine station and sensors cleaning and servicing;
- Cleaning of sensors per month
- Monitoring of operations to trigger immediate maintenance and replacement of parts and/ or preventative and corrective maintenance during quarterly servicing;
- Monitoring of stations' communication to trigger corrective and preventive maintenance for minimising communication failure;
- Scheduled calibration of sensors once as guided by manufacturer and system requirements;

The technical specification for new instruments and observing systems for the procurement process in Malawi[21] is provided. This should be supplemented by the GBON Tender Specification for AWSs[22] and GBON Tender Specifications for Upper-air Stations (radiosonde)[23].

[19] Charting a Course for Sustainable Hydrological and Meteorological Observation Networks in Developing Countries
[20] GBON technical specifications for Upper-air Stations (radiosonde).
[21] Malawi AWS specifications
[22] GBON Tender Specifications for AWSs
[23] GBON Tender Specifications for Upper-air Stations (radiosonde).

3.2. Design of the ICT infrastructure and services

At DCCMS, AWS uses GPRS for communication. The networks in use are for Malawi mobile service providers (Airtel Malawi and Telecom Network Malawi (TNM)). This is either on a contract (post-paid) or pay as you go (prepaid). Since data generated and communicated by AWS is not large, no data bundles are required. AWSs sends data to a server in the Server room at HQ in Blantyre. Preferred temporal steps are hourly or half hourly. From here weather data is available for integration into a climate database management system, input into data visualization and processing systems (e.g., Synergieweb). Data on the station's status is also sent, and using relevant software it is visualised as part of monitoring performance.

In the server room all servers are powered by a solar-Mains hybrid power backup system which minimises operations disruptions in case of blackouts. The servers are all on a local network, and data transfer for archiving or processing is done locally. A selected number of stations were also piloted on WIS2Box implementation. These transfer data to WIS2Box in the cloud using ftp. Global data transfer to GTS and NWP centres are done from WIS2Box. in the case of GTS, DCCMS is using a Netsys message handling system. The current challenge with this is that it is working well for manual stations only where meteorological coded alpha-numeric SYNOPs are generated and manually entered for exchange through GTS.

The WMO WIS2BOX pilot project in Malawi in April 2023 benefited DCCMS as it enabled hourly AWS data exchange for the first time and had a few officers trained on operation of the WIS2Box software[24]. Observations (hourly real-time data) from selected stations in Malawi are exchanged internationally through WIS 2.0 to Global NWP Centers in BUFR format albeit with some challenges. As such, only 30% of the designated GBON stations in Malawi have been reliably compliant to GBON. Since the WIS2box pilot project by WMO ended in September 2023, the current challenges related to data transmission to the global NWP centre, including the viability of the current infrastructure (Amazon Web Services) system in DCCMS should be mapped and the required components for continuous and reliable provision of hourly real-time observations fully ascertained during the SOFF investment phase.

The Technical specifications for the data collection system from the observing station to the collection point and of the data services (compatible with the requirements of WIS 2.0) is included in the Malawi AWS specification document summary.

The full data processing and transmission chain from an observing station to the national CDMS should be performed through reliable ICT infrastructure. In DCCMS, the main factors that threaten the resilience and continuity of full data processing are mostly related to the failure in the AWS system and the communication infrastructure. They include but are not limited to; difficulty in acquiring (locally) and replacing spare parts, inadequate vehicles for timely maintenance on a need basis and vandalism of stations (targeting solar panels and batteries). Some stations are old and the manufacturers have since stopped manufacturing them or their parts. These risk factors on the observing network affect observations being received. Measures that are being taken and being proposed for resilience of operations include:

- **joint awareness raising with community leaders** in the area to install a station. This instils a sense of ownership of the station and has significantly reduced acts of vandalism, with one case occurring in the past the past two and a half years;
- **addition of extra security infrastructure;** solar panels are erected on a high pole. Barbed wire and sharp pointed metals are attached to the poles so as to limit access to the panel;
- **Site selection:** prioritised areas for stations installation are primarily government premises where security is offered and has possibility of easily linking with responsible officers in the case of operations disruptions;
- **Lobbying for operational vehicles;** this is being pursued because it is the main cause of delayed action when operations are affected by various causes. This is being pursued with the government as the main funder of climate services and with donor partners as well.

[24] https://docs.wis2box.wis.wmo.int/en/1.0b4/

- **Pursuing partnership (PPP) with TNM, the mobile service provider:** this is being done in order to ensure continuously available communication means through mobile and internet services. There is also an opportunity of reducing the costs since some services will have to be provided as part of corporate social responsibility of the service provider;
- **Lobbying for more government funding:** DCCMS is also pursuing this in order to have access to sufficient funds to ably procure spares. Existing threat to this is the lack of forex as the enabling factor to procure internationally.
- **Explore new partnership** proposed in 2b through continuous stakeholder engagement to build collaboration with sustained third-party funding for the sustainability of operation of the observation networks.
- **DCCMS CLIMSOFT database management system capabilities** should be explored including capacity of staff to manage the system, back-up and data storage capabilities and the entire data services systems.
- **Adopt new technologies** that aid in the integration of data from various automated systems. One such tool is the AWS Data Tool (ADT) that was developed by the International Research Institute of the University of Columbia, USA, which has recently been adopted by DCCMS and is able to integrate data from different brands of AWSs.
- The IE with support from the peer advisor will ensure that the budget allocated to the ICT infrastructure during SOFF will be sustainable throughout the lifespan of the network. Emphasis is needed on the human capacity requirements (Table 4)

3.3. Design the data management system

Meteorological Data Management System at DCCMS

Data management is required at two stages; **Stage1** from observation station to the data acquisition and status monitoring server including short-term data storage, exchange and access by various data processing and data transmission systems such at the GTS and WIS2Box. These requirements are included in the Technical Specification for Automatic Weather Station in Malawi and associated services. **Stage 2** is data management and archiving in a CDMS

- Data from observations is most likely to be of ascii or tabular format. For data exchange through WIS2Box, the AWS will be configured to push/ send data through relevant protocols (FTP/ MQTT) to the WIS2Box cloud server where WMO recommended BUFR messages format will be transmitted to global NWP centres.
- Observation data from manual stations in the server for short-term storage and processing will also be in a position to send to GTS through the Message Handling System (MHS). This requires acquisition of extra processes (software) to automate the data transfer and generation of alpha-numeric WMO messages. This has been confirmed to be possible although it may be short-lived due to the transition to WIS2Box.
- **Stage 2** involves data transmission from the server to the national climate database management system for archiving. Current CLIMSOFT CDMS operations have shown limitations in handling automatically generated and transmitted data. The recommendation is to upgrade the CDMS for enhanced uptake of AWS data and other automatically generated data.
- Under Stage 1, the supplier is expected to provide the software for managing data from stations. This includes details of the station itself (metadata) and its current operating status in terms of power, and efficiency of sensors and parts. For ease of access and interpretation, the software is expected to have an API or other interface that will ably identify a unique station and display all required metadata and data.
- In Stage 2 a WMO recommended CDMS will be in use either through upgrading the **CLIMSOFT** or acquiring a more robust CDMS. Ability to integrate AWS data will be a priority in the operations of the CDMS.

Organisational datasets management throughout the entire value chain include data ingestion, data quality control and assessment, storing, metadata management and data retrieval. Effective functionality of the data management system components require reliable IT infrastructure. Skilled IT specialists for developing and sustaining increased data processing and data management

capabilities are critical for DCCMS and the sustainability of SOFF projects. All the data management applications will also depend on the reliability of the national climate database capabilities. WMO provides Climate Data Management System Specifications[25] that are relevant for DCCMS

Presently observations from selected stations in Malawi are exchanged in real-time (hourly) internationally through WIS 2.0 to Global NWP Centers in BUFR format albeit with some challenges. It is therefore highly recommended that the current related challenges should be resolved such that all national and international data transmission processes at DCCMS network are based on the WIS2box software and synchronised to the national CDMS CLIMSOFT. The data delivery component functionality to CLIMSOFT should include:

- Proper data discovery (both observational data and metadata)
- Data ingested should be stored in WMO format and in the right locations for long term preservation and delivery
- Data delivery and publication services should be based on open spatial standards (e.g, the Open Geospatial Consortium (OGC) , Web Map Service Interface Standard (WMS), the International organisation for Standardization (ISO) 19100 series or the Open-source Project for a Network Data Access Protocol (OPeNDAP))

With regards to metadata management, two complementary types of metadata are required;

- discovery metadata, used for relevant data discovery, access and retrieval. They describe who did what, where and when, how to access data and potential constraints on the data
- descriptive metadata , enables data values to be interpreted and discovered in context. They help connect users to the data, and provide important context about the data discovered.

The WIGOS Metadata standards (WMO, 2019)[26] can be used to identify conditions under which observations were made in addition to other aspects to determine whether observations are fit for purpose. The recent discovery metadata standard for the WIS2.0 platform by the "WMO Core Metadata Profile (WCMP) Version 2[27]" defines the content, structure, and encoding for the WMO Core Metadata Profile (WCMP). The a profile and extension of the OGC API - Records standard[28].

Monitoring of data, processing and services will depend on the capabilities and viability of the DCCMS CLIMSOFT database system and in-house capacity. Guidelines on Surface Station Data Quality Control and Quality Assurance for Climate Applications (WMO-No. 1269)[29] provides recommendations when designing a monitoring system. Automatic data quality control technique is recommended sub-hourly to hourly AWS data with further checks. Even then, the data quality and assurance system at DCCMS should be adapted to fit to the local meteorological environment and to the local technical and needs. Procedures applied whether manual or automated in the entire data life cycle should be well determined with a long-term perspective.

Re-design the data management system at DCCMS to be fit for purpose needs to be addressed in the investment phase. The IE in collaboration with the peer-advisor will ensure that the relevant technologies in data management, archive and access are acquired, and that capacity is built to manage these.

3.4. Environmental and sustainability considerations

While SOFF is expected to contribute to the improvement of climate and weather services, surface observing networks, infrastructure and operations may have environmental impacts. To address the likely impact DCCMS will as much as possible take the following into consideration:-

- The project work and its implementations will require several travels, DCCMS will strive to make collaboration digitally when possible and reduce the number of trips whenever possible

[25] Climate Data Management System Specifications
[26] WIGOS metadata standard, (WMO-No. 1192)
[27] WMO Core Metadata Profile (WCMP) Version 2
[28] OGC API - RECORDS
[29] Guidelines on Surface Station Data Quality Control and Quality Assurance for Climate Applications (WMO-No. 1269)

to keep the carbon footprint to a minimum. When necessary to travel we will buy offsets like biofuel and climate quotas.

- DCCMS has prioritised, and will as much as possible use solar panels as power supply for observation stations. DCCMS is already operating a solar-Mains hybrid power system which has improved the work efficiency on top of championing the use of clean energy.
- In the future necessary transport will be as much as possible with electrical vehicles.
- DCCMS wants to reuse as much equipment as possible and strives to reduce the use of single-use plastics and with relevant technical capacity building reuse of parts will be promoted.
- DCCMS will consider the environmental accreditations of vendors and procure high quality equipments that are sustainable throughout their intended lifetime,
- Procurement of open architecture solutions systems (i.e data logger, sensors and CDMS) to improve interoperability
- Increased and improved capacity of DCCMS staff (through training) to ensure dependency on local contractors for upper-air sounding:
    - Continued focus on training and capacity building
- Reduce the number of field visits and if possible use of hybrid vehicles to reduce emissions and costs.
    - This can be facilitated by having scheduled preventive maintenance and calibration plans with reliable field equipment that reduces costly back and forth maintenance trips that could have otherwise been avoided.
        - Having scheduled preventive maintenance and calibration plans also lengthened the lifecycle of sensors.
        - Having contact personnel in remote stations with capabilities for simple maintenance check e.g changing of batteries
        - Enhancing capacities for remote system diagnostics and alarms crucial to minimise maintenance trip. This is possible through improved telecommunication capabilities.

Module 4. GBON Human Capacity Development Module

4.1. Assessment of human capacity gaps

A summary of staff in different fields at DCCMS including their education levels, age and gender is provided in Table 3. A detailed organogram is also provided in annex 7. Capacity of staff in different fields at DCCMS for GBON stations operations for technicians, experts, and management is provided in table 4. The table also summarised analyzed gaps and recommendations on training activities and recruitment required for successful GBON compliance within the SOFF framework.

Table 3: Composition of DCCMS staff with information on education, age and gender

	Head-quarters	Regional Center	Education (number of staff with BSc or higher)	Age (number of staff older than 40 years)	Gender
Corporate support	8	2	1 (10%)	8 (80%)	Women: 6 (60%) Men:4
Meteorologist	14	20	25 (74%)	15 (44%)	Women: 8 (24%) Men:26
Meteorological technicians	1	61	> 5 ** (10%)	19 (31%)	Women: 18 (29%) Men:44
Hydrologists	NA	NA	NA	NA	NA
Hydrological technicians	NA	NA	NA	NA	NA
Climatologists	NA	NA	NA	NA	NA
Researchers	*				
IT	7	2	5 (71%)	7 (78%)	Women: 1 (11%) Men: 8
Other	12	37	0	29 (59%)	Women: 15 (31%) Men:34
Total	42	122	37 (23%)	78 (48%)	48/116 (29/71%)

*Meteorologists work informally in research; **Used 6 to calculate percentage of educated staff

Table 4: Capacity development activities for technical staff and senior management for GBON stations operations at DCCMS

Personnel	Task	Available at DCCMS	Education & Credentials	Analyzed Gaps and Recommendation
Network Management planning specialists	Including those who work in service, incident, change and process improvement management, and life cycle support.	4	1- MSc Applied Meteorology and Climatology & BSc Physics; 2- MSc Applied Meteorology and Climate with Management/BSc in ICT; 3- Post Graduate Diploma (PGD) Met & BSc in IT 4- Adv Dip. Computing	Gaps: ● No formal training in ICT/ network management while on job; ● No training plan to guide further capacity building; Recommendations: ● Training on ICT and network management ● CCNP certification ● Development and implementation of training plan
Field technicians (system operators or system observers)	technical tasks of maintenance, repair, and upgrades to the meteorological system	5	1- Dip in CISCO Engineering; 2- Dip in Electronic Engineering; 3- Dip. in Telecommunications; 4- Bsc in IT ; 5- Malawi School Certificate of Education (MSCE)	Gaps: ● Acquired capacity is only from Factory trainings for specific systems; ● No training plan to guide further capacity building; Recommendations: ● Development and implementation of training plan ● Widen ICT training scope to improve competency and skill to include electronics and programming ● Capacity building in meteorological installations, operations and maintenance ● Training on calibration of meteorological instruments
Operational support 24/7	from the IT service desk to log field site, communications, or server failures to ensure repairs are affected in a timely manner.	0		Gaps: ● Limited capacity for 24/7 operational support. Recommendations: ● Establish support help-desk operations ● train in service desk operations, and develop SOPs for management of queries

IT Specialists	supporting data ingestion, QA/QC functions, storage, and the flow of data and products to forecast models.	Same as that of Network Management planning specialists		Gaps: ● Limited number of specialists with sound knowledge of CDMS in use, CLIMSOFT; ● Limited programming for automation capacity; Recommendations: ● Training on CLIMSOFT and other CDMS; ● ICT trainings to support data integration, ingestion and other processes
Specialists /data scientist	analyse, interpret, and apply AWS information	0		Gaps: ● There are no established or assigned duties for this; Forecasters assume this duty in addition to their daily tasks ● Limited capacity to utilise available data analysis tools Recommendations: ● Training on CLIMSOFT and other CDMS; ● capacity building in the use of Climate Data Tool (CDT) and AWS Data Tool (ADT) of IRI University of Columbia ● Capacity building in statistical applications in climate
Engineers		See the number for Field technicians	-	Gaps: ● Limited access to WMO certified meteorological engineering/ basic instruments management courses ● No formal training in calibration of meteorological instruments ● lack of capacity to establish process approach to operations and management Recommendations: ● Capacity building trainings in installation, systematic O&M, calibration and quality management systems for effecting process approach to services

Managers	Manage the data acquisition and station infrastructure activities Administer and manage the whole ICT functions of the Institute Lead activities related to stations management and data acquisition at the regional levels	8 (including 4 Network Management planning specialists in row 1)	1- Ph D Natural Sciences in Climate Impact Research; 2- MSc Applied Meteorology and Climatology & BSc Physics; 3- MSc Applied Meteorology and Climate with Management/BSc in ICT; 4- MSc in Agrometeorology (2 officers); 3- Post Graduate Diploma (PGD) Met & BSc in IT 2 officers);(4- Adv Dip. Computing	Gaps: ● Weak institutional capacity to offer proper management training/ courses; ● Limited project management skills; ● Limited exposure to tailored meteorological management courses Recommendations: ● Access to meteorological management courses; ● Capacity building in project management; ● Access to WMO initiated management courses for climate services

4.4. Gender and Civil Society organisations (CSOs) considerations

DCCMS partners with most CSOs and NGOs linked to climate sensitive sectors in Malawi through the Civil Society Network on Climate Change especially in agriculture, disaster risk management and climate change adaptation. CSOs are among DCCMS key partners and these collaborations have been key in climate service delivery and dissemination. DCCMS in collaboration with MET Norway and the IMO held a SOFF stakeholders meeting in Lilongwe Malawi in September 2023. The meeting brought together different stakeholders including governmental ministries, UN agencies, foundations, regional knowledge-based institutions, NGOs, CSOs, private sector as well as academia across the meteorological value chain in Malawi. The aim was to facilitate dialogue and consultations that will promote future collaboration with DCCMS especially on sustainability of observation networks. The workshop was a good start to extend awareness of DCCMS activities and how these activities can be complemented. The meeting report[30] is provided. It is recommended that further consultative platforms which foster cooperative dialogue and engagements with CSOs be enhanced and on a regular basis to further improve partnerships that are beneficial for the sustainable operation of SOFF projects.

In this field of work in Malawi, there are still quite few females in scientific positions, as IT developers, climate researchers and meteorologists. The proportion of the staff working in different fields at DCCMS has a higher percentage of men (71%) than women (29%). While DCCMS encourages active participation of women in climate services, and has been working on improving participation when recruiting, the current gender disparity is rather obvious.

DCCMS should first conduct a gender assessment analysis to identify why there is a noticeable gender disparity, thereafter commit to a progressive effort in mainstreaming gender. This will facilitate establishment of a gender policy with affirmative actions to bridge the gap between female and male staff.

DCCMS should also as much as possible try to to comply with actions provided in the WMO gender action plan[31] in the SOFF project groups.

[30] Report Soff-Malawi Stakeholder Consultation Workshop_18sept2023
[31] WMO Gender Action Plan

For SOFF implementation, DCCMS should adopt the SOFF gender action plan that requires all the GBON National Contribution Plans to include gender considerations to promote gender equality and empowerment. In the Investment Phase, DCCMS and the implementing team are expected to have 50% participation of women in capacity building activities and 50% participation of women in consultations with CSOs. The following activities during SOFF implementation in DCCMS as recommended by SOFF are provided in table 4.

Table 4: Gender considerations for SOFF activities in DCCMS

Activity	Indicator
Deliver capacity building activities on gender-sensitive topics in the context of SOFF operations	Report on technical capacity building workshop at DCCMS on gender sensitive topics to mainstream the government strategies and development plans on gender concerns
Conduct a gender assessment analysis as part of the human capacity assessment (including areas as gender discrimination, harassment, gender balance etc.) and provide recommendations accordingly.	Reports on the gender assessment analysis, highlighting findings and recommendation on affirmative action to bridge the gap where necessary
Organise stakeholder engagement workshops/consultations including, where possible, civil society organisations (CSOs) focused on women's empowerment	Further stakeholders' engagement activities that involve CSOs focused on women' empowerment recommended in the National Contribution Plan ● Through the SOFF project, DCCMS has already held a stakeholder workshop in collaboration with MET Norway and IMO.
Promote gender equality by establishing minimum thresholds for female participation in SOFF-related activities	Ideally, women should represent at least ● 50 %[32] of all participants in SOFF-related and supported trainings ● 50 % of all participants in SOFF consultations, planning workshops, etc. ● 50 % of staff for operating and maintaining GBON stations ● 50 % of decision-making and project management positions where applicable DCCMS should set up an affirmative action plan with progressive effort in mainstreaming gender balance hence increasing women representation. .

In all of the training activities, DCCMS state that women will be given priority.

[32] In cases where it is not possible to meet this threshold a strong justification should be provided.

Module 5. Risk Management Framework

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

Table 5: Operational Risks of SOFF Malawi

Operational risks	Analysis of risks	Actions for mitigating the risks	Monitor and evaluate risks following implementation of mitigation actions
Infrastructure challenges	Includes in-house infrastructure, unstable power supply, operational vehicles, unstable internet connectivity, vandalism of monitoring equipment **Risk level is high.**	Lobbying for acquisition of new infrastructure, vehicles; Raising awareness on the safeguarding of meteorological equipment at communities around installation sites; Adopt alternative energy sources Public-private partnership for sustaining good status of infrastructure Enhance security measures at installation and monitoring sites	Maintain records of interventions and their impacts
Human capacity	High turnover of competent staff through mainly retirements and pursuing greener pastures **Risk level is medium.**	Advocate for recruitment of more officers; Provide for good working environment at meteorological offices; Develop and implement staff development training plan;	Monitor progress in the execution of deliberate interventions for improving work environment and staff morale

		Champion and encourage innovation in services delivery	
Land ownership	In the past there have been problems with accessing land areas for meteorological observing stations. There is a risk of stations being removed. **Risk level is low.**	Pursue the use government institutions to host systems; Have MOUs/ agreements with the host institutions;	Records of MOUs signed; Sites with enhance sec
Securing proper site for establishing new stations	Specifically in big cities where there are no old stations, securing the required size of site may be a problem. Or getting a piece of land for establishing a station may take a long time. **Risk level is low.**	DCCMS may acquire land for new stations through coordination with the Ministry of Lands which is responsible for all land under government operations	Review based on planned station expansion and progress reports
High turnover of new and advanced technologies	As advancement of technology an advantage that have positive consequences in achieving the desired goals but could not be handled without properly training on the use staff on the use of the new technology **Risk level is medium.**	Allocate budget Continuous upgrading training of staff at DCCMS on emerging technologies Undertake targeted capacity building activities. Recruitment of international consultants	Follow up on the usage of new technologies by trained experts

Module 6. Transition to SOFF investment phase

This module involves supporting the beneficiary country and the IE in preparing the Investment phase funding request based on the recommendations provided in the Plan.
Please provide any additional recommendation relevant for the translation of the National Contribution Plan into an Investment Phase Funding Request.

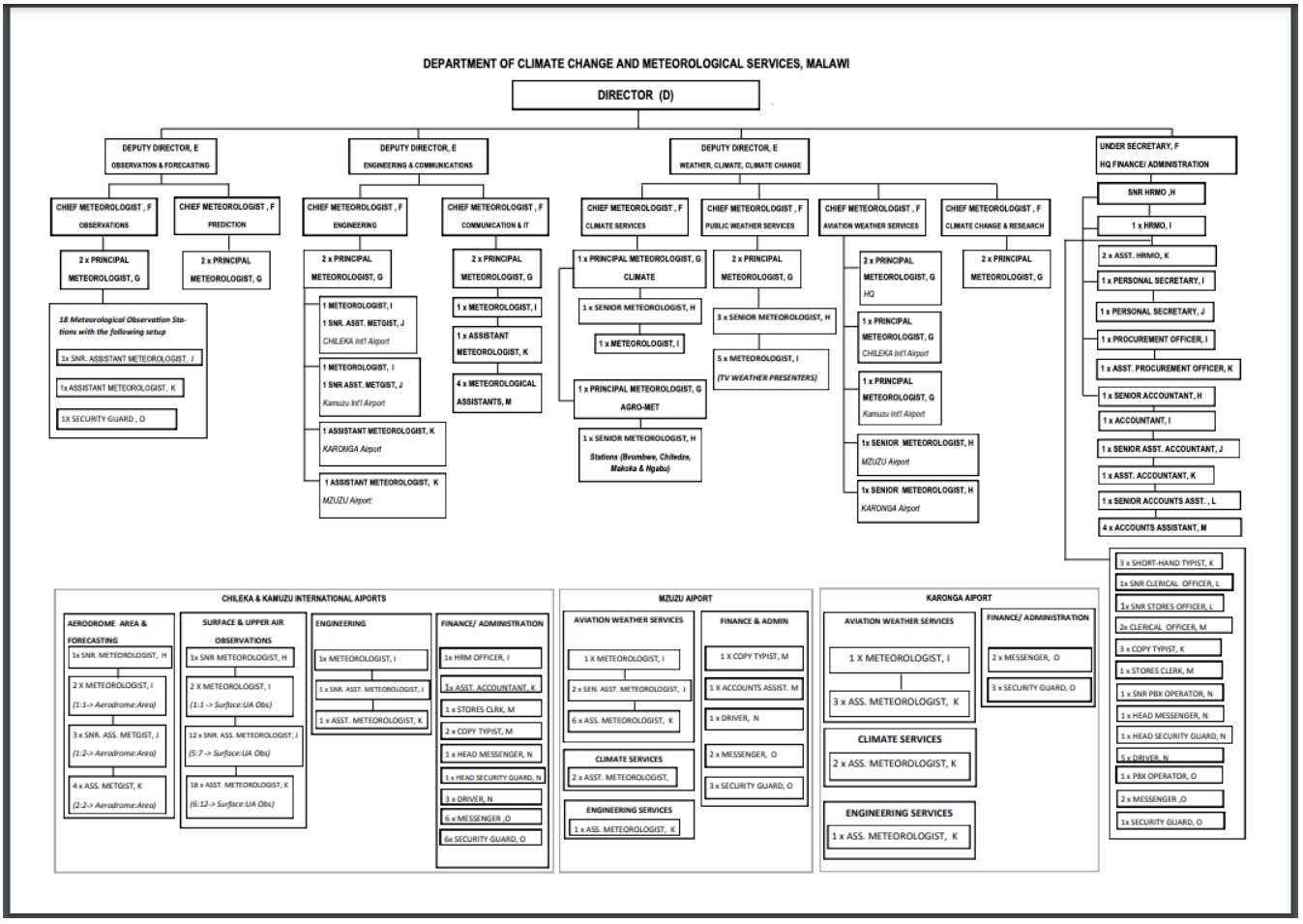
Summary of GBON National Contribution Plan

Components	Recommended activities
Module 2. GBON business model and institutional development	1. Establish formal partnership and collaboration with existing governmental and private institutions and strategise ways to develop and foster sustainable cooperation with the recommended potential partners.
	2. Explore sub-regional dialogues and co-ordinations with Tanzania, Zambia and Mozambique for resource optimisation during SOFF investment phase - Foster regional approaches
	3. Explore new partnership through continuous stakeholder engagement to build collaboration with sustained third-party funding for the sustainability of operation of the observation networks.
	4. Finalise the already drafted DCCMS Strategic plan, which has to be better integrated with other important national and international efforts and programs.
	5. Fast track the enactment and implementation of the Meteorological Act for meteorological services that is currently under review. An updated National Climate Change Management Policy (2016) and the National Meteorological Policy(NMP) (2019) should also be of priority.
Module 3. GBON infrastructure development	1. Based on Malawi's GBON Gap Analysis and this report, the foundation for capacity development should be prioritised throughout network design and planning, particularly for the upper air observation network.
	2. Ensure that the budget allocated to the ICT infrastructure during SOFF will be sustainable throughout the lifespan of the network. Emphasis is needed on human capacity development.
	3. Prioritise capacity development during SOFF for effective functionality of the data management system; including setting up components requirements for a reliable IT infrastructure for sustaining increased data processing and data management capabilities are critical for DCCMS and the sustainability of SOFF projects.
	4. Explore the proposed recommendation on environmental and sustainability. This requires multiple stakeholders engagement through the entire value chain from observing network procurement and management.
Module 4. GBON human capacity development	1. 2. 3. Create a capacity development plan with regards to the analysed human capacity gaps and recommendation provided for DCCMS. This is possible through sufficient funding both to increase manpower and capacity development through training and benchmarking programs as identified. Lobbying for more government funding to supplement the SOFF investment funding phase by increasing the internal training budget,

	including exploring other sources through regional and international collaborations to cover training expenses.
	4.The SOFF stakeholder workshop was a good start to extend awareness of DCCMS activities to governmental partners as well as CSO. Further stakeholder engagement workshops/consultations with civil society organisations (CSOs) focused on women's empowerment should be fostered.
Module 5. Risk Management	Action plan for mitigating the identified operational risks at DCCMS will be best achieved through co-operations and collaborations. This plan needs to be included in DCCMS' strategic planning
Module 6. Transition to SOFF investment phase	The implementing entity, peer advisers, and beneficiary have submitted a SOFF investment funding request for the implementation phase. The request includes recommendations and activities from the GBON National Contribution Plan and Gap Analysis Report.

Annexes

1. Meteorological Data Policy In Malawi.pdf
2. SOFF Expenditure Estimate for Malawi.pdf
3. DCCMS Strategic Plan 2017-2022 Main Document.Pdf
4. Proposed GBON Surface Land Stations.pdf
5. Malawi AWS Specifications.pdf
6. Report Soff-Malawi Stakeholder Consultation Workshop_18sept2023.pdf
7. DCCMS, full organogram (pr. September 2023)



Report completion signatures

Peer Advisor signature Oslo, 16.01.2024 
Beneficiary Country signature Blantyre, 17.01.2024 
WMO Technical Authority signature