

COUNTRY HYDROMET DIAGNOSTICS

Informing policy and investment decisions for high-quality weather forecasts, early warning systems, and climate information in developing countries.



April 2024

Zambia NMHS Peer Review Report

Reviewing Agency: Met Office

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World Food Programme

ZAMBIA METEOROLOGICAL DEPARTMENT

Met Office





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Authorisation for release of this report has been received from the Peer Reviewing Agency and the Country NMHS as of (02/04/2024).

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Executive Summary

Zambia is a large landlocked country in Southern Africa and experiences a tropical climate, moderated by its location and elevation. It has two seasons, a rainy season between November and April and a dry season between May and October. The main environmental hazards affecting the country are flooding and drought. A large proportion of the population are highly vulnerable to these hazards, so having improved awarenesses to the risks is an essential mitigating factor.

The Zambia Meteorological Department (ZMD) are a well-established and well led National Meteorological Service (NMS) in Southern Africa, members of the World Meteorological Organisation (WMO) and the Meteorological Association of Southern Africa (MASA). They are mandated to provide aviation services, and beyond that, the legislation is pending approval by Parliament.

The government budget allocation to ZMD is sufficient for covering day-to-day staffing costs and doesn't allow for development and growth of the staff, infrastructure and service. This is left to donor funded projects that only partially deliver to the needs of ZMD. Often, they overlap and leave development gaps, and frequently leave a legacy of burden for the ZMD leadership.

A high priority recommendation is to provide support to ZMD to strengthen their links with government. Support the adoption of the Meteorological Bill in Parliament, to provide a clear mandate and budget support for ZMD to provide essential weather and climate services for the nation. To support ZMD develop their evidence base of the value and benefits they can bring to the nation. The evidence should include a socio-economic benefit analysis of ZMD for now and the potential and highlight the cost benefit of forecast based early action. The ZMD Strategic Plan should be updated and presented to government. This plan will guide other proposed recommendations. These include the modernisation of existing section, such as observations networks, forecasting, climatology and applied services. In addition, it's proposed to develop the stakeholder relationship function at ZMD, to allow full-time support to external facing activities, such as public, government, private sector and donor engagement.

Adoption of these recommendations will support ZMD develop and become a stronger, more beneficial, valued and recognised institution of the government of Zambia.

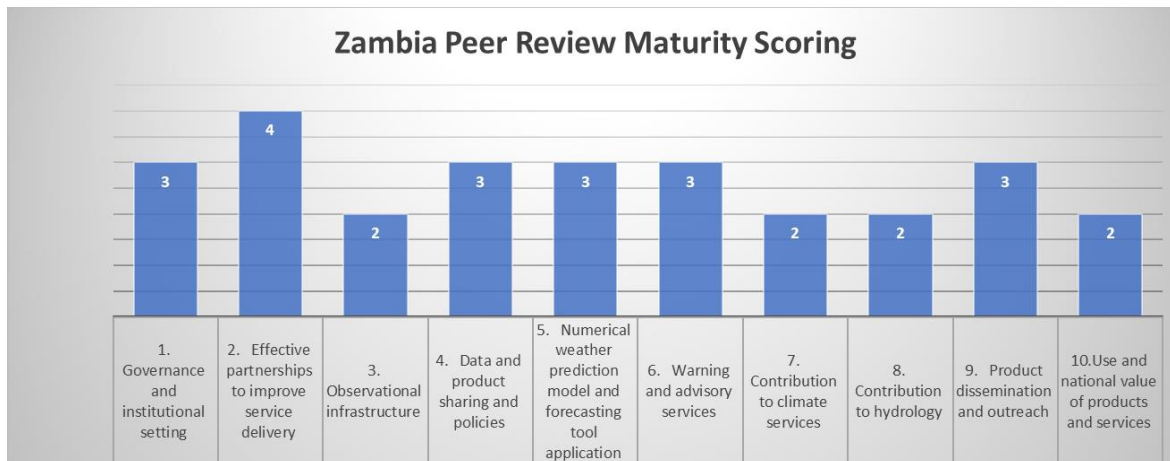


Fig 1: Summary of Maturity Level Assessment of Zambia Meteorology Department

Element	Maturity level score
1. Governance and institutional setting	3
2. Effective partnerships to improve service delivery	4
3. Observational infrastructure	2
4. Data and product sharing and policies	3
5. Numerical weather prediction model and forecasting tool application	3
6. Warning and advisory services	3
7. Contribution to climate services	2
8. Contribution to hydrology	2
9. Product dissemination and outreach	3
10. Use and national value of products and services	2

Table 1: Summary of Maturity Level Assessment of Zambia Meteorology Department as in Fig 1 above.

Chapter 1: General information

Introduction

Zambia is a landlocked country in south-central Africa, surrounded by seven other countries: Angola, Democratic Republic of the Congo, Malawi, Mozambique, Namibia, Tanzania, Zimbabwe and Botswana (Figure 2). It has a total of 5664 Km of land boundaries. The 752,618 km² of land is mostly high plateau with some hills and mountains. The country has four valleys, the Zambezi, the Kafue, the Luangwa, and the Luapula. The highest point is Mafinga Central at 2339 m above sea level, and the lowest point is the Zambezi River at 329 m. Lake Kariba, the second largest manmade lake in the world, stretches along the southeast border of the country.

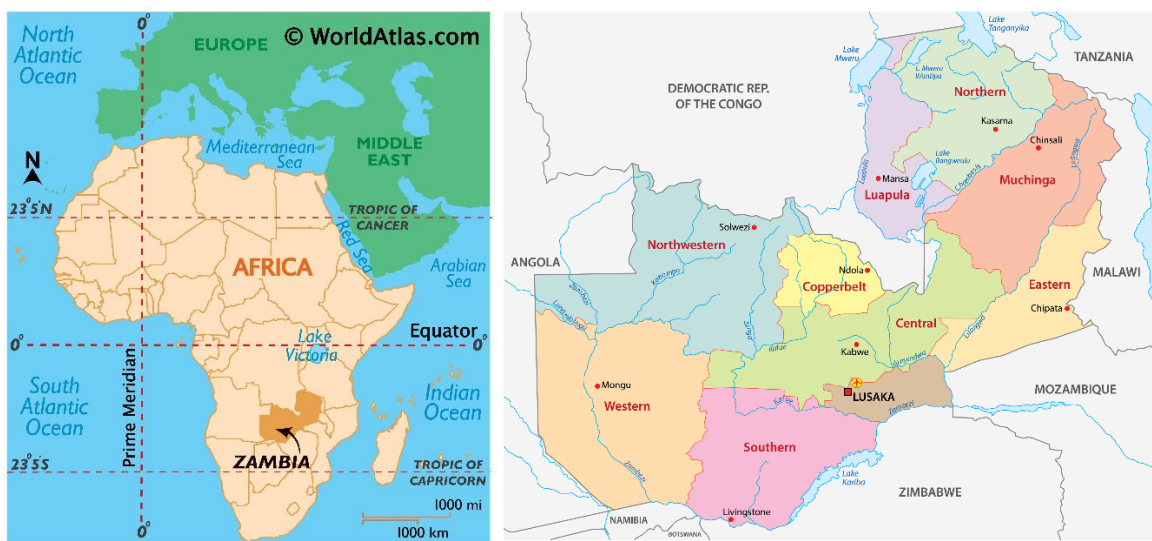


Fig 2.1: Map showing Zambia as part of Africa and a country map. Both © 2024 worldatlas.com

Zambia experiences a sub-tropical climate with three major seasons. It has a cool dry season from April to August, a hot dry season from August to November, and a warm wet season from November to April. Rainfall is largely influenced by the movement of the Intertropical Convergence zone as well as the El Niño Southern Oscillation (ENSO). El Niño conditions (warm phase) brings drier than average conditions in the wet summer months (December-February) in the south of the country, whilst the north of the country simultaneously experiences significantly wetter than average conditions. The reverse pattern occurs with La Niña (cold phase). The maximum temperature is experienced during November, and the maximum rainfall is received during December. The annual rainfall is 700 mm in southern parts, and 1,400 mm in the northern parts (World Bank 2021).

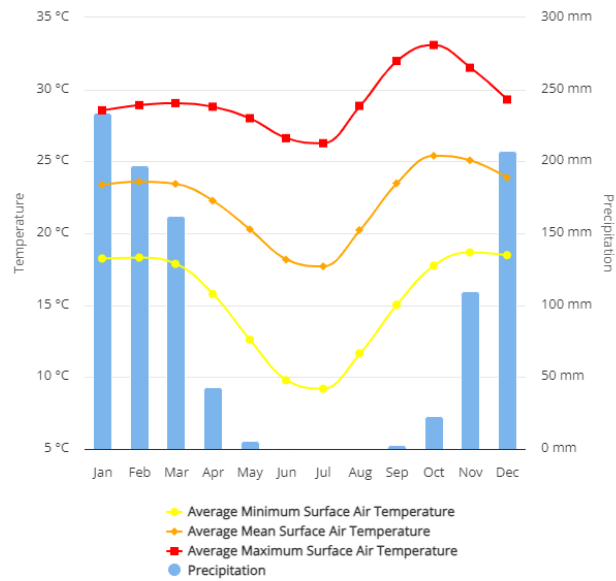


Fig 2.2: Monthly Climatology of average minimum surface air temperature, average mean surface air temperature, average maximum surface air temperature and precipitation 1991-2020; Zambia. (World Bank, 2021)

Zambia is considered to be vulnerable to climate change because the majority of its population rely on agriculture for their livelihoods. Climate research projects that Zambia’s temperatures will increase by 1.82°C and rainfall will reduce by 0.87% by 2050 (Ngoma et al, 2021).

CHD methodology

The approach taken has followed the Country Hydromet Diagnostics (2022) methodology. A desk review was undertaken, utilising information from the Zambia Meteorological Department (ZMD). An in-country visit was also undertaken for direct discussions with ZMD and for inspection of observation sites. These discussions were subsequently followed up via email as necessary.

Chapter 2: Country Hydromet Diagnostics

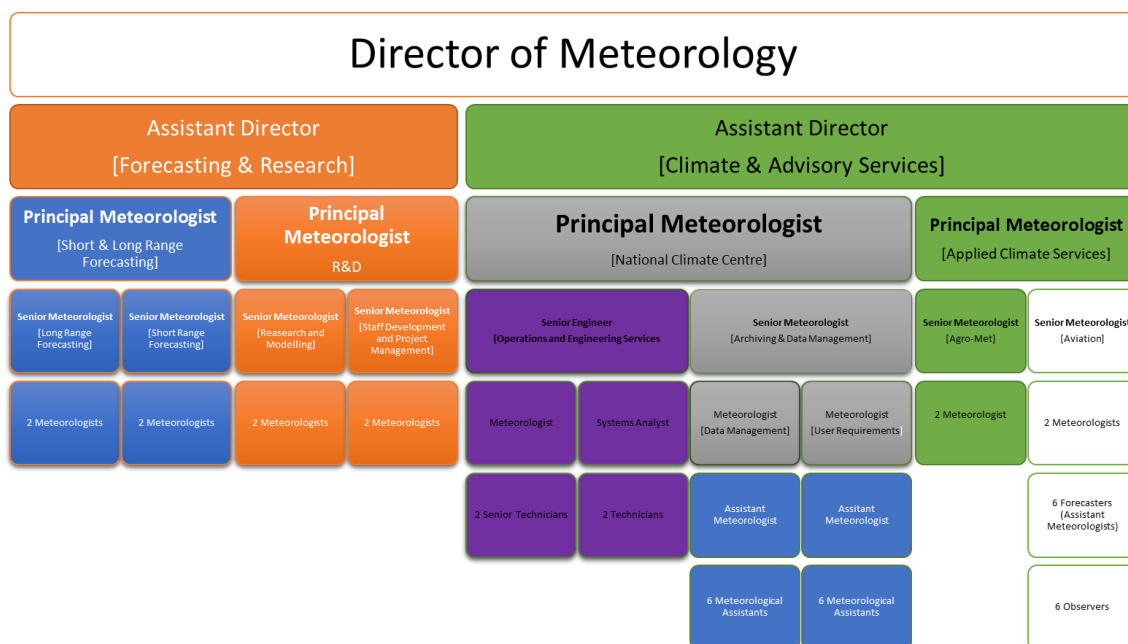
Element 1: Governance and institutional setting

1.1 Existence of Act or Policy describing the NMHS legal mandate and its scope

The Zambia Meteorological Department (ZMD) is a department of the Ministry of Green Economy and Environment.

The Ministry of Green Economy and Environment is mandated to promote the effective and sustainable use of the environment, while at the same time, facilitating support for adaptation to, and mitigation of the effects of climate change.

As a part of this ministry, the role of ZMD is to produce and disseminate weather and climatic information to the aviation, agriculture and other sectors in order to facilitate informed decision making. Their structure (as of 2023) is shown below.



The Department performs the following specific functions:

- Generate and disseminate meteorological information to stakeholders and the Public
- Establish, upgrade and maintain meteorological stations countrywide
- Collaborate with various stakeholders on meteorological matters
- Undertake research in meteorology and related matters
- Facilitate the domestication and implementation of international, regional treaties and protocols on meteorology matters
- Sensitize and educate the public on meteorological matters

ZMD has three department units:

1. Forecasting Unit

This unit is responsible for: -

- Conducting research on Zambian weather and climate and coordinate with relevant institutions at home and abroad;
- Analysing current weather scenarios;
- Collecting and disseminating maritime weather, information and products.
- Coordinating and managing the operations of surface, upper air and maritime observations to ensure high quality observatories data.

2. Climatology and Advisory Services Unit

The functions of this Section are: –

- To process and analyse climatic data publications and archive/store them.
- To collect, process and analyse rainfall data and provide hydrological analysis and advise for other resources management.
- To collect, process and analyse radiation, seismological and background air pollution data.

3. Engineering and Computer Services Unit

This is a technical Unit responsible for: –

- Installing, repairing, and maintaining instruments and equipment meteorological instruments and equipment.
- Calibrating meteorological instruments and equipment.
- For computer services in the Department.

ZMD have a formal policy in place and there’s a Meteorological Bill going through Parliament (see [Annex 4](#)).

1.2 Existence of Strategic, Operational and Risk Management plans and their reporting as part of oversight and management.

ZMD have a Strategic Plan in place for 2019 – 2024 (see [Annex 4](#)) and are revising this plan for future years. The plan has 6 Strategic Objectives (see table below) with the full strategies outlined in the Strategic Plan.

Goal	Strategic Objective
Improved quality of weather and climate information, products and early warnings	To enhance the resilience of citizens, institutions, and economy to severe weather and climate extreme events associated with climate change by providing diverse, timely, accurate and high-quality weather and climate services to support decision-making to address the impacts.
Improved access to services	To make it easy for citizens, institutions and the media to access services on time.
Improved relevance of services	To improve the ability of users to integrate weather and climate information into decision making to enhance their resilience to climate change and climate variability.

Enhanced partnerships	To improve the involvement of stakeholders in the development of user-oriented services, resource mobilisation and provision of feedback.
Enhanced resource mobilization	To enhance investment in meteorological services to improve infrastructure and human resources needed to provide high-quality weather and climate services.
Zambia Meteorological Department is transformed into an Authority	To transform Zambia Meteorological Department into an Authority with a responsive management and operational structure capable of providing high-quality, accurate and timely meteorological products and services to all sectors and communities, and attract investments.

ZMD also have an operating plan in place for 2019 – 2024 (see [Annex 4](#)) with 6 defined goals:

- Goal 1 - Improved quality of weather and climate information, products and early warnings
- Goal 2 – Improved access to services
- Goal 3 – Improved relevance of services
- Goal 4 – Enhanced partnerships
- Goal 5 – Enhanced resource mobilisation
- Goal 6 – Zambia Meteorological Department is transformed into an agency

1.3 Government budget allocation¹ consistently covers the needs of the NMHS in terms of its national, regional, and global responsibilities and based, among others, on cost-benefit analysis of the service. Evidence of sufficient staffing to cover core functions

The budget is allocated on a monthly basis, with specific funding lines and profiles, until the end of the year. The primary expenditures follow a priority order:

- staff emoluments
- utilities
- equipment maintenance
- staff training
- quality management systems (QMS).

While the budget adequately covers the available staff positions, the staffing levels fall short in meeting the increased demand for services and infrastructure.

Unfortunately, the funding does not fully meet ZMD’s needs, preventing it from functioning at its fullest capacity and acquiring necessary equipment.

1

https://www.parliament.gov.zm/sites/default/files/images/publication_docs/07%20Main%20Report%20Budget%202023%20%282%29.pdf

The budget prioritizes services related to departmental operations and equipment maintenance, but these allocations are insufficient and not always released when needed.

Additionally, donors supplement activities based on their ultimate goals and operate within their defined areas of interest. Consequently, securing comprehensive support for the department's nationwide operations becomes challenging.

There has been more than a 20% increase in funding since ZMD moved from Ministry of Transport and Communication to the Ministry of Green Economy and Environment. There is also likely to be increased support to strengthen provision of meteorological services arising from the current drought conditions where the lowest rainfall on record has been observed over the southern half of the country adversely impacting key economic sectors on Zambia including, agriculture, water, energy and health among others.

1.4 Proportion of staff (availability of in-house, seconded, contracted- out) with adequate training in relevant disciplines, including scientific, technical, and information and communication technologies (ICT). Institutional and policy arrangements in-country to support training needs of NMHS.

ZMD staff has a diverse range of educational qualifications. The majority (58%) hold certificates, while 20% have earned degrees, and 10% have obtained master's degrees.

The workforce is composed of 25% females and 75% males.

In terms of positions, they have:

- 1 Director
- 2 Assistant Directors
- 3 Principals
- 1 Senior Engineer
- 1 Systems Analyst
- 4 Senior Technicians in Telecom
- 7 Senior Meteorologists
- 23 Meteorologists
- 1 Agro-Meteorologist
- 23 Assistant Meteorologists
- 97 Meteorological Assistants
- 4 Radar Technicians

Access to internal training is somewhat limited due to resource availability. Government sponsorship, which is tied to allocated funds, can only accommodate up to 10 students. In the past, 10% of officers were able to attain diplomas through a specific project, and 5% of officers received ICT training.

1.5 Experience and track record in implementing internationally funded hydromet projects as well as research and development projects in general.

ZMD has been involved in several internationally funded projects over the past 5 years:

- TRALARD is a World Bank project in Luapula, Northern, and Muchinga provinces. ZMD expands and modernizes observation stations. 120 AWS have been installed.
- SCRALA is a Green Climate Fund project to help smallholder farmers cope with climate change. ZMD installs 20 AWS and improves climate services for farmers.

- CRIIZ is a Germany GIZ project to provide better climate services and reduce climate risks.
- WISER ESA is a UK aid project to improve weather and climate information services. The project improves data quality and accessibility, increases user uptake and use, enhances provider capacity and capability, and strengthens regional and national coordination and collaboration.

Summary score and recommendations for Element 1

Zambia is assessed as **Maturity Level 3** on the CHD scale – ***Moderately well mandated, managed and resourced and clear plans for, and sufficient capacity to address operational gaps.***

The Zambia Meteorological Department (ZMD) are a well-established and well led National Meteorological Service (NMS) in Southern Africa and overachieve with the resources at their disposal. A high priority recommendation is to provide support to ZMD to strengthen their links with government. Support the adoption of the Meteorological Bill in Parliament, to provide a clear mandate and budget support for ZMD to provide essential weather and climate services for the nation. In addition, it is recommended to review and modernise the current departments within the service and create/enhance the stakeholder function, as this is essential to achieving relevance and sustainability.

Element 2: Effective partnerships to improve service delivery

2.1. Effective partnerships for service delivery in place with other government institutions.

ZMD have well established and effective service delivery partnerships with many institutions and agencies, both nationally and internationally. International partnerships include, WMO, MASA, SADC-CSC, and others. The list below identifies the key national partners from government, private sector, and academia:

- Disaster Management and Mitigation Unit (DMMU)
- Ministry of Agriculture (MoA)
- Water Resources Management Authority (WARMA)
- Ministry of Energy
- ZESCO Limited
- Zambezi River Authority (ZRA)
- University of Zambia (UNZA)
- Copperbelt University (CBU)
- Mulungushi University (MU)

It is important for ZMD to get the correct legislative context to allow them to collaborate more effectively with the institutions listed above.

ZMD also works closely with the Zambia Civil Aviation Authority regarding the operation of both observation stations and provision of weather services at several airports around the country.

Another key government department that ZMD cooperates with is Defence. ZMD headquarters is located at Lusaka City Airport and manual observations here are already made by a team that is jointly managed by the Zambian Air Force.

2.2. Effective partnerships in place at the national and international level with the private sector, research centres and academia, including joint research and innovation projects.

ZMD has a multitude of partnerships at this level:

- Disaster Management and Mitigation Unit (DMMU) – ZMD provide guidance to DMMU at times of high-impact weather.
- Ministry of Agriculture (MoA) – ZMD provides agromet bulletins to MoA across several timescales, from day-to-day weather forecast, to seasonal predictions.
- Water Resources Management Authority (WARMA) – ZMD provides rainfall catchment data to WARMA.
- Ministry of Energy – ZMD provides rainfall data across several timescales to MoE.
- Universities of Leeds – ZMD are collaborating on WISER Africa.
- Oxford and Reading
- IRI Uni of Columbia – ENACTS interface.

- University of California (San Diego)
- Local Universities
- WMO SWFP (Flash flood guidance system)
- Negotiations with International seed companies
- Campbell Scientific for observations – ZMD are collaborating on the World Bank Funded TRALARD project.
- Insurance companies for weather-based insurance products.

2.3. Effective partnerships in place with international climate and development finance partners.

As noted above, ZMD has good partnerships with a range of international partners. Specific to climate and development finance partners are the following:

- World Meteorological Organisation, Systematic Observations Financing Facility (SOFF)
- World Bank, Transforming Landscapes for Resilience and Development (TRALARD)
- World Bank, Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA)
- UNDP Green Commodities Programme – Scaling up Climate Ambition (SCALA)
- Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL)
- World Food Programme, R4 Rural Resilience
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Digital Climate Service for Smallholder Farmers in Zambia (E-PICSA)

2.4. New or enhanced products, services or dissemination techniques or new uses or applications of existing products and services that culminated from these relationships.

A recent innovation for new products has been the IRI supported project “Enhanced National Climate Services (ENACTS) platform” that provides rainfall and temperature data every four (4) kilometres across the country, and data analysis and visualization services. These new products are mainly supporting the agriculture sector and have the potential to be adopted by other sectors, such as water management, health and energy.

Summary score, recommendations, and comments for Element 2

Zambia is assessed as **Maturity Level 4** on the CHD scale – ***Effective partnerships with equal status in most relationships and approaching relevant funding opportunities in a coordinated manner.***

We recommend that ZMD makes a formal arrangement with Zambia Air Force to utilise

the military staff that work with them at Lusaka City Airport in order to sustain the radiosonde launches at the frequency required by GBON.

ZMD are also exploring collaboration with the Zambia Metrology Agency, who may be able to provide instrument calibration facilities to support AWS operations.

It is also recommended that ZMD establish a MOU with WFP to provide logistical support for remote site visits as part of the SOFF investment and compliance phases.

As with the element 1 recommendations, the recommendation here is to strengthen the legislation with government, thus enabling greater collaboration, effectiveness and efficiency with other institutions, particularly national ones.

Element 3: Observational infrastructure

3.1. Average horizontal resolution in km of both synoptic surface and upper-air observations, including compliance with the Global Basic Observing Network (GBON) regulations.

The map in the figure below illustrates the GBON registered stations that are currently reporting data to the GTS. This map is taken from the WIGOS Data Quality Monitoring System (<https://wdqms.wmo.int/>) and reflects recorded, versus expected, pressure observations that were used by NWP monitoring centres on the 6 March 2024. There are 16-stations across Zambia that are currently reporting some observations. These are manual sites which are submitting three hourly synoptic reports whilst offices are open. This is reflected in the red dots as GBON is expecting hourly observations.

The proposed GBON network (captured within the SOFF Gap Analysis and National Contribution Plan) includes 21 stations which aligns to the horizontal 200km resolution required by GBON. The black dots on the map reflect the work that is being undertaken by Zambia Met Department to register Automatic Weather Stations that will replace the manual observations to form the GBON compliant network.

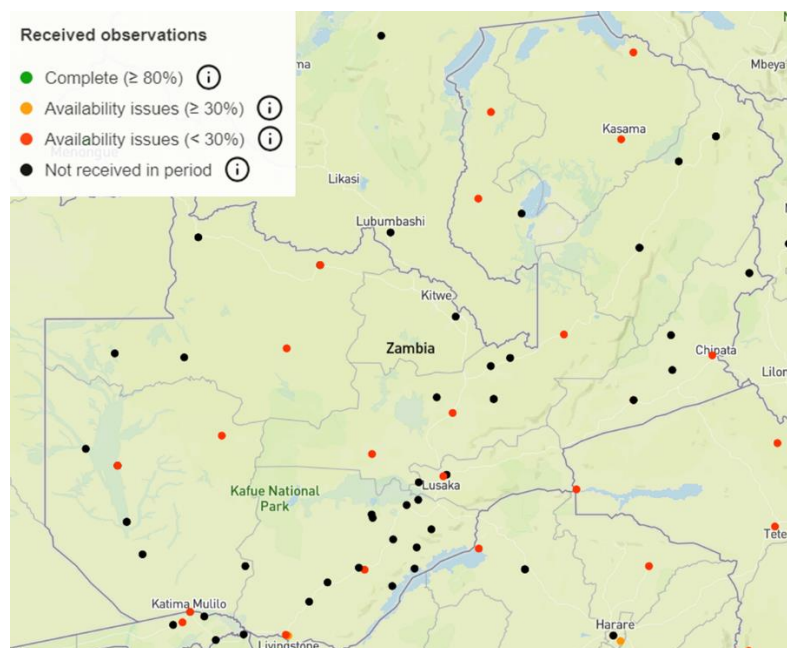


Figure 3.1: Zambia GBON Registered Stations recorded as reporting pressure observations on the WIGOS Data Quality Monitoring System 06/03/2024

Zambia currently has four upper air stations registered on GBON, none of these are active. The SOFF proposal, outlined in the National Contribution Plan, recommends initially establishing a single radiosonde station at the Zambia Met Department headquarters in Lusaka. Any further investment in radiosonde stations should follow the sustainable operation of this initial station for at least 2-years.

3.2. Additional observations used for nowcasting and specialized purposes.

Zambia is in the process of installing and commissioning a network of 120 Campbell Scientific Automatic Weather Stations through the World Bank funded TRALARD Project. This follows an investment in a further 30 Campbell Scientific stations that were installed under a previous UNDP funded SCRALA project. There is also another older network of AWSs that uses different technology.

This means that the challenge in Zambia is not associated with the availability of the observing hardware. However, the proliferation of AWSs across the country presents many challenges, not least in keeping the sites secure, maintained, calibrated and maintaining communications.

There is also a challenge in making the data from all of these AWS sites available for forecasting and climate purposes. Currently much of the data from these sites is being captured and successfully transmitted to headquarter, but the data is not being used operationally by forecasters or transferred into the Climate Data Management System (CDMS).

3.3. Standard Operating Practices in place for the deployment, maintenance, calibrations and quality assurance of the observational network.

Currently, much of the maintenance and quality assurance of the observing network in Zambia is ad-hoc and reactive. There is strong governance around the deployment of the AWSs under the TRALARD project, this is being coordinated through Campbell Scientific together with a second commercial delivery partner. The NCP proposes training and capacity development activities in order to establish SOPs for the installation, maintenance, calibration and quality assurance of the observational network. This includes the existing AWS sites that are being proposed for GBON as well as the proposed upper air station.

3.4 Implementation of sustainable newer approaches to observations.

The Campbell Scientific AWS network in Zambia is able to communicate the observation data via MQTT protocol to a [WIS2.0 in a box](#) as well as to ZMD Headquarters in Lusaka. This is illustrated in the figure below.

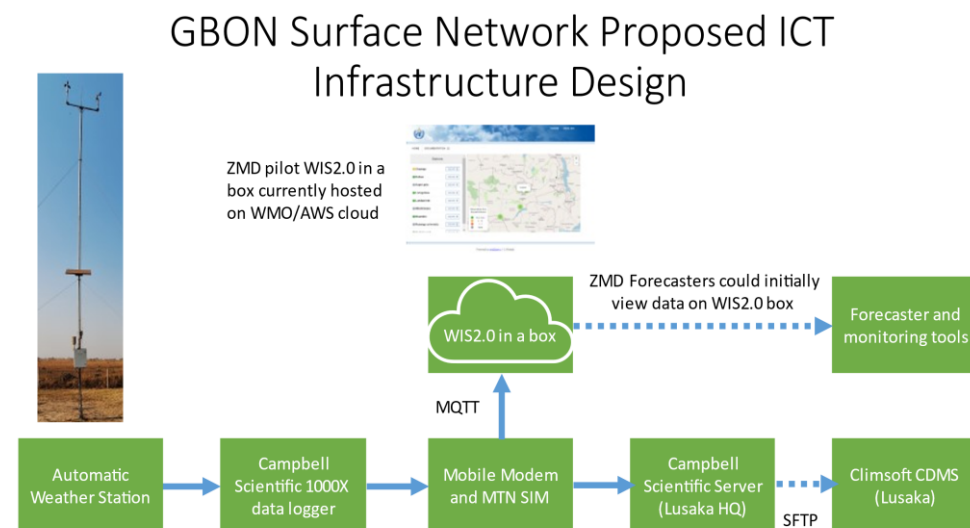


Figure 3.4a: Proposed GBON Surface Network ICT Design

The WIS2.0 in a box was developed in partnership with WMO as part of a pilot in 2023 and is currently hosted in the WMO AWS (Amazon Web Services) cloud. As WIS2.0 is not currently operational, this data is not yet finding its way to NWP centres and into WMO monitoring systems. The project team has made good progress in sharing the data with the WIS2.0 box. The figure below illustrates the data available on 07/03/24. Green dots indicate a number of stations that are routinely reporting 24 hours a day.

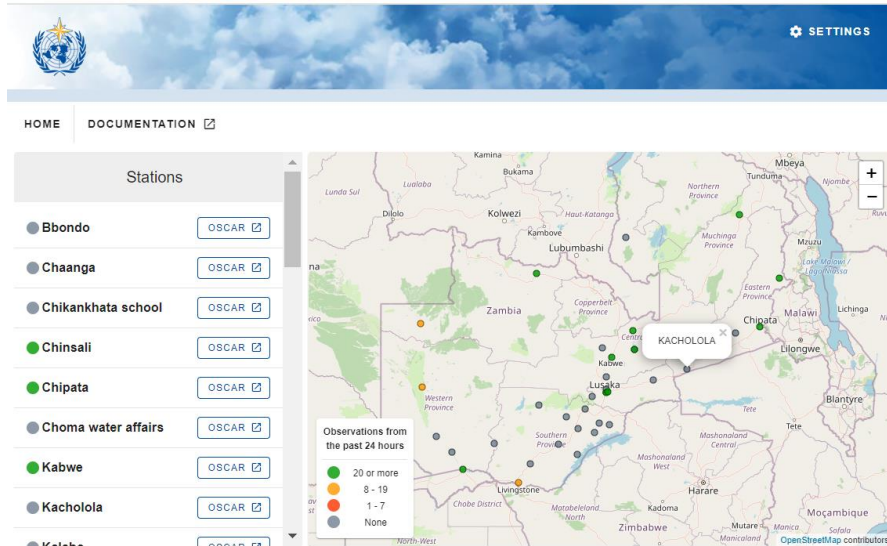


Figure 3.4b: Zambia WIS2.0 in a box pilot

This represents an innovative and potentially resilient IT architecture.

Data is passed to the WIS2.0 box as well as ZMD Headquarters via a mobile phone modem.

The data charges are affordable (approximately USD \$2 per month per site).

It is a resilient solution as there is no dependence on internet connectivity through a central hub. If Lusaka HQ is offline, individual stations can still report to WIS2.0.

This approach to data management needs to be supported, both through central investment in WIS2.0 capabilities, and IT support to ZMD in establishing and maintaining the data connections and cloud systems, as well as the required meta-data in WMO systems (such as OSCAR). For example, it doesn't really make sense that each met service through SOFF maintains its own WIS2.0 capability when this could be centralised or outsourced.

3.5. Percentage of the surface observations that depend on automatic techniques.

The percentage of observations that are currently reported to the WDQMS that are completely automatic is 0%, which is a result of the lack of data transmission and international data sharing as opposed to issues with the instruments themselves. However, this does not paint a fair picture of the progress being made by Zambia Meteorological Department. If the 150 Campbell Scientific AWSs that are being installed and connected across Zambia are taken into account, it is fair to say that 90% of the surface observations are automatic (150 AWS (150 AWS+16 Manual)).

Summary score, recommendations, and comments for Element 3

Zambia is assessed as **Maturity Level 2** on the CHD scale – **Basic network, large gaps, mostly manual observations with severe challenges and data quality issues.**

It is recommended that investment in Zambia for Surface Observations is focussed on how the observations can be maintained rather than the installation of any new equipment.

This includes establishing and implementing SOPs for maintenance, calibration and operation of the network.

Zambia has made excellent progress in establishing a high density network of more than 150 AWSs across the country. It is going to be a real challenge to sustain all of these stations. It is recommended that Zambia adopts a tiering approach to how it maintains its network, so that resources can be focussed on the 21 GBON sites, as well as other key locations such as airports and defence sites.

Zambia currently doesn't have any upper air sites. It is recommended that ZMD focus on establishing a single site at their headquarters in Lusaka and sustaining this for 2-3 years before consideration is given to establishing further sites elsewhere in the country.

An ongoing commercial partnership with the observation equipment suppliers is one way that ZMD can make sure that it is able to sustain the sites in the medium term. It is recommended that this is established and maintained for both surface and upper air stations (note that this is true for most SOFF countries).

The WIS2.0 in a box capability represents a significant opportunity for the transmission of observation data to the international community and Zambia has invested in making sure that new AWS sites are connecting to this capability. At the moment, this is only operating in pilot mode working in partnership with WMO. It is recommended that consideration is given to how this capability is properly operationalised and sustained. It doesn't make sense that this is done at an individual country level, so investment should be considered at a regional, or global level.

Element 4: Data and product sharing and policies

4.1. Percentage of GBON compliance – for how many prescribed surface and upper-air stations are observations exchanged internationally. Usage of regional WIGOS centres.

Currently Zambia is 11% GBON compliant but they are moving towards: 19 GBON stations have been initially identified, 16 of these regularly report to the Global Telecommunications System (out of roughly 150 observation sites). ZMD does cooperate with the Aviation Department regarding the operation of both observation stations and provision of weather services at several airports around the country. This includes sites where Automatic Weather Stations have been installed. These sites are favourable for selection as GBON stations where this is possible, as there is high security and good communication availability. Airport sites also tend to be well exposed.

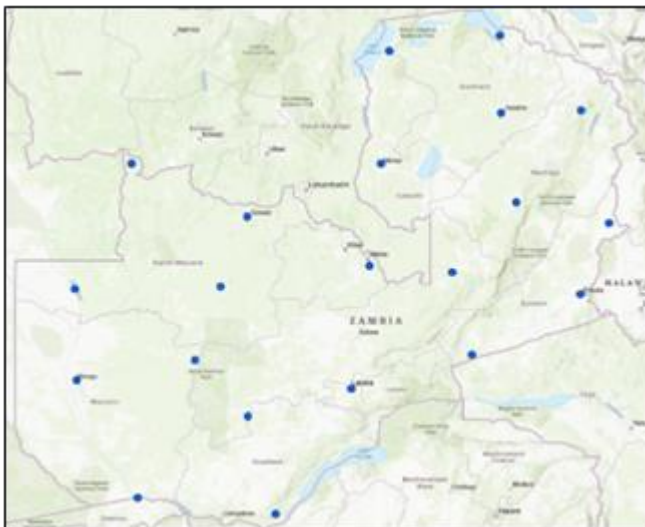


Figure 4.1: Proposed GBON Network in Zambia

Currently no upper air stations so 0% GBON compliant in that respect, however, ZMD headquarters is next to a Zambian Airforce site and manual observations are made here by a team that is jointly managed by the Zambian Airforce. Whilst it is recommended that GBON surface stations are AWS sites and not manual sites, so that the frequency requirements can be met, the military staff that are available here could be trained to conduct radiosonde launches. This initial station would give a horizontal resolution of approximately 900km and if the network is eventually extended to four stations in the future this would increase resolution at least 500km in line with GBON recommendations.

Zambia are not currently part of the WIGOS regional network.

4.2. A formal policy and practice for the free and open sharing of observational data.

ZMD's practice is to share all data, this is the culture of their organisation and not in a formal policy. Zambia as a WMO Member, participates in the global data sharing framework articulated by the WMO Unified Data Policy, including the free and open sharing of observational data. Discussions with ZMD staff suggested they would like to share observations more widely and use them to verify warnings in the future which the move to GBON will support.

4.3. Main data and products received from external sources in a national, regional and global context, such as model and satellite data.

ZMD receive data and products from various external sources. Observation data is received from other NMS and Institutions through the Automatic Message Switching System (AMSS) (Corobor System) linked to the Regional Telecommunication Hub in South Africa under the GTS. Other sources are through Eumetsat (EUMETCast) to the PUMA system and the Pilot briefing system, and through the MetOffice UK Secure FTP SADIS. Near real-time satellite images and products, NWP model output from a number of centres including the ECMWF, Met Office UK, Meteo-France, DWD, NCEP are also received through the PUMA EumetCast systems. In addition, the Regional Specialised Meteorological Centre (RSMC) portal delivered by the South Africa Weather Service (SAWS) as part of the Severe Weather Forecasting Program² which gives them access to the portal. This portal allows them a one stop area to look at model products from the South African models, ECMWF, Met Office models and probability forecasts. In addition, written guidance is offered on the portal for any likely areas of severe weather which ZMD can add local detail to and make further forecasts from.

ZMD also use the Met Office portal called African Web Viewer to access Global model data and African 4km data for the north of the country. ZMD have a Synergy puma 4.7 forecasting display system station which is not currently functional, likely due to software issues. However, ZMD can freely access the ECMWF website for EC data and other free source data to compare other models. They use EUMETSAT data from the website directly or ADAGUC to put together different layers of data. The ZMD forecasters are experienced in using different sources of data and making model comparisons.

Observation data is emailed around the forecasters from observations the day before and used to help make forecasts each morning from around 20 sites, probably those reporting regularly. Forecasters can also access observation data from OGIMET.

Summary score, recommendations, and comments for Element 4

Zambia is assessed as **Maturity Level 3** on the CHD scale – ***GBON data sharing compliance with regards to either surface or upper-air data and a data policy and practices and infrastructure in place that promote the free and open use of data for research and academic purposes as well as the in-house use of external data.***

The ZMD observation network is well managed and resourced, with plans for dealings with the operational gaps.

In order to move to the next maturity level ZMD could continue to move towards full GBON compliance with the installation of the new AWS systems and development of the reporting of observations in the Global Telecommunications System – see SOFF National Contribution Plan for ZMD.

An additional recommendation is that ZMD makes a formal arrangement with Zambia Air Force to utilise the military staff that work with them at Lusaka City Airport in order to sustain the radiosonde launches at the frequency required by GBON. Then plan further to increase the density of upper air observations.

As ZMD moves forward with AWS data it is recommended that an up-to-date visualisation system is considered to better display and use data.

² [Severe Weather Forecasting Programme \(SWFP\) | World Meteorological Organization \(wmo.int\)](#)

Element 5: Numerical model and forecasting tool application

5.1. Model and remote sensed products form the primary source for products across the different forecasting timescales.

ZMD produce Aviation forecasts and also a range of other forecasts, including seasonal rainfall forecasts, Agrometeorological Bulletins every 10 days, flash flood bulletins, daily forecasts and 7-day forecasts for the public. Forecasts are mainly communicated via WhatsApp and Facebook; a new Facebook account has recently been established and forecasts are more frequently being posted online since February 2024.

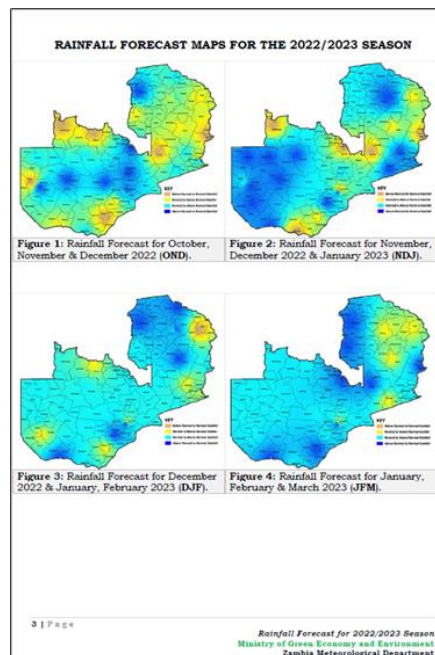


Figure 5.1a: Rainfall forecast maps for 2022/2023

ZMD have access to various global numerical models and the South Africa 4km resolutions model through public weather sites and portals which they use as the primary source for products. They have a Synergy puma 4.7 forecasting display system station which is not currently functional, likely due to software related issues. The model data they use is therefore mostly image data. They have access to Met Office Africa Viewer which displays UM Global model and Tropical Africa gridded data. They also have access to a WISER RSMC web portal displaying South African Model data, in addition the forecasters use NWP from ECMWF, NCEP, ARPEGE so that they can use model comparison techniques to help inform production of their forecasts. ZMD also use ensemble products viewed from ECMWF, SAWS and NCEP to make forecasting decisions.



The screenshot displays the RSMC Pretoria website interface. At the top, there are logos for WMO and the South African Weather Service, along with a search bar. The main content is organized into three columns:

- Left Column:** 'Guidance Products' section containing links for 'NWP & EPS Products' (Regional Models like UM_SA4_00 UTC, UM_SA4_12 UTC, Arome La Reunion, Met Office: Africa Web Viewer; Global Products like NOAA, ECMWF: EPS, Met Office: EPS, SAWS: EPS (NOAA); Training Website like Met-eLearning; SWFDP Training Nov 2012 (GDPFS, PWS); SWFDP Training Nov 2013 (GDPFS, PWS); SWFDP Training Nov 2014 (GDPFS, PWS)).
- Middle Column:** 'Guidance Products' section with 'Short-range (1-2 Days)' (Map Day 1, Map Day 2, Risk Tables, Discussion) and 'Medium-range (3-5 Days)' (Map Day 3, Map Day 4, Map Day 5, Prob Tables, Discussion). Below this is a 'SWFDP Evaluation Form' with a 'Click Here' link.
- Right Column:** 'Guidance Products' section with 'Flash Flood Guidance' (SARFFG Portal), 'Regional and International Centers' (ECMWF, NCEP, UK Met Office, WMO, RSMC - Reunion, ACMAD), 'SADC Countries' (SADC Countries National Meteorological Services), and 'Other Services and Products' (Short-range, Long-range (Seasonal)).

At the bottom of the middle column, there is a 'Nowcasting Products' section with two sub-sections: 'Satellite-Based Rainfall' (Hydro-Estimator Rainfall Totals for 1hr, 3hr, 6hr, 24hr; Hydro-Estimator Rainfall Totals In Days for 10 Days, 30 Days, 60 Days) and 'Convective Thunderstorm Forecasts' (Probability of Convective Thunderstorms with CII and Description of Product; Rapidly Developing Thunderstorms with RDT_SADC and Description of Product).

Figure 5.1b: Example of RSMC portal used by ZMD

Satellite data is primarily accessed from EUMETSAT and often Windy is used for Satellite loop imagery of IR data and ADAGUC is also used to visualise satellite data and verify forecasts.

ZMD recently took part in a EWSA Nowcasting testbed (February 2024) and are exploring ways of continuing a Nowcasting service in the future and are exploring how to develop this forecasting capability further including developing links with DMMU and delivering Impact Based forecasting nowcasts.

5.2. a) Models run internally (and sustainably), b) Data assimilation and verification performed, c) appropriateness of horizontal and vertical resolution.

WRF (3 variants), one uses data assimilation, and one uses data assimilation from NCEP. Horizontal resolution is 15 to 30km. No verification is done at the moment. WRF runs up to 5 days in forecast mode.

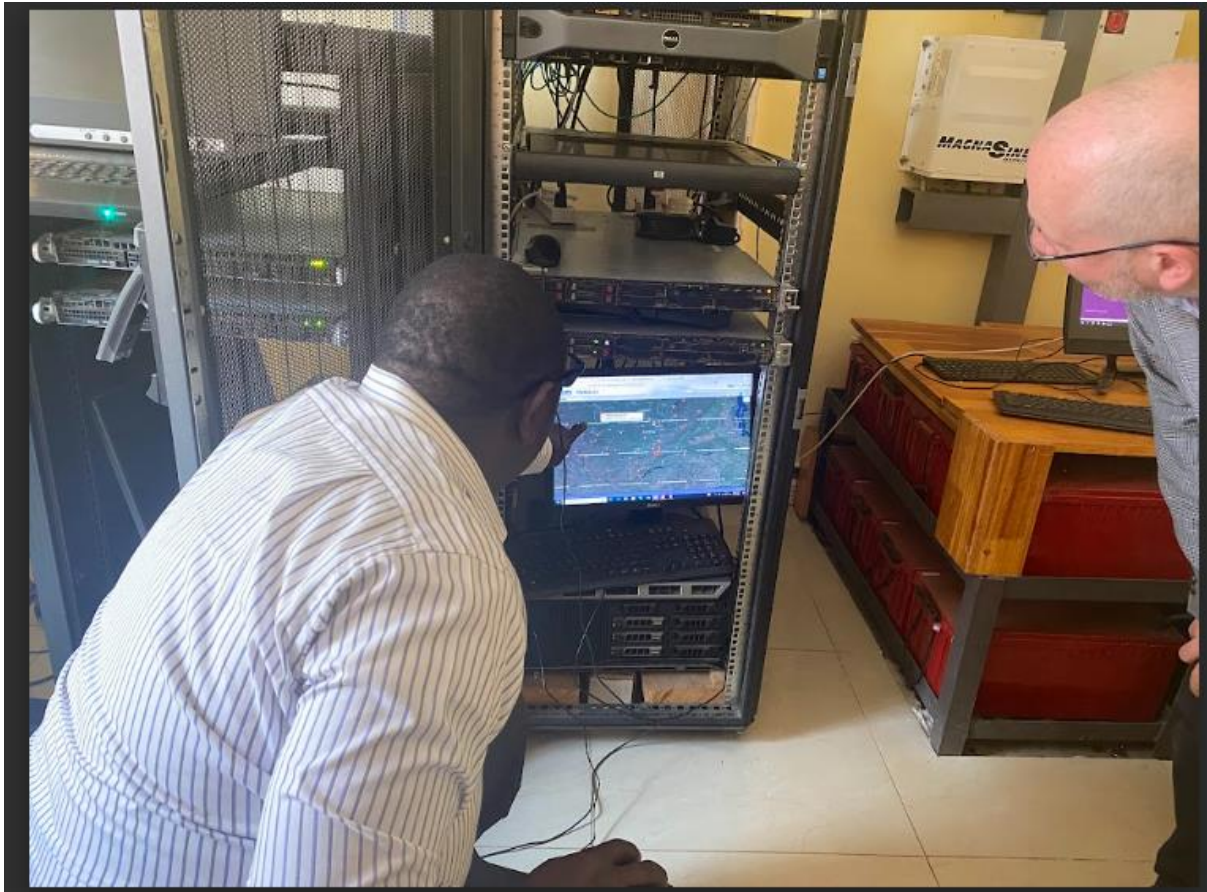


Figure 5.2a: WRF model

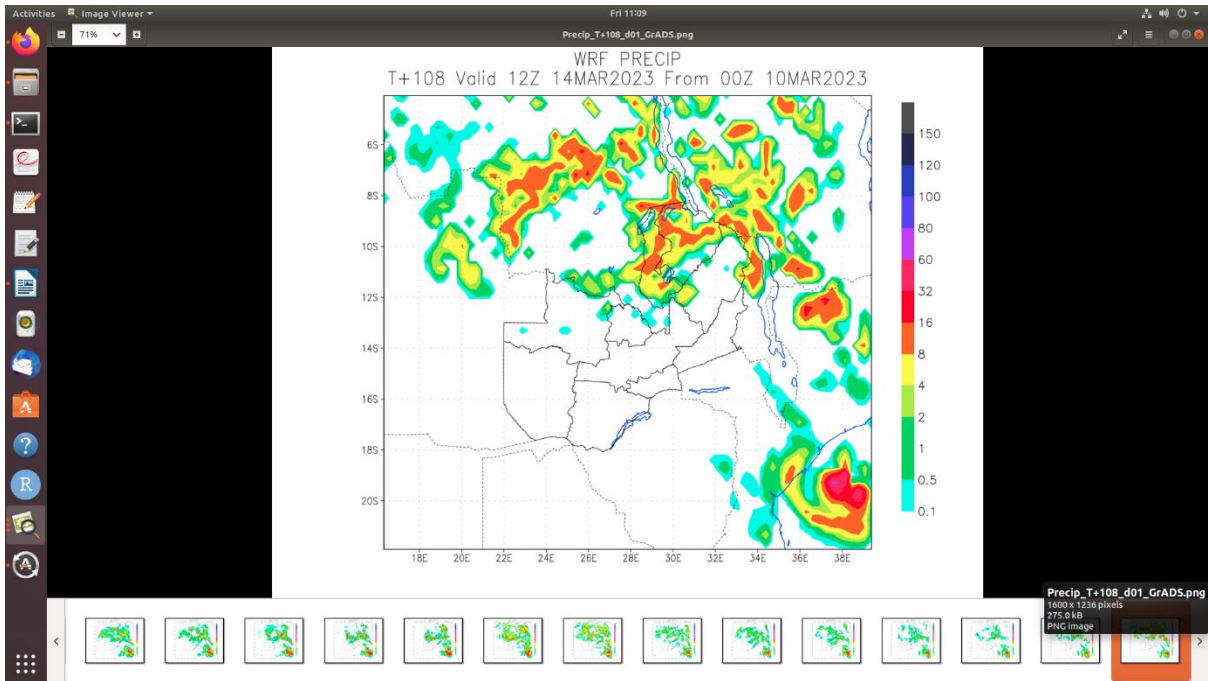


Figure 5.2b: Output from WRF model

5.3. Probabilistic forecasts produced and, if so, based on ensemble predictions.

Probabilistic forecasts are used in forecasting using NCEP and ECMWF ensemble predictions from their internet sites and also ensemble products that can be accessed through the SWFP portal (RSMC) including Met Office Mogreps products. (Probabilistic forecasts were produced in the recent Nowcasting testbed to deliver risk maps of heavy rainfall.) Ensembles are not produced locally.

Seasonal timescale products include probabilities.

Summary score, recommendations, and comments for Element 5

Zambia is assessed as **Maturity Level 3** on the CHD scale – **Prediction based mostly on model guidance from external and limited internal sources (without data assimilation) and remotely sensed products in the form of maps, figures and digital data and cover nowcasting, short and medium time ranges.**

Further development of internal systems and visualisation of model data internally would help ZMD advance their forecasting and more use of available probability products to assess risk of more severe outcomes in the forecasts.

Advancing IBF forecasting would be an enormous benefit to ZMD and continuing to develop nowcasting abilities would help deliver IBF forecasts to the public and government agencies. Developing methods of disseminating forecasts to those who need them would also help ZMD. Developing a legal framework and stakeholder relationships to oversee the provision of meteorological services would be of great benefit.

Element 6: Warning and advisory services

6.1. Warning and alert service cover 24/7.

ZMD has capacity to issue 24/7 warning and alert services and issue extreme weather warnings and share them with the Disaster Management and Mitigation Unit (DMMU); this is a formal arrangement, although limited interface with communities is acknowledged as a current challenge. The DMMU then consult with relevant sectors.

Warnings are issued for extreme weather (heat, cold, heavy rain, strong winds, thunder, etc) and disseminated to relevant stakeholders, including government agencies, media outlets, aviation authorities, agricultural departments, emergency management agencies, and the general public using appropriate communication channels, such as websites, social media, WhatsApp, press releases, and email distribution lists, to ensure widespread access to weather forecasts – for example, see figure 6.1. ZMD also issue aviation specific warnings to that sector. It has been highlighted that some private radio stations require payment for issuing warnings.

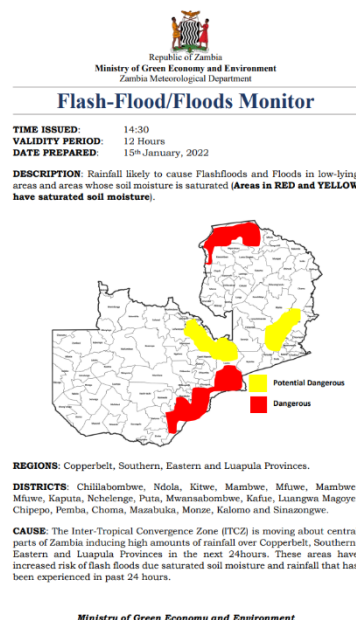


Figure 6.1: Flash flood guidance for Zambia

6.2. Hydrometeorological hazards for which forecasting and warning capacity is available and whether feedback and lessons learned are included to improve warnings.

Flash Flood warnings is the only hydrometeorological hazard with warning capacity available. SOPs are being developed with Water Resources Management Unit and DMMU in respect to warning protocols.

From the Standard Operating Procedure for Severe Weather Bulletins:

- Encourage feedback from users, stakeholders, and the public regarding the accuracy and usefulness of the weather forecasts.
- Periodically evaluate and review the SOP to identify areas for improvement and incorporate advancements in meteorological techniques and technologies.

- **Note:** The SOP should be regularly reviewed and updated to reflect changes in technology, procedures, or organizational requirements to ensure the effectiveness and efficiency of daily weather forecasting operations.

The EWSA Nowcasting Testbed held in February 2024 focussed on Nowcasting of rainfall and the ability to warn at short notice, however warnings were not disseminated publicly during the Testbed and further procedures would need to be developed.

6.3. Common alerting procedures in place based on impact-based services and scenarios taking hazard, exposure and vulnerability information into account and with registered alerting authorities.

The World Meteorological Organization (WMO) recognizes the Zambia Meteorological Department (ZMD) as the official alerting authority. The WMO's Permanent Representative (PR) for Zambia is responsible for maintaining the country's entries and registering all nationally recognized alerting authorities.

Here are the steps that ZMD has taken to implement the Common Alerting Protocol (CAP):

1. An initial training session was conducted with the assistance of a WMO expert. This session involved various stakeholders, including the Red Cross, the Disaster Management and Mitigation Unit (DMMU), and the Water Resource Management Authority (WARMA).
2. The WMO expert provided further training and guidance on implementing CAP for weather-related hazards.
3. The WMO's Permanent Representative, who is also the Director of ZMD, nominated individuals to compose and authorize messages. Their names and email addresses were submitted to the WMO.
4. The WMO issued passwords to these nominees, granting them access to the register of Alerting Authorities.
5. The WMO provided a CAP feed URL: <https://cap-sources.s3.amazonaws.com/zm-zmd-en/rss.xml>.
6. ZMD implemented CAP in early 2023.
7. The alerts are not yet live as they are awaiting authorization and guidance from the WMO.
8. ZMD has assisted DMMU and the Red Cross in registering as alerting institutions for other hazards. However, the nominees for composers and authorizers have not yet been submitted to ZMD.

Although the CAP format warnings have been implemented, Impact Based Warnings are not yet implemented and there are problems with the subscription for SMS services.

The Red Cross are managing a project with the DMMU and ZMD to introduce impact-based forecasting products.

Summary score, recommendations, and comments for Element 6

ZMD are assessed as being at **Maturity level 3** for this element - ***Weather related warning service with modest public reach and informal engagement with relevant institutions, including disaster management agencies.***

ZMD provides a good range of warning and alert services. The principles developed during the WISER Africa Nowcasting Testbed in collaboration with the WRM and DMMU will help work towards the next level of the maturity level tables. Improvements to warning dissemination and working on community engagement should also be considered. There is scope to improve these outputs, and the development of stronger links with government and its institutions would help. In particular, the further development of Impact-Based Early Warning Services requires strong collaboration between government institutions and the need for this should be correctly mandated by the government.

Element 7: Contribution to Climate Services

7.1. Where relevant, contribution to climate services according to the established capacity for the provision of climate services.

ZMD have not yet developed a National Framework for Climate Service (NFCS) with their government. The flooding and drought hazards regularly faced by Zambia, identify the clear need for this service to be established and the need for its co-development between ZMD and the relevant government institutions. This is another example of where a strengthening of formal links with government is essential. The Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) is aiming to establish an NFCS in Zambia.

Summary score, recommendations, and comments for Element 7

Zambia is assessed as being at **Maturity level 2** for this element - ***Essential Capacity for Climate Services Provision.***

There is a clear need for climate services in Zambia, defined by a NFCS. The strong recommendation is to support ZMD in providing the evidence to government of the specific details of the climate impacts already affecting the nation and the need for a climate service, so that preventative actions can be taken.

Element 8: Contribution to hydrology

8.1. Where relevant, standard products such as quantitative precipitation estimation and forecasts are produced on a routine basis according to the requirements of the hydrological community.

WARMA and ZMD are two government institutions that work together on water resources management and climate services in Zambia. WARMA stands for Water Resources Management Authority, and ZMD stands for Zambia Meteorological Department.

Some of the areas of collaboration between WARMA and ZMD are:

- Data sharing and quality control: WARMA and ZMD share hydrological and meteorological data to ensure accuracy and consistency. They also jointly operate and maintain some of the stations that collect the data.
- Product development and dissemination: WARMA and ZMD develop and disseminate tailored products and services that meet the needs of different stakeholders, such as farmers, fishers, and disaster managers. They also provide feedback and training to users on how to access and use the products and services.
- Project implementation and coordination: WARMA and ZMD are involved in several projects that aim to improve water resources management and climate services in Zambia, such as the SCRALA, CIEWS, and WISER ESA projects. They coordinate with each other and other partners to ensure effective and efficient delivery of the project activities and outcomes.

8.2. SOPs in place to formalize the relation between Met Service and Hydrology Agency, showing evidence that the whole value chain is addressed.

WARMA (Water Resources Management Authority) actively participated in the development process of Standard Operating Procedures (SOP). They currently possess copies of ZMD's SOPs, which guide them in delivering their services. The adherence to established procedures ensures efficient and consistent service provision.

8.3. Data sharing agreements (between local and national agencies, and across international borders as required) on hydrological data in place or under development.

The Zambia Meteorological Department (ZMD) has some hydrometeorology data sharing agreements with other agencies, such as:

- The Water Resources Management Authority (WARMA), which is responsible for regulating and managing water resources in Zambia, and collaborates with ZMD on hydrological data and services¹.
- The Zambezi River Authority (ZRA), which is a corporation jointly and equally owned by the governments of Zambia and Zimbabwe, and operates and maintains the Kariba Dam on the Zambezi River, and uses ZMD's data and services for water resources management and dam safety.
- The World Meteorological Organization (WMO), which is the United Nations specialized agency for meteorology, hydrology, and related sciences, and supports ZMD in implementing the WHYCOS project, which aims to standardize data sharing in hydrology.

8.4 Joint projects/initiatives with hydrological community designed to build hydrometeorological cooperation.

ZMD and WARMA (Water Resources Management Authority) are collaborating on two significant projects:

SCRALA Project (Strengthening Climate Services):

- The SCRALA project aims to enhance climate services.
- Hydro-meteorological equipment has been procured and installed at sites of mutual interest to both ZMD and WARMA. This joint effort ensures improved climate monitoring and prediction capabilities.

TRALARD Project (Transforming Landscapes for Resilience and Development):

- ZMD and WARMA are working together especially in identifying the gaps in the hydro meteorological network and development of specifications for observation infrastructure in TRALARD project.

These cooperative endeavours demonstrate the commitment of both organizations to enhancing climate resilience and sustainable water management in Zambia.

Summary score, recommendations, and comments for Element 8

Zambia is assessed as being at **Maturity level 2** for this element - ***Meteorological input in hydrology and water resource management happens on an ad hoc basis and or during times of disaster.***

Flooding in Zambia is one of the main hazard faced by the population, and having effective collaboration between these two disciplines is essential. Currently, there is minimal collaboration and so a clear need for improvement. There is a strong recommendation to strengthen the formal and operational contact between ZMD and WARMA, and for this to be correctly mandated in legislation.

Element 9: Product dissemination and outreach

9.1. Channels used for user-centred communication and ability to support those channels (for example, does the NMHS operate its own television, video or audio production facilities? Does it effectively use cutting-edge techniques?).

ZMD runs a video and audio production studio. It does not have its own television station. Instead, it maximizes its reach by collaborating with existing broadcasting networks (national and private TV stations) to disseminate information.

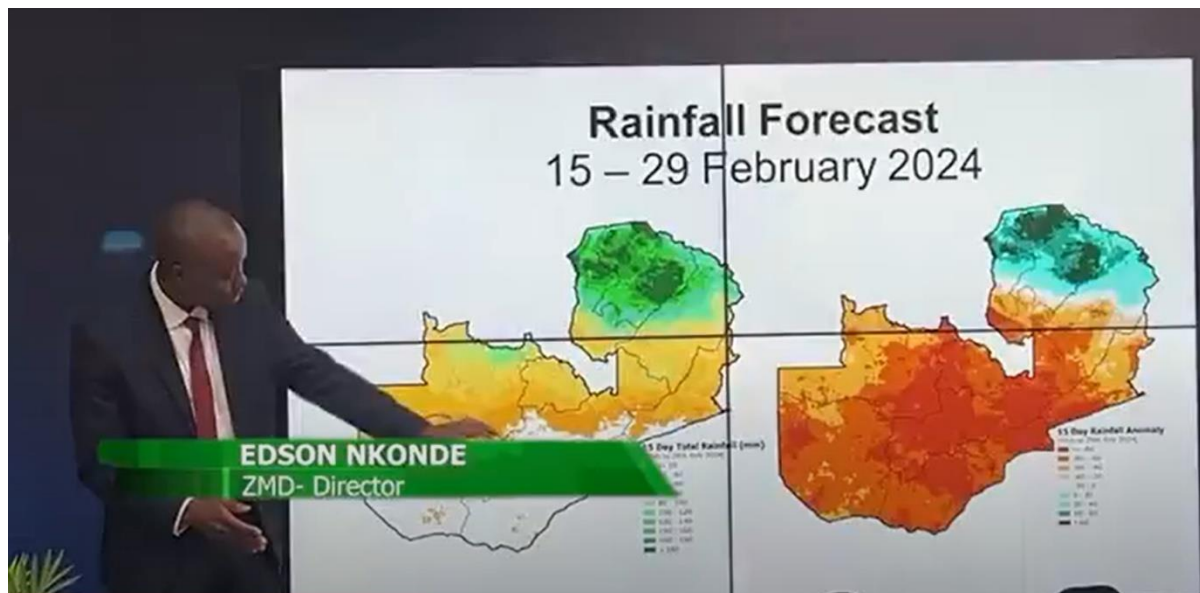


Figure 9.1: ZMD Director Edson Nkonde appears on 'Zambia Today' to inform about the weather forecast

The ZMD studio utilizes state-of-the-art equipment that was delivered by the UK Met Office under the WMO Voluntary Cooperation Programme (VCP). This ensures high-quality production standards.

ZMD maintains an active Facebook page where it shares weather-related information and updates with the public. Additionally, they engage with users through WhatsApp groups (10 groups with at least 500 people), fostering communication and knowledge exchange.

ZMD collaborates with over 20 Community Radio Stations to reach diverse audiences across the country. There is also a dedicated WhatsApp channel for Agriculture Extension Officers, facilitating information dissemination in rural areas.

9.2. Education and awareness initiatives in place.

The Zambia Meteorological Department (ZMD) actively promotes meteorological understanding through regular school visits, averaging two per week. ZMD introduces primary school pupils to meteorological instruments, provide secondary school geography students with in-depth meteorological insights, and support university students in their research by sharing climate data.

ZMD is also committed to enhancing the capabilities of Agriculture Camp Extension Officers.

They have successfully trained officers in 10 districts under the SCRALA project and plan to extend this training to five more districts in 2024. The training covers a range of topics,

including the influence of climate on crops, water balance concepts, packaging of soil water indices, and interpretation of the agro meteorological bulletin. This initiative contributes to sustainable agricultural practices and food security in the SCRALA project districts.

ZMD participates in annual agricultural shows and provincial expos, providing a platform to engage with farmers, stakeholders, and the public. These events highlight ZMD work, including the display of state-of-the-art meteorological instruments and technologies, presentation of comprehensive climate data, capacity building efforts, and real-world examples of how accurate climate information influences agricultural practices and food security. The attached image captures a pivotal moment during the training of Extension Officers for Kazungula and Gwembe Districts at Fairmount Hotel in Livingstone, Zambia, conducted in August 2022.

9.3. Special measures in place to reach marginalized communities and indigenous people.

The Zambia Meteorological Department recently conducted Testbed 1 of the Weather and Climate Information Services (WISER) Early Warning for Southern Africa (EWSA) project, led by the National Centre for Atmospheric Science and the University of Leeds. This project aims to transform access to weather early warning systems for marginalized communities in South Africa, Zambia, and Mozambique from 2023 to 2025. It supports the delivery of timely weather information to socially disadvantaged urban and marginalized populations, focusing on reducing storm-related damages. As part of this initiative, capacity for nowcasting was built, using real-time satellite images and other tools to predict weather conditions within the next 0-6 hours. The strategic approach involves hosting testbeds to assess existing weather services and establish new, user-tailored services. The WISER EWSA project is dedicated to advancing weather services and fostering capacity development in nowcasting for effective decision-making.

The Zambia Meteorological Department has initiated the Digital Participatory Integrated Climate Services for Agriculture (E-PICSA) program to empower farmers in marginalized communities. E-PICSA targets agricultural communities and aims to enhance their decision-making and improve agricultural practices by providing precise climate and weather data.

These initiatives highlight the Zambia Meteorological Department's commitment to serving marginalized populations through improved weather services and informed decision-making.

Summary score, recommendations, and comments for Element 9

Zambia is assessed as being at **Maturity level 3** for this element - ***A moderately effective communication and dissemination strategy and practices are in place, based only on in house capabilities and supported by user friendly website.***

ZMD utilises several communication channels but more needs to be done to gather feedback on how many people are being reached and if / how they are responding to the information and utilising the information. The recommendation is to capacitate the stakeholder relationship function at ZMD to manage the product and service development process.

Element 10: Use and national value of products and services

10.1. Formalized platform to engage with users in order to co-design improved services.

ZMD conducts and annual questionnaire surveys with its stakeholders, a quarterly aviation questionnaire, and annual seasonal and agromet forecasts at relevant events and in person. There is no formal mechanism for this feedback to influence products and services.

10.2. Independent user satisfaction surveys are conducted, and the results used to inform service improvement.

ZMD conducts user satisfaction surveys at the rainy season forecast dissemination events. These surveys serve two critical purposes:

1. Assessing Impact:
 - ZMD evaluates how its meteorological products and services impact local communities.
 - By analyzing user feedback, ZMD gauges the effectiveness of its forecasts, warnings, and communication strategies during the rainy season.
 - The goal is to ensure that ZMD's information reaches and benefits as many people as possible.
2. Collaboration with Private Institutions:
 - ZMD is actively engaging with private institutions to partner and focus on:
 - Packaging: How meteorological information is presented and delivered to end-users.
 - Interpretations: Ensuring that weather forecasts are easily understandable.
 - Communication Strategies: Identifying effective ways to reach diverse audiences.
 - By involving private entities, ZMD aims to enhance its overall service provision.

10.3. Quality management processes that satisfy key user needs and support continuous improvement.

ZMD has implemented a Quality Management System (QMS) for services specifically related to aviation. These services ensure that aviation-related weather information is accurate, reliable, and timely for safe flight operations.

QMS Manuals and Guidelines:

- ZMD maintains QMS manuals and other relevant guidelines.
- These documents are displayed in ZMD offices.
- The display is done either monthly or annually to ensure accessibility and adherence.

Verifications:

- Performance audits are conducted to verify compliance with established standards.
- These audits assess the effectiveness and efficiency of ZMD's processes and services.

Compliance Documentation:

- All compliance activities are meticulously documented.
- These records are securely kept in a cabinet at the site.
- This documentation serves as evidence of adherence to QMS protocols.

Reporting:

Reports are generated at various levels within ZMD. The frequency of reporting depends on the specific activity:

- Monthly reports: Provide regular updates on implementation.
- Annual reports: Summarize achievements and challenges over the year.

Summary score, recommendations, and comments for Element 10

Zambia is assessed as being at **Maturity level 2** for this element - ***Service development draws on informal stakeholder input and feedback.***

There is minimal formal interaction with stakeholder to influence the co-design and development of products and services from ZMD. The nation does experience significant hardship from either flooding or drought, so there is a clear need to strengthen the links between stakeholders and ZMD. The strong recommendation is to capacitate the stakeholder management function at ZMD.

Annex 1 Consultations (including experts and stakeholder consultations)

Zambia Meteorological Department

Annex 2 Urgent needs reported

To strengthen the formal and operational contact between ZMD and WARMA, and for this to be correctly mandated in legislation.

Annex 3 List of materials used

Ngoma, H., Lupiya, P., Kabisa, M. *et al.* Impacts of climate change on agriculture and household welfare in Zambia: an economy-wide analysis. *Climatic Change* **167**, 55 (2021). <https://doi.org/10.1007/s10584-021-03168-z>

World Bank, Climate Knowledge Portal, Zambia Climatology.
<https://climateknowledgeportal.worldbank.org/country/zambia/climate-data-historical#:~:text=The%20annual%20rainfall%20in%20Zambia,rainfall%20between%20May%20and%20August.> [Zambia - Climatology | Climate Change Knowledge Portal \(worldbank.org\)](#) 2021