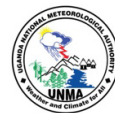# COUNTRY HYDROMET DIAGNOSTICS

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

April 2024

Uganda Peer Review Report

Reviewing Agency: Koninklijk Nederlands Meteorologisch Institute (KNMI)
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The findings, interpretations and conclusions expressed are those of the named authors alone and do not necessarily reflect those of the agencies involved.

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Disclaimer

Acknowledgements

List of Abbreviations

- AWS: Automatic Weather Station

- AWOS: Automated Weather Observing System

- CAP: Common Alerting Protocol

- CCD: Convention to Combat Desertification

- CHD: Country Hydromet Diagnostics

- CREWS: Climate Risk and Early Warning Systems

- DWD: Directorate of Water and Development

- DWRM: Department of Water Resources Management

- ECMWF: European Centre for Medium-Range Weather Forecasts

- ED: Executive Director

- FTE: Full-Time Equivalent

- GBON: Global Basic Observing Network

- GFCS: Global Framework for Climate Services

- GTS: Global Telecommunication System

- GoU: Government of Uganda

- IBF: Impact Based Forecasting

- ICAO: International Civil Aviation Organization

- IFRC: International Federation of Red Cross and Red Crescent Societies

- IPCC: Intergovernmental Panel on Climate Change

- ICPAC: IGAD Climate Prediction and Applications Centre

- KNMI: Koninklijk Nederlands Meteorologisch Institute / Royal Netherlands Meteorological Institute

- MARS: WMO Meteorological Archiving and Retrieval System

- MWE: Ministry of Water and Environment

- NAP: National Adaptation Plan

- NARO: Uganda National Agricultural Research Organization

- NCOF: National Climate Outlook Forum

- NDP: National Development Plan

- NECOC: National Emergency Coordination and Operations Centre

- NMC: National Meteorological Center

- NMTS: National Meteorological Training School

- NWP: Numerical Weather Prediction

- NWFC: National Weather Forecasting Centre

- OSCAR: Observing Systems Capability Analysis and Review Tool

- PA: Peer Advisor (here KNMI)

- PWC: Parish Weather Clinics

- PWS: Public Weather Services

- QC: Quality Control

- QMS: Quality Management System

- RWC: Regional WIGOS Centre

- SCIEWS: Strengthening Climate Information and Early Warning Systems

- SNCOF: Sub-National Climate Outlook Forum

- SOFF: Systematic Observations Financing Facility

- SWF: Severe Weather Forecasting

- UBC: Uganda Broadcasting Corporation

- UCAA: Uganda Civil Aviation Authority

- UNBS: Uganda National Bureau of Standards

- UNMA: Uganda National Meteorological Authority

- URCS: Uganda Red Cross Society

- USSD: Unstructured Supplementary Service Data

- UA(S): Upper Air (Station)

- Ushs: Uganda Shilling

- WB: World Bank

- WFP: World Food Program

- WIDS: Weather Information Dissemination System

- WIGOS: World Meteorological Organization Integrated Global Observing System

- WIS: World Meteorological Organization Information System

- WMO: World Meteorological Organization

- WRF: Weather Research and Forecasting model

Table of Contents

Executive Summary

The Uganda National Meteorological Authority (UNMA) is at a critical juncture, requiring comprehensive development support to enhance its capacity in delivering reliable weather and early warning services. This need is particularly urgent in light of the Systematic Observations Financing Facility (SOFF) and Global Basic Observing Network (GBON) initiatives, as well as the broader context of UNMA's mission. Key challenges and urgent needs include:

1. **Funding and Legal Framework**: The existing funding model and legal framework restrict UNMA's ability to recover costs and secure the necessary resources for sustainable operations and the development of value-added services. This limitation is significant given the pivotal role of weather and climate services in mitigating Uganda's socio-economic vulnerability to extreme weather.
2. **Institutional Status**: The ongoing debate over UNMA's semi-independent status and potential reintegration poses risks to its operational independence and international collaborations. Maintaining its current status is crucial for preserving the autonomy of weather and climate observations.
3. **Human Resource Constraints**: Significant understaffing and recruitment challenges across the observation data chain jeopardize UNMA's capacity for data development and quality assurance. Targeted training and capacity-building initiatives are urgently needed to address these gaps.
4. **Gender Equity**: Addressing gender equity, especially at the management level, is essential for ensuring inclusivity in climate change adaptation and disaster resilience strategies.
5. **Maintenance and Observation Network**: UNMA's observation infrastructure is in dire need of rehabilitation, particularly the Automatic Weather Stations (AWS) and improving data connectivity (e.g., via GTS or WIS). Observation quality and consistency are further compromised by inadequate maintenance and calibration capacity, necessitating serious attention.
6. **Technical and Infrastructure Gaps**: Critical gaps in UNMA's observation systems, including the absence of a lightning detection system and the unutilized capacity of weather radar data, hinder effective nowcasting and early warning services. The lack of an integrated data management system further compounds these challenges.
7. **Customer Engagement and Service Capacity**: Despite effective customer engagement efforts, rapidly increasing demands outpace UNMA's service capabilities. Enhancements in communication strategies and the exploration of mobile applications for weather information dissemination are necessary.
8. **Forecasting and Data Management**: The adoption of an automated forecast verification system and the development of impact-based forecasting and advanced climate predictions are imperative for improving service accuracy and relevance.
9. **Strategic Cooperation and International Support**: Enhanced regional cooperation, strategic partnerships, and international support are vital for leveraging resources, knowledge exchange, and technical expertise. Specifically, donors are encouraged to align their support with UNMA's priorities, ensuring that funding directly benefits its critical needs.

Despite these challenges, UNMA's collaborative spirit, the committed engagement of its staff and management, openness to discussion, the drive to enhance performance, and active participation in international cooperation programs merit significant recognition.

The Royal Netherlands Meteorological Institute (KNMI) stands ready to assist UNMA in addressing it's challenges, fostering strategic and operational advancements, and modernizing its meteorological services for the benefit of the people of Uganda.

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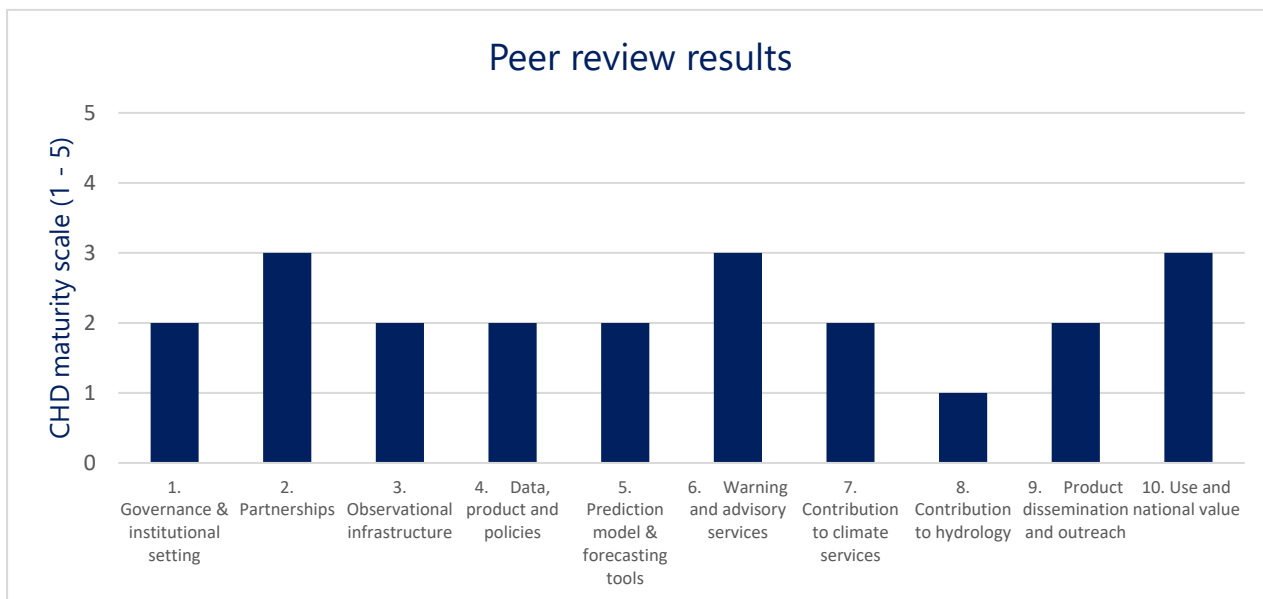
Element	Maturity level score
1. Governance and institutional setting	3
2. Effective partnerships to improve service delivery	3
3. Observational infrastructure	2
4. Data and product sharing and policies	2
5. Numerical weather prediction model and forecasting tool application	2
6. Warning and advisory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

Chapter 1: General information

Introduction

Uganda is a land-locked country in East-Africa covering about 241,550 km[2] (2021, World Bank) with moderately homogeneous topography. The population of Uganda is 48.6 million people (in 2021[1]). An excellent overview of Uganda's climate is presented in the World Bank Uganda Climate Risk Country profile (World Bank, 2020)[2]. Uganda's climate is largely tropical[3] with two rainy seasons per year, March to May and September to December. Uganda lies within a relatively humid equatorial climate zone. The northern region, which forms one quarter of the country lies outside the rainfall regime, and experiences only one longer rainy season from March to October. Topography, prevailing winds, and lakes (mainly Lake Victoria) contribute to the differences in rainfall patterns across the country. The weather and seasonal patterns are largely determined by the large-scale Indian Monsoon, Congo air mass, Indian Ocean Dipole system, Inter Tropical Convergence Zone and the El Nino Southern Oscillation (ENSO) phenomena, which are the principal drivers for intra-annual to inter annual rainfall variability.

Overall, Uganda experiences moderate temperatures throughout the year, with an average surface air temperature of 22.8°C, with monthly temperatures ranging between 21.7°C (July) and 23.9°C (February). However, the country's diverse topography results in wide-ranging temperature, from the ice-capped Rwenzori Mountain Range and Mount Elgon to 30°C in the north-eastern areas of Gulu, Kitgum and Moroto.

Total annual average precipitation is 1,197 mm, with mean monthly precipitation varying from 39.6 mm in January to 152.7 mm in April. Precipitation patterns in Uganda indicate varied rainfall distribution with areas like Karamoja receiving the lowest amounts of rainfall of approximately 400 mm a year and areas around Lake Victoria and Mount Elgon receiving the highest amounts of rainfall, of up to 2,200 mm.

Uganda is at risk of natural disasters. Extreme weather events have led to mudslides, landslides, and flooding, particularly in the country's mountainous regions. Extreme events have increased over the last 30 years[2]. Flooding has become more frequent, largely due to more intense rainfall. Over the past two decades, an average of 200,000 Ugandans are affected each year by natural disasters. Uganda's vulnerability is exacerbated by to its high level of poverty and its high dependence on 'climate sensitive' sectors: agriculture, water, fisheries, tourism, and forestry.

The Uganda National Meteorological Authority (UNMA, formerly Department of Meteorology) under the Uganda Ministry of Water and Environment is a semi-independent government institution for weather and climate services (UNMA Act. 2012)[4] and a focal institution to Inter-Governmental Panel on Climate Change (IPCC).

UNMA is responsible for establishing and maintaining weather and climate observing stations network, collection, analysis and production of weather and climate information, (including warnings/advisories) to support social and economic development in Uganda.

UNMA is considered as a key contributor to:

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[1] https://www.unfpa.org/data/world-population/UG

[2] https://climateknowledgeportal.worldbank.org/sites/default/files/2020-06/15464-WB_Uganda%20Country%20Profile-WEB_v1.pdf

[3] https://climateknowledgeportal.worldbank.org/country/uganda/climate-data-historical

[4] https://climate-laws.org/document/uganda-national-meteorological-authority-act-2012_48c4#

- Uganda Vision 2040[5]
- Third National Development Plan Uganda 2020/21 – 2024/25[6] (NDP III)
- National Disaster Risk Management Plan and the National Adaptation Plan (initiated in 2022 and 2023 respectively).

Its critical contribution includes its forecast products and early warning climate information services that are expected to inform decision making in infrastructure development and maintenance through availing ease of access to historical, monitoring and prediction climate data for specific locations.

CHD methodology

The Country Hydromet Diagnostics (CHD) report was generated parallel to the GBON National Gap Analysis and contributes to the National Contribution Plan.
During the SOFF Readiness project, a SOFF Uganda project team was established, including the KNMI Peer Review Team and UNMA representatives, in particular Dr. Godwin Ayesiga (Head of Research and Training) and Mr. James Magezi Akiiki (local consultant).

Activities relevant for the CHD include:
- A weeklong mission by KNMI to UNMA included UA and AWS stations and facilities visits and several stakeholder dialogues (Uganda Red Cross Society, Uganda National Farmers Federation; Greater Entebbe Fishers Development Initiative, and Prime Minister's office responsible for disaster preparedness and management).
- Full inventory of all 11 WIGOS registered stations and three existing stations not registered yet for GBON, newly proposed to become part of the network, has been conducted by the local consultant.
- Several remote sessions were organized to review and verify gaps in terms of GBON compliance followed by preparing the SOFF documents of the Gap Analysis, CHD (this report) and the National Contribution Plan.
- The local consultant facilitated information gathering and verification within the UNMA.

Fig. 1: First UNMA – KNMI field mission within the context of SOFF program.
At Entebbe Station with UNMA staff. From left Eric Mauso, James Magezi Akiiki, Sharon Najjuma, Raimond Hafkenscheid (KNMI), Marlies van der Schee (KNMI), Fred Ssebabi, UNMA staff, Rubert Konijn (KNMI), Dr. Godwin Ayesiga on 14th of February 2024.

Chapter 2: Country Hydromet Diagnostics

Element 1: Governance and institutional setting

1.1 Existence of Act or Policy describing UNMA's legal mandate and its scope

Uganda national meteorological Authority (UNMA) is an ISO 9000:2015 certified institution of the Government of Uganda, acting as the national focal institution to the Inter-Governmental Panel on Climate Change (IPCC). In the National context, UNMA executes its mandate in-line with the Constitution of the Republic of Uganda of 1995 as amended, the UNMA Act of 2012 and the Public Finance Management Act 2015. The overarching policy framework governing planning in Uganda is the Comprehensive Development Planning Framework.

The mandate of UNMA is to establish and maintain weather and climate observing station networks, collection, analysis and production of weather, climate and atmospheric pollution information, warning, and advisory services to support the socio-economic development in Uganda.

The Ministerial Policy Statement FY 2022/23[7] restates UNMA's mission and strategic objectives to a) provide tailored quality meteorological services on weather, climate, and atmospheric pollution for socio-economic development of Uganda; b) improve the quality and quantity of meteorological services; c) promote the use of meteorological services and d) strengthen the institutional capacity to provide quality and timely meteorological products.

Scope

The Act of Uganda's Parliament (UNMA Act 2012) established UNMA as a body corporate and provides with respect to its administration, internal organization, functions, and powers, etc. UNMA has the responsibility to establish and maintain an effective national weather forecasting centre for short-, medium-, and long-term applications using state-of-the-art technology and contemporary best practices to monitor the state of the atmosphere in Uganda. Its function is to apply meteorology to aviation, marine transport, water resources management, agriculture, health, national defence and security, disaster preparedness, and other socio-economic developmental activities.

UNMA has the responsibility to promote- and build capacity at local government levels to the use of weather and climate services in development planning; to build strategic partnership with national and international governments, agencies, academic institutions, civil society organizations, cultural and other institutions and to mobilise resources to support climate and weather programmes and activities. UNMA exercises authority over the National Climate Data Bank and Archive.

UNMA falls under the responsibility of the Minster for Water and Environment, subject to the declared policy of the Government and except as otherwise provided in the Act, be independent in the performance of its functions and duties. UNMA represents the Government of Uganda in the World Meteorological Organization (WMO) and the Intergovernmental Panel on Climate Change (IPCC).

UNMA collaborates with the Uganda Climate Change Department (CCD) within the Ministry of Water and Environment, with CCD focussed on strengthening Uganda's implementation of the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol (KP).

National policy relevance

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[7]https://budget.finance.go.ug/sites/default/files/Sector%20Spending%20Agency%20Budgets%20and%20Performance/Uganda%20National%20Meterological%20Authority.pdf

UNMA collaborates with the Office of the Prime Minister (OPM), responsible for Disaster Preparedness and Management, the Uganda Red Cross and the International Federation of Red Cross and Red Crescent Societies (IFRC) on early warning and disaster preparedness. Hydrological services are limited to forecasted and past rainfall distribution and intensity and are carried out in collaboration with the Directorate for Water resources Management within the Ministry of Water and Environment. UNMA's services and information products are input to major development and climate change related policies, for example via the:

- The climate change agenda within overarching national planning framework for Uganda Vision 2040.
- The National Development Plan III (NDPIII), aimed at achieving the Uganda Vision 2040. From NDPIII, UNMA is expected to increase the accuracy of meteorological information from 80 percent to 90 percent and increase the percentage of automation of weather and climate network from 30 percent to 80 percent.
- The Programme Implementation Action Plans for Natural Resources, Environment, Climate Change Water and Land Management; and the Agro industrialisation Programme Implementation Action Plans.

Operational standards

UNMA operates in accordance with guidelines provided by the World Meteorological Organization (WMO), the International Civil Aviation Organization (ICAO), and other international and regional (regulatory) bodies in meteorology. Agrometeorological services are carried out in collaboration with the Uganda National Farmers Federation. Marine meteorological services to the Lake Victoria fishing communities are carried out in partnership with the Greater Entebbe Fishers Development Initiative. Aeronautical services are provided from the Uganda National Meteorological Centre (NMC) / Directorate of Forecasting Services at Entebbe International Airport, in close cooperation with the Uganda Civil Aviation Authority, compliant with ICAO requirements.

Governance

UNMA is headed by a Board which is appointed by the Minister of Water and Environment with the approval of Cabinet in line with Part 1, Section 5 of the UNMA Act, 2012. The Board is responsible for overseeing the implementation of UNMA's plans and programmes and it is constituted of a chairperson and five other members. At least one-third of the members of the board shall be women. At present 3 out of 6 members are women.

The overall management of UNMA is overseen by the Executive Director (ED) who is appointed by the Minister of Water and Environment upon recommendation by the Board. The ED is assisted by five (5) Directors. In addition, the Office of the Executive Director directly supervises the Legal Unit, the Public Relations Unit and the Internal Audit Unit. The Composition of UNMA is summarized in Table 1 while the detailed organizational structure of UNMA is presented as Annex 1.

UNMA's position as a semi-independent authority is currently under discussion, with the ongoing discussion of the incorporation of UNMA in the Ministry of Water and Environment as a viable option. Continuation of the current status is advised upon, considering the guarantee of independency related to weather and climate observations.

Table 1: Overview of UNMA's directorates, units, and sections.

DIRECTORATES	DEPARTMENTS/UNITS
Directorate of Station Networks and Observations (DSNO)	Meteorological installations and maintenance
	Weather networks operations
Directorate of Forecasting Services (DFS)	National Meteorological Centre (NMC) which is responsible for Weather forecasting, Aeronautical Meteorology Services and Weather Modelling.
	Engineering and ICT Services
	Severe Weather Unit
	Marine Weather Services
Directorate of Applied Meteorology, Data and Climate Services (DADCS)	Applied Meteorology and climate analysis (Agro meteorology, Hydrometeorology, Disaster management)
	Data Centre and climate services
Directorate of Training and Research (DTR)	Training
	Research
	National Meteorological Training School (NMTS)
Directorate of Finance and Administration (DFA)	Finance and Accounts
	Administration and Human Resource management
	Procurement and Supplies
	Planning, Monitoring and Evaluation

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

Strategy, operations, and risk management plans are very clearly outlaid in the Second Strategic Plan (SP II). The SP II has been developed in alignment with the third National Development Plan (NDPIII) covering 2020/21-2024-2025. SP II follows SP I (2015/2016-2019/2020, aligned to NDPII).

SP II includes a full description of national and international institutional setting, as well as capacity and financial overviews. UNMA SP II, which was developed following a participatory and all-inclusive approach, is effective until 2025, and includes organisation SWOT analysis, as well as stakeholder analysis frameworks. Annual work and budget planning is based on strategic goals. The utilisation of resources is governed by the Public Finance Management Act 2015, and the procurement function at UNMA is guided by the Public Procurement and Disposal of Public Assets Act of 2003. At the end of every Financial Year (FY), the Office of Auditor General (guided by the Audit Act 2008 and Public Finance Management Act 2015) undertakes an audit to assess the value for public resources. The process for developing SP III for the period 2025 – 2028 has already started. SP III will be aligned with NDP IV.

SP II contains a thoughtful, comprehensive, and ambitious outline of strategic objectives, planned interventions and actions programs. UNMA achieved a Quality Management System (QMS, ICAO) certification in 2018, with an ISO 9001:2015 QMS Certificate, coupled with staff competence assessments and certifications. To maintain the QMS standards, UNMA undertakes regular competency assessments guided by WMO's Competency Assessment Toolkit. The latest competency assessment and an associated refresher training for Aeronautical Meteorological Observers and Aeronautical Meteorological Forecasters is planned for March – April 2024. This suggests that UNMA is focused on

maintaining quality standards in its operations and has an ability to integrate risk management practices into the new strategy. Communications and feedback strategies; roles and responsibilities of internal and external stakeholders; risk management; and monitoring and evaluation frameworks are all included in the SP II.

1.3 Government budget allocation consistently covers the needs of UNMA 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.

Annual governmental budget allocations (fiscal year 2022/23) total 17.656 billion Ushs (Uganda Shilling), approximately 4.55 mil. $US per year (Feb. 2024). Governmental budget allocation for UNMA is assumed to be stable for 2022 - 2027[8].

Budget cuts have reduced UNMA's performance over the last 2 years. For the fiscal periods 2016 - 2020 total annual budget ranged from 24- 29.5 billion Ushs, including a significant development budget ranging from 14.2 to 16.3. billion Ushs. The latter was mostly committed for the procurement and installation of three (3) weather radars and the supporting infrastructure. In 2022/23 development budgets were reduced to 6.557 billion Ushs.

Wage budget has been unchanged since 2016 at 7.413 billion Ushs, despite inflation and increased HR demands. Non-wage operational budget ranged from 4.2 – 5.1 billion Ushs (2016-2020) but were significantly reduced in 2022/23 to 3.686 billion Ushs, representing 27% of the total annual budget. The budget for hardware maintenance and replacement is 25 million Ushs (2023 data) representing just 0.1 – 0.2% of the total annual budget, which explains UNMA's difficulties related to network operations (see also element 3). For 2024/25, the GoU invested approximately 3.2 billion Ushs in the procurement of a Low-Level Wind Sheer Alert System (LLWSAS) to be installed at Entebbe International Airport.

The primary source of funding is the government. External (domestic and international collaboration and development projects) represented 1.5 – 2.2 billion Ushs during 2016-2019, and primarily consisted of cost reimbursements from the Uganda Civil Aviation Authority (UCAA) for aviation meteorological products. However, since the fiscal year 2019/20 CAA stopped its payments, while UNMA continued its service provision. UNMA continues to engage with UCAA to reinstate the reimbursement for the services provided.

Overall, funding from GoU to UNMA is considered insufficient, with UNMA's capacity reduced to about 50% from the fiscal periods of 2016 – 2020 and considering its performance improvement ambitions. UNMA performance was most severely hampered in fiscal year 2019/2020 when less than 50% of the approved budget was released due to the onset of COVID-19 which affected Uganda's economic performance.

Station rehabilitation and upgrades, instrument maintenance, calibration and replacement, infrastructure and housing maintenance, computing facilities (hardware and software), transport facilities and human resources are all affected negatively by limited funding.

The current cost recovery mechanism is inadequate. UNMA plans to undertake a comprehensive study of the benefit-costs ratio of weather and climate information services provided by UNMA. For example,

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[8]

https://budget.finance.go.ug/sites/default/files/Sector%20Spending%20Agency%20Budgets%20and%20Performance/Uganda%20National%20Meterological%20Authority.pdf

cost-benefits analysis for weather and climatological services from the WISER Programme[9] (2021) indicated a benefit to cost ratio between 7:1 and 26:1 for the WISER national project in Uganda.

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 UNMA.

Staff

In 2023 UNMA counted 185 staff members, against the approved staffing level of 218 staff spread across the 5 constituent departments (Table 2). In March 2024, 42 positions, 28% of the required HR capacity, remained vacant, mainly in supportive positions. Core meteorological, weather observation positions are well covered.

The current doppler radar facilities in three locations require increased staffing on hardware and maintenance (electrical engineering, 2 FTE) and software engineering (2 FTE) to mobilise the full meteorological and socio-economical potential of these devices. International collaboration, and UNMA participation in international (research) programs is hampered by lack of project proposal development skills.

At present, data management is the Achilles heel of UNMA, affecting data security, quality, and dissemination capacity. Data management, data communications, data rescue and data achieving require improved software engineering / development capacity.

Table 2: 2023 overview of UNMA staff, positions, and gender distribution

Staff information	Total number	
Managers and administrative support staff	15	
Met services (forecasters, met applications, data quality control, department managers)	28	
Met technicians' observations and (observation officers, supervisors, instrument maintenance, calibration, etc)	70	
Research		
Information technology (ICT services)	7	
Others, specific experts	6	
General support staff (drivers, etc)	59	
Total employees (2023)	185	
Staf disaggregated by gender	**Number**	**Percentage**
Male	126	68
Female	59	32

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https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/business/international/wiser/wiser-seb-results_final-web.pdf

Gender

Of the 185 staff (2023), 32% are women. UNMA's gender strategy is currently under review; specific objectives to institutionalize systems for promotion of gender and equity are expected at the end of 2024. It is advised to also consider the gender balance in management positions. Also at KNMI, as with many Met offices, the gender balance is far from what is desired.

Capacity building

UNMA made great strides through short- and long-term capacity building to cope with the rapidly changing technology in meteorology. Between 2016 - 2020, trainings have been undertaken for staff to attain qualifications in meteorology: staff were able to attain four Doctors of Philosophy (Ph.D.), 14 Master's degrees, 21 Bachelor's degrees and other specialized trainings in weather, climate and related sciences under Diploma and Certificate levels. The internal training program is guided by a training policy (2020) under the responsibility of the ED and director Training & Research. The reviewed policy (Training Policy 2024) is currently being discussed by UNMA board. UNMA's capacity for inhouse HR development is very limited; twinning and strategic partnerships with other NHMS's, including the peer reviewer, or regional training initiatives (e.g. under CREWS) are considerate options.

Currently, UNMA does not have a strategic capacity development plan to ensure enhancing staff capacity is guaranteed. The Human Resources Manual requires management to develop an annual capacity development plan. At present, capacity development is being guided by the training needs assessment.

GoU regulations do not allow UNMA to head-hunt capacity and talent; internal scouting and inhouse training programs (within international collaboration schemes) seems to be the best option.

However, training needs are extremely high, with over 80% of all employees requiring additional training, with specific attention to be paid to meteorological data processing and analysis; development of meteorological products; database and computer network management; and application and use of meteorological radars and satellites. Training on maintaining meteorological sensors, including maintaining a calibration facility is missing in Uganda.

UNMA in charge of the National Meteorological Training School[10], located in Entebbe, with approx. 100 students active in a 2-year program for a diploma in Meteorology and diploma in Agrometeorology. Currently, Makarere University provides a Bachelor of Science in Meteorology course (3 years) and a post graduate program in meteorology (one year) within the college of agricultural and environmental sciences. Mbarara University of Science and Technology offers a Diploma in Agricultural Meteorology within its bachelor program of science in agriculture program.

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

UNMA has a strong and significant track record in implementing internationally funded (hydro)meteorological projects. UNMA holds strong partnerships with national and international organizations to ensure sustainable and impactful results from projects, and deliver on socio-

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[10] https://nmts.unma.go.ug

economic demands, especially in the domain of agriculture, early warning and disaster preparedness and management.

Recently finished and ongoing programs include:

- Strengthening Meteorological Products, Services and Use in the Agriculture and Water Sectors (SMEPS) Project[11] 2014-2016. GIZ USAID
- Strengthening Climate Information and Early Warning Systems Uganda (SCIEWS) 2013-2018. UNDP[12]
- Adaptation Fund – ACREI – IGAD- ICPAC 2017
- Weather and Climate Information Services (WISER) for Africa (Phase II)[13] 2015 – 2021. Foreign, Commonwealth and Development Office (FCDO), United Kingdom
- WISER Developing Risk Awareness through Joint Action (DARAJA)[14]
- High Impact Weather Lake System (HIGHWAY)[15] 2017-2020, FCDO, United Kingdom
- HydroSOS Lake Victoria Basin[16] – 2021, WMO
- CREWS – East Africa[17]: Funded by WMO, since 2023
- National Early Warning System (NEWS) Uganda
- Global Resilience Partnership with the Trans-African Hydro-Meteorological Observatory (TAHMO)[18]
- National Adaptation Planning efforts (Uganda NAP, initiated 2023, UNDP)

Summary score and recommendations for Element 1

Summary score for this element is 3 on the CHD scale, reflecting "*Moderately well mandated, managed and resourced and clear plans for, and sufficient capacity to address operational gaps*".

However, based on the financial and HR constraints, increasing demands, and decreasing financial support one can argue that UNMA, if funding/resourcing does not improve in the short to medium term, is at the risk of sliding back to CHD score 2, reflecting "*Effort ongoing to formalize mandate, introduce improved governance, management processes and address resource challenges*."

Strengths: The legislative background, governance structure and support for UNMA is strong. Organizational structure clearly distributes responsibilities. Funding scheme supports basic operational duties but is very limited for development activities. (Potential) participation of internationally funded projects is a strength of UNMA, but capacity in that area should be improved.

Gaps: The current cost-recovery mechanism is inadequate. For the coming years explicit data on cost-recovery potential is foreseen. Budget development does not meet requirements to follow services demands. In-house capacity building requires further development to ensure sustainability and

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[11] https://unma.go.ug/partners/giz-usaid

[12] https://adaptation-undp.org/resources/report-strengthening-climate-information-and-early-warning-systems-sciews-projects-team

[13] https://www.metoffice.gov.uk/about-us/what/working-with-other-organisations/international/projects/wiser

[14] https://www.metoffice.gov.uk/about-us/what/working-with-other-organisations/international/projects/wiser/daraja,

[15] https://www.metoffice.gov.uk/about-us/what/working-with-other-organisations/international/projects/wiser/highway

[16] https://community.wmo.int/en/activity-areas/global-hydrological-status-and-outlook-system-hydrosos/meetings/HydroSOSLVBWorkshop

[17] https://www.crews-initiative.org/en

[18] https://www.globalresiliencepartnership.org/challenge-project/meteorological-early-warning/

independence in the terms of institutional capacity. The organization would benefit from stronger institutional capacity in the whole value chain (from planning to overseeing and reporting). The semi-independent position of UNMA is currently under discussion.

Element 2: Effective partnerships to improve service delivery.

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

UNMA's effectiveness in delivering weather and climate services is significantly enhanced by its strategic collaborations with various governmental bodies. Central to these efforts is the partnership with the Ministry of Local Government, which is instrumental in disseminating essential weather and climate updates. UNMA has established an extensive communication network, leveraging email and WhatsApp to rapidly disseminate information to District Local Governments, including key personnel like District Production and Environment Officers. This initiative is part of a broader strategy to decentralize meteorological services by integrating meteorological staff into every district's infrastructure.

A cornerstone of UNMA's collaborative efforts is its relationship with the National Agricultural Research Organisation (NARO). NARO, operating under the Ministry of Agriculture, Animal Industry, and Fisheries, not only hosts UNMA weather stations across its facilities but also joins hands with UNMA in pioneering multi-disciplinary research projects.

Further extending its outreach, UNMA has forged a partnership with the Uganda Broadcasting Corporation (UBC), ensuring that weather forecasts are a staple feature following daily news segments. These partnerships are illustrative of UNMA's broader engagement with an array of Government Ministries, Departments, and Agencies (MDAs), showcasing a united front in the co-production of seasonal forecasts and advisories, thereby optimizing the delivery of meteorological services across Uganda.

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

UNMA is committed to developing dynamic partnerships at both national and international levels, spanning private sector entities, academic institutions, and research centers. These collaborations have been instrumental in fostering innovation and advancing meteorological research and services.

A key partnership with Makerere University facilitated the development and operationalization of the Weather Information Dissemination System (WIDS)[19], a platform designed to deliver real-time, accurate weather information via web and mobile USSD interfaces to a broad spectrum of stakeholders.

Noteworthy collaborations include:
- Busitema University (BU): Joint initiatives with BU have focused on resource mobilization and the development of a Postgraduate Diploma Course aimed at bolstering human resource capabilities within UNMA.
- International Crane Foundation (ICF)/Endangered Wildlife Trust (EWT): This partnership has been pivotal in mobilizing resources and disseminating weather and climate information to communities coexisting with grey hair cranes.
- Uganda Red Cross Society (URCS): Collaborative efforts during the National Climate Outlook Fora (NCOFs) have enhanced the dissemination of vital weather and climate information and improving URGSs disaster preparedness capacity.
- Lira University: Hosting one of the three weather radars stations, the university has engaged in joint resource mobilization and research projects with UNMA.
- Jane Goodall Institute (JGI): A collaboration aimed at resource mobilization and the dissemination of weather and climate information in the western districts of Hoima and Kikuube.

On the international front, UNMA has established a memorandum of understanding (MoU) with China's Nanjing University of Science and Technology focusing on capacity development. Further strengthening its international ties, UNMA is enhancing collaboration with meteorological services within the East

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[19] https://www.wids.unma.go.ug

African Community, including a pending MoU with Tanzania's meteorological services. UNMA's active participation in the African Ministerial Conference on Meteorology (AMCOMET) underscores its dedication to regional meteorological cooperation and advancement.

UNMA and KNMI consider their collaboration under the current SOFF program as a strategic twinning partnership, rather than a mere peer-review relationship.

2.3. Effective partnerships in place with international climate and development finance partners.
UNMA collaborates with global partners like UNDP, GIZ, USAID, KOICA, and Enabel, thus enhancing Uganda's meteorological services and climate resilience.

Key contributions include:
- UNDP: Funded the SCIEWS project, bolstering climate monitoring and early warning systems.
- GIZ: Supported the development of UNMA's website for improved information dissemination.
- KOICA & Enabel: Focused on human resource development through targeted training.

These partnerships enhance UNMA's capabilities and highlight the role of international cooperation in climate action. UNMA's involvement and participation in international cooperation programmed is highly encouraged, both at national and at regional level. These programs could significantly help to further develop UNMA's operations and capacity. It would be advised to further work on professionalizing the project management department, the interaction with donors and the capacity to write professional project proposals.

Donors are advised to further build on the work that has been done, carefully listen to the priorities of UNMA and to make sure that the majority part of the available funding is destined for UNMA itself.

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.
The collaborations with partners have yielded significant advancements in meteorological services, including:
- UNMA Website: A centralized portal for accessing weather updates and climate information.
- Weather Information Dissemination Systems (WIDS): Facilitates real-time, accurate weather information delivery through web and USSD mobile interfaces.
- Television-based Information Dissemination: Supported by Uganda Broadcasting Services, this platform extends the reach of weather forecasts and climate information to a broader audience.

These products enhance UNMA's capability to disseminate critical weather and climate information effectively.

Summary score, recommendations, and comments for Element 2
The summary score for this element is 3 on the CHD scale, reflecting "*Moderately effective partnerships but generally regarded as the weaker partner in such relationships, having little say in relevant financing initiatives.*"

Recommendations: UNMA's commitment to international cooperation and partnerships is evident through the role of the International Program Manager and the enthusiastic, open stance towards partnerships and international engagements by both staff and management. The political and social stability in Uganda significantly enhances its attractiveness for international collaborations. However, UNMA's capacity, both in terms of human and financial resources, currently limits its ability to fully engage with international programs at both national and regional levels. There is a strong case for fostering long-term strategic partnerships that focus on innovation and the further development of customer-oriented service delivery for specific user groups, such as those involved in natural hazard

and disaster preparedness, agriculture, and fisheries (especially in Lake Victoria). Given appropriate support and guidance, UNMA has the potential to position itself—and Uganda— as a key partner and hub for innovation in weather forecasting and its socio-economic impacts.

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.

Uganda's land area spans 241,550 square kilometers. Currently, it operates 12 synoptic manual weather stations registered in OSCAR/SURFACE (see Fig. 2), each theoretically covering a horizontal resolution of approximately 16,710 km2. 11 of these stations are affiliated within GBON, but none transmit data via GTS/WIS due to technical challenges between Entebbe and Nairobi. The station at Makerere University in Kampala is not WIGOS/SURFACE-registered but its records are stored in MARS. There is uncertainty about the registration status of the Kiigi station (central Uganda).

All stations are manned. Only Entebbe operates a 24-hour shift; other stations operate at 12-hour shifts. Additionally, Uganda maintains a single upper-air station tasked with covering the entire national territory, which has been inactive since 2016 and is not registered in WIGOS. Presently, neither surface nor upper-air stations adhere to GBON requirements, highlighting a significant gap in compliance and data sharing.
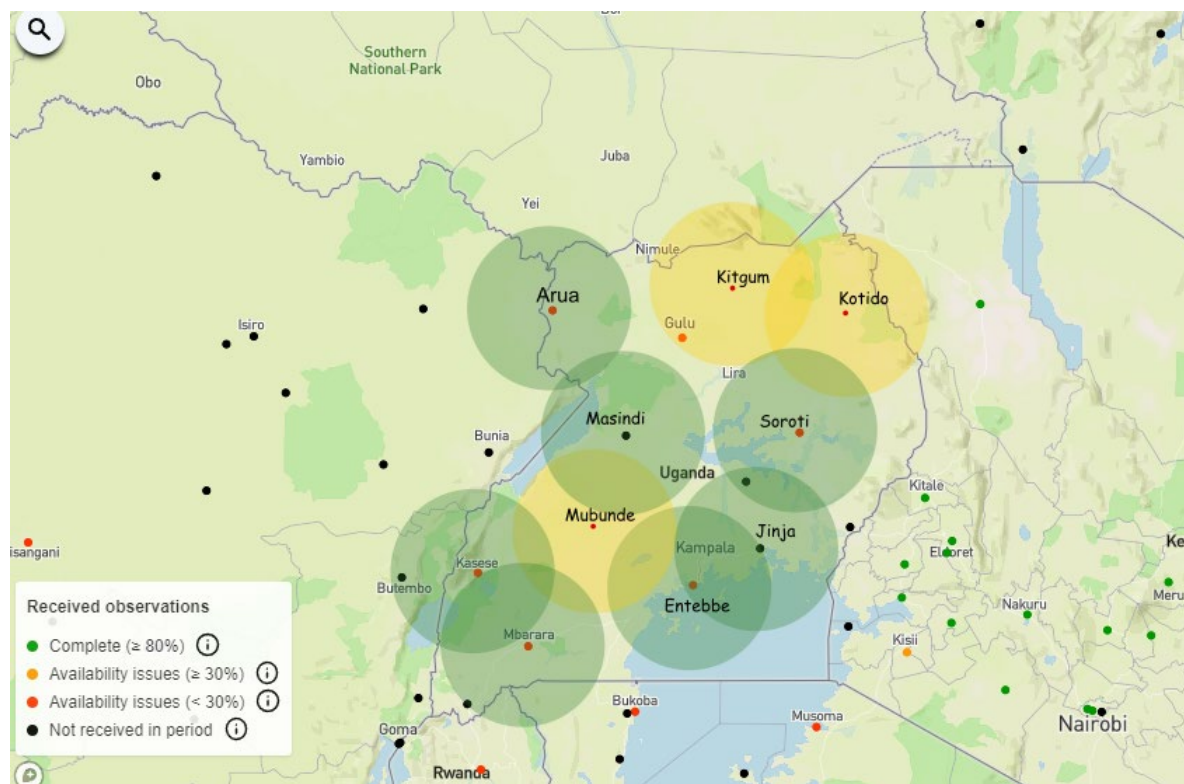
Figure 2: Taken from Uganda National Gap Analysis (NGA) Report. Black, green and red dots indicate stations registered with WIGOS ID available in OSCAR/SURFACE. GBON affiliated surface stations in Uganda are encircled (not exact locations) with diameter 200 km green circles as an indication of station coverage. Three stations (in yellow circles) namely Kotido, Kitgum and Mubende are exiting UNMA AWSs that are not yet registered in OSCAR/SURFACE but are proposed as SOFF GBIN station to facilitate full nation coverage of Ugada. Source map: OSCAR/SURFACE.

3.2. Enhanced Observations for Nowcasting and Specialized Applications

Uganda has three weather radar stations (two operational as of March 2024), which aims to improve nowcasting forecasting of thunderstorms and heavy rainfall by tracking their formation and development, yet specialized nowcasting products are not developed or disseminated publicly. The country also hosts nine operational weather buoys across Lake Victoria, Lake Albert, and Lake Kyoga, which are currently underutilized for nowcasting. The inactivity of the upper-air station since 2016, due to issues with a hydrogen generator, further limits observational capacity.

3.3. Observational Network Management Practices

Uganda's NDPIII[20] reflects intentions to enhance access and uptake of meteorological information and install new and adequately equip and maintain existing automatic weather stations to ensure maximum functionality.

Guidelines stipulate that each of Uganda's 147 districts should host at least one automatic weather station (AWS), with an ideal target of three per district, totaling 441 AWS (OPM, communications via UNMA). However, the expansion of AWS installations has relied mostly on donor support, with the most recent contribution of 23 AWS supported by the GIZ/USAID-funded SCIEWS[21] program in 2015 and 2016, 20 AWS supported by UNDP in 2016, 25 AWS provided by UNDP in 2019, and the remaining numbers provided by the GoU. Currently, UNMA maintains a network of 87 AWS manufactured by OTT/ADCON.

Operational maintenance of surface weather stations follows Standard Operating Procedures (SOPs) based on manufacturers' guidelines, though financial and logistical constraints severely hamper preventive maintenance efforts. UNMA lacks its own calibration facility for weather sensors, necessitating either engaging the private players accredited by Uganda National Bureau of Standards (UNBS) or occasionally undertakes calibration of the sensors from the Kenya Meteorological Department (KMD). This underscores the urgent need for infrastructure and procedural enhancements to ensure reliable and comprehensive weather observations.

Validation and Quality Control of Data

The framework for validation and Quality Control (QC) of meteorological data is outlined in manual for Climsoft; a Climate Data Management System (CDMS) aiming to ensure the integrity and accuracy of data collected. Despite these guidelines, the effective implementation of QC processes is hindered by constraints such as limited financial resources, insufficient technical capacity, and the lack of necessary infrastructure. These challenges significantly impact UNMA's ability to consistently apply QC measures across its observational network. Also, homogenization must be undertaken between the manual observations and the AWSs installed, which has not been executed yet. Currently, there are 37 stations in which records are available for both manual and automatic observations for over 3 years.

WIGOS/OSCAR Integration and Governance

UNMA has designated a single contact person for OSCAR/SURFACE, highlighting its preliminary level of engagement. The absence of a formal governance structure for OSCAR/SURFACE within UNMA suggests a nascent stage in its integration process. Two (2) staff members have received training focused on WIGOS and OSCAR/SURFACE responsibilities, indicating a commitment to developing expertise in this area, though the scope and effectiveness of this training remain to be fully realized.

Collaboration and Data Sharing

The relationship between UNMA and the Regional WIGOS center in Kenya is characterized by minimal interaction, predominantly confined to basic data transfers via SMS or email from the Entebbe NMC.

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[20] https://www.health.go.ug/wp-content/uploads/2020/08/NDP-3-Report.pdf
[21] https://erc.undp.org/evaluation/documents/download/10488

Regional communications and data sharing mechanisms are notably underdeveloped, lacking a robust platform for exchange and collaboration. Furthermore, there is no targeted meteorological collaboration among the countries surrounding Lake Victoria, underscoring a significant gap in regional cooperation and the potential for enhanced collective efforts in weather monitoring and forecasting.

3.4 Implementation of sustainable newer approaches to observations.
The current meteorological stations in Uganda are not automatically connected to the GTS, highlighting a significant gap in the country's observational infrastructure. This limitation is due to a dearth of resources, including both the human capacity (in terms of personnel numbers and technical expertise) and the physical infrastructure necessary to integrate new stations with AMSS, GTS, WIS, and potentially WIS 2.0 in the future.

UNMA's ability to harness the full potential of its three operational radar stations, particularly in the realms of nowcasting and the development of app-based public information services, is severely constrained. Critical deficiencies exist in computing hardware, data storage capabilities, sufficiently trained staff (esp. in software engineering) and the integration of radar data with additional forecasting tools.

The current network of automatic weather stations could be upgraded with more energy-efficient data loggers, such as those from ADCON, which operate on a low-power 3-9 volts system. Low-power stations and loggers necessitate smaller solar panels, reducing vulnerability to theft and fitting within compact shelters. Additionally, new loggers could enable direct weather data transmission to the UNMA server, eliminating the need for costly data transfer subscriptions associated with logger lease. Implementing ADCON loggers could halve the cost of transmitting weather data to UNMA to just half a US dollar per logger per month**.**

However, the current data loggers though efficient in energy use and cost they lack the module to convert the weather data into binary format which continues to limit the automatic integration of the data into the GTS.

3.5. Percentage of the surface observations that depend on automatic techniques.
Based on the Gap Analysis, Uganda operates a total of 87 automatic and 37 manual surface weather stations, plus an additional 150 rain gauge stations (Table 3). 12 of the automatic stations are synoptic. Eleven (11) stations are affiliated with GBON and are visible in the WIGOS Data Quality Monitoring System database.

None of the stations is automatically linked to the GTS. Data is manually transferred to the NMC via WhatsApp, SMS, or email at half hourly intervals, during daytime only. From there, data reporting to the Regional WIGOS Centre in Kenya is done manually (by email).

Table3: Summary of number of stations per station Type. Abbreviations: T; temperature, H: humidity, GLP: Ground level Pressure, W: wind, P: Precipitation.

Type of Station		Number (registered/active)	Variables
Fully automated surface Weather Stations		90/87, 12 of which are synoptic	T, H, GLP, W, P, Of 87 AWS, 50 have no GLP, 26 have no W
Climate stations and agro stations		54/37	T, H, GLP, W, P GLP at only 12 synoptic stations
Manual rain gauges		150/150	P
Automated rain gauges		0/0	N/A
Community stations and observations		0/0	N/A

Summary score, recommendations, and comments for Element 3

The summary score for this element is 2 on the CHD scale, representing "*Basic network, large gaps, mostly manual observations with severe challenges and data quality issues.*"

The current network density of 12 synoptic weather stations is insufficient, with only one manual station operational around the clock (Entebbe). Additionally, none of the stations report automatically to GTS. Recommendations to enhance the network include:

- The synoptic station's life expectancy of approximately 10 years (referring to the AWS stations supported by the GIZ/USAID-funded SCIEWS[22] program in 2015 and 2016) will require an intensive replacement program over the next two to four years. All of the proposed stations under SOFF will fall within this category. As such, total rehabilitation of the selected SOFF stations is expected (see NGA report).
- Transitioning to more energy-efficient AWS data loggers capable of transmitting weather data in binary format to improve data transmission efficiency.
- Revitalizing the oneupper air station, inactive since 2016, by procuring a new hydrogen generator, computer hardware, and replenishing the stock of balloons and radiosondes. UNMA specifically states its ambition for the instalment of a second (and new) upper air station in either Gulu or Lira. UNMA and the PA realize this ambition to be outside of the scope of the current SOFF phase. A second UAS station is recommended as a long-term target.
- Enhancing capacity for station maintenance, repair, and sensor calibration, including access to regional calibration facilities in Nairobi. This involves securing additional resources, manpower, and transportation for station visits.

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[22] https://erc.undp.org/evaluation/documents/download/10488

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 centers.

As of now, Uganda has registered 11 GBON surface weather stations registered within WIGOS, yet none of these stations actively reports to the Regional WIGOS Centre (RWC) in Nairobi, Kenya. None of the stations are automatically connected to GTS. Furthermore, the implementation of the WMO Information System (WIS) version 2.0 has not been realized. The WIGOS Data Quality Monitoring system reveals that none of the 11 stations meet the GBON requirements with availability issues (< 30%), indicating significant gaps in compliance and data sharing capabilities.

Data transfer protocols from manned stations, which operate 12 hours a day, 7 days a week, involve half-hourly data transmission to the Entebbe National Meteorological Centre (NMC) for the 12 hours of operation. However, communication from Entebbe NMC to the RWC Nairobi is limited to 30 minutes and hourly email reports.

There is a notable absence of a national strategy for the implementation of the GBON requirements in Uganda. UNMA requires support from SOFF to initiate and maintain automatic data transmission from its registered stations to WIGOS, leveraging GTS in the immediate term and transitioning to WIS 2.0 in the foreseeable future. Additionally, it is important to note that UNMA has not operated an upper-air station since 2016, further limiting the scope of atmospheric data collection and sharing.

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

UNMA currently engages in the exchange of data from 18 surface weather stations with the Regional WIGOS Centre (RWC) in Nairobi on an hourly basis, during 12 hours of operations (not 24h). This exchange is conducted exclusively via email. Additionally, data sharing agreements with the Uganda Civil Aviation Authority are in place, operating under a cost-sharing policy[23]. Similar arrangements exist for sharing both conventional and automatic weather station datasets with other stakeholders, again based on a cost-sharing approach.

UNMA commits to the dissemination of early warning products, including forecasts, to the public at no cost, as part of UNMA's mandate to bolster socio-economic activities in Uganda. Access to raw data is provided through a designated website, although specifics on the website's availability are not mentioned. Currently, there is no dedicated open data portal specifically for meteorological data, and such data remains under the proprietary control of UNMA. The Government of Uganda (GoU) has not established an open data policy, nor is there an existing open access data sharing policy among East African nations. The East African Meteorological Society has not been active in promoting the exchange of synoptic and climate data within the region. Nevertheless, data requests are fulfilled via email upon request.

Quality control (QC) measures for data collected are implemented at UNMA headquarters. There is an expressed need for the enhancement of human resources and the modernization of the database management system to achieve efficient and effective QC. UNMA employs the CLIMSOFT data management system/tool for archiving and managing climate datasets. UNMA has a formal calibration protocol. However, the lack of a functioning calibration center for meteorological and air quality sensors, coupled with insufficient maintenance capacity and a shortage of spare sensors, has adversely affected data quality. Sending sensors to Nairobi, Kenya for calibration is hampered by limitation of funding and puts the sensors at the risk of damage.

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[23] Since fiscal year 2019/202 cost recovery payments by the CAA have haltered, for reasons unknown to the reviewers.

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

UNMA leverages a comprehensive array of satellite-derived historical datasets and forecasting models to enhance its predictive capabilities. This arsenal includes, but is not limited to, datasets such as CHIRPS, ERA5, MERAv2, JRA55, TAMSAT, GPCC, and ARC. For generating forecasts across various time frames—from hourly to monthly—UNMA utilizes the GFS and CFS models within the framework of the WRF model. This approach is complemented by incorporating forecast products from international entities like NOAA-CPC, ICPAC, and ECMWF, ensuring a broad spectrum of data inputs for increased accuracy.

To understand and predict the impact of global climate phenomena, UNMA depends on specialized data concerning climate drivers such as the Madden Julian Oscillation, Indian Ocean Dipole, and El Nino Southern Oscillation (MJO, IOD, and ENSO), sourced from NOAA and the Australia Bureau of Meteorology (BOM).

Seasonal forecasting efforts are further bolstered by the application of GCM models from a diverse array of sources including NNME, various European models, and the Canadian model suite (e.g., CanSIPSv2.PRCP, CanSIPSIC3.PRCP, CCSM4.PRCP, GEOSS2S.PRCP, CFSv2.PRCP, SEAS5.PRCP, SPEAR.PRCP). These models provide the foundation for downscaling exercises that support both National and Sub National climate outlook forums.

Central to UNMA's forecasting operation is the in-house execution of the WRF model, configured to run on a nested domain with a resolution of 10 km. This setup is instrumental in producing detailed 10-day and monthly forecasts, among other outputs, enabling UNMA to deliver accurate and localized weather predictions.

Summary score, recommendations, and comments for Element 4

Element 4 receives a score of 2 on the CHD scale. This indicates "*A limited amount of GBON compliant data is shared internationally. The existing data sharing policies or practices or the existing infrastructure severely hamper two-way data sharing.*"

Urgent development needs include:
- Modernize the data transmission process from both the automatic weather stations and local manual stations to the Regional WIGOS Centre (RWC) in Nairobi via GTS or expedite the adoption of WIS2.0 with the free and open-source software WIS2BOX[24].
- Enhance automation, quality control (QC), (seasonal) forecast verification, human capacity, and calibration capacities as crucial for success.
- Re-establish at least one upper-air station in Uganda to significantly improve weather forecasting and climate monitoring capabilities.

Policy and Collaboration:
- Advocate for the Government of Uganda to develop an open data policy.
- Promote the creation of a regional data sharing policy among East African nations, possibly together with WMO regional Climate Centre, ICPAC.

Data Management and Expansion:
- Support UNMA in funding data rescue activities and in developing a modern weather and climate data archive, including historical data from the East African and British colonial periods.
- Address the underutilization and short-term storage of data from UNMA's operational weather radars by expanding storage capacities and providing training on radar technology applications.

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[24] https://docs.wis2box.wis.wmo.int/en/1.0b6/

Capacity Building:
- Facilitate training for technical staff in dynamical modelling and establish a modelling lab to diversify forecasting techniques through the use of additional boundary condition datasets.
- Prioritize the integration of phenological observations to enhance agricultural drought monitoring.

Implementing these recommendations will significantly improve data sharing capabilities, forecasting accuracy, and overall meteorological services in Uganda.

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.

UNMA harnesses a comprehensive suite of forecasting products from both global and regional centers. This includes outputs from the UK Met Office, the Global Forecast System (GFS), and the European Centre for Medium-Range Weather Forecasts (ECMWF). Additionally, UNMA incorporates predictions from tools like Windy, Ventusky, and Meteosat, which are connected to the Deutscher Wetterdienst's (DWD) ICON Model.

To aid the forecasting endeavor, UNMA utilizes a variety of satellite products from EUMETSAT and SAT24. However, the Puma Synergy System[25], customized for local application, is currently inoperative and urgently requires updates to be functional again. Another digital resource, "Nullschool[26]," provides real-time data on wind, weather, ocean, and pollution conditions through an interactive, animated map updated every three hours.

UNMA operates three weather radars located in Lira, Entebbe, and Rwampara. Positioned strategically across different regions, these radars, when combined, offer comprehensive coverage across Uganda and its surroundings. The imagery from these radars is crucial for nowcasting and generating short-range forecasts. They play a pivotal role in tracking and analyzing the development, peak, and dissipation of convective systems in the atmosphere. The system's potential for public weather services is not yet unlocked.

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

UNMA employs the Weather Research and Forecasting (WRF) model for numerical weather prediction, producing forecasts across 10-day, monthly, and seasonal timescales. This model facilitates the generation of various meteorological forecast products, including 10-day agrometeorological bulletins, monthly climate outlooks, and seasonal climate forecasts. The predictive accuracy of these seasonal forecasts is approximately 85%. The WRF model utilizes boundary and initial conditions from the Global Forecasting System (GFS) and the Climate Forecast System (CFS).

Data Assimilation and Model Verification

Currently, UNMA's implementation of the WRF model features a single nested domain, with the outer domain encompassing much of the African continent to effectively include the influences of major semi-permanent pressure systems (St. Helena, Mascarine, Arabian high and the Azores). The model operates at a horizontal spatial resolution of 30km for the parent domain and 10km for the nested domain, extending vertically to 5km above the Earth's surface.

Data assimilation practices are in the preliminary stages, hindered by a lack of necessary expertise. Initiatives are underway to incorporate meteorological station observations and eventually radar data into the model. Future training sessions are planned to develop capabilities in running the WRF model with data assimilation.

The chosen horizontal and vertical resolutions are tailored to balance computational efficiency with the need for detailed forecast products at national scales.

UNMA's Severe Weather Forecasting (SWF) and Numerical Weather Prediction (NWP) unit is tasked with operating NWP models, analyzing conditions for severe weather, and verifying forecast accuracy.

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[25] https://sftp.eumetsat.int/public/folder/uscvknvooksycdgpmimjnq/User-Materials/PUMA/Current_PUMA_MESA_2015/ISO/ISO_Documents/MFI%20PUMA%20SYSTEM_Release%20Note_final%20version%20v1.0.pdf

[26] https://earth.nullschool.net

Verification processes assess performance across decadal, monthly, and seasonal forecasts. In February 2024, a UNMA staff member participated in a WRF output verification training program in Finland highlighting the agency's commitment to continuous improvement in forecast reliability and accuracy.

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

UNMA generates probabilistic forecasts by leveraging model guidance obtained from external sources, including leading global forecasting center. However, the organization's current computational infrastructure limits its capacity to conduct in-house ensemble forecasting. For sub-seasonal to seasonal forecasts, UNMA disseminates information categorized into terciles, representing Below Normal, Normal, and Above Normal conditions.

Summary score, recommendations, and comments for Element 5

The summary score for the above element is 2 on the CHD scale, reflecting "*Basic use of external model output and remote sensed products in the form of maps and figures, covering only a limited forecast time range*".

The primary observations and recommendations are as follows:
- The computing infrastructure at UNMA headquarters, particularly in terms of RAM and processing speed, is inadequate for running long-range and short-range forecasts simultaneously at optimal speeds.
  It is recommended that:
- Either UNMA invests in high-performance servers to establish a more capable computing cluster, enhancing model processing speeds. Furthermore, there's a significant need to enhance technical capacities, including hardware, software, and human resources, for integrating automated weather station (AWS) and radar data into model simulations.
- Or consideration could be given to prioritizing access to external modelling products as an interim solution to improve forecast accuracy for short to medium-range forecasts. KNMI, as the peer reviewer, is in favor of this option.
- The restoration of the PUMA Synergy System is critical to ensure real-time access to additional model outputs and satellite imagery, which is vital for enhancing short-range forecast accuracy.
- Strengthening collaborations with WMO Global Producing Centers for Long-Range Forecasts is essential to enrich the WRF model initialization process in addition to other input datasets from global centers such as ERA5, GloSea5, and Meteo France.
- There is a clear need for upgrading WRF verification skills through targeted training programs for the continuous improvement of forecast reliability and accuracy.

Collaboration within the East-African region is encouraged to benefit from the existing knowledge through capacity building and knowledge exchange.

Element 6: Warning and advisory services

6.1. Warning and alert service cover 24/7.
UNMA efficiently issues impact-based warnings for severe weather phenomena, including floods and extreme heat, through a dedicated Severe Weather and NWP unit. This ensures national warnings are disseminated promptly. For multi-hazard bulletins, UNMA collaborates with the National Emergency Coordination and Operations Centre (NECOC) under the Office of the Prime Minister's Disaster Preparedness Department, benefiting from a liaison officer for streamlined communication.

Impact based forecasting (IBF), indicating the consequences of severe weather, rather than just the weather itself, is in early stages of development at UNMA, an estimated 20% of its prediction products to be geared towards impact. Occasionally, UNMA staff has received basic training in IBF, but the approach has not yet been well developed and operationalized. PA KNMI is facing similar challenges. Both entities recognize the potential of IBF. UNMA has the ambition to further explore this development via training, and development of robust verification methodologies.

UNMA has basic facilities to be able to deliver 24/7 year-round early warning services, especially for the agricultural and fishery communities. However, there is room for improvement, including the set up of a 24/7 staffed emergency focused weather room. PA KNMI is willing to assist UNMA to improve early warning "weather room" facilities, including the ability to send out color coded weather warnings. The socio-economic consequences and related responsibilities of such warnings should not be underestimated.

Using the unit on Marine Weather Services, UNMA is in position to warn lake users regarding heavy winds, thunderstorms, visibility, high tides, and waves, in collaboration with fishing community representatives.

Furthermore, UNMA partners with organizations like FAO, WFP, IOM, and the Red Cross for development of multi-hazard bulletins, to further support disaster preparedness and response initiatives. However, these partnerships are primarily project-based, hampering the continuation of the activities after the project duration.

To ensure broad and efficient dissemination of alerts, UNMA utilizes a mix of digital platforms like emails, WhatsApp, Telegram, and the Common Alerting Protocol (CAP), ensuring the public receives critical weather information swiftly and accessibly. Such initiatives are jointly organized with, for instance, the Greater Entebbe Fishers Development Initiative.

It is recommended that lead times for issuing early warning alerts will be standardized within EW SOPs.

6.2. Hydrometeorological hazards for which forecasting and warning capacity is available and whether feedback and lessons learned are included to improve warnings.
UNMA proactively issues warnings and alerts for a wide range of weather-related hazards, including wind, floods, extreme rainfall and storms, strong winds, lightning, thunderstorms, droughts, and dry spells. Additionally, it conducts impact analyses and coordinates Multi-hazard Early Warning systems to enhance preparedness and response. UNMA plays a key role in the National Emergency Coordination Operations Center (NECOC) and leads a dedicated hydrometeorology unit led by a Senior Meteorologist with specialized expertise.

Through its Marine Weather Services unit, UNMA is equipped to issue timely warnings to lake users about hazardous conditions such as heavy winds, thunderstorms, reduced visibility, and significant tides and waves, ensuring safety and minimizing risks.

Significant collaborations, particularly with the FAO and WFP, have led to the development of specific triggers for floods and droughts, notably in the Karamoja sub-region of Uganda. These partnerships underscore UNMA's commitment to disaster management coordination, facilitating effective responses to weather-related challenges across the country.

It is recommendations to standardize hazard warning protocols in cooperation with the NECOC. UNMA should continue addressing stakeholders to evaluate warning effectivity, message design and user needs.

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.
UNMA has staff trained in the international Common Alerting Protocol (CAP) Standard. Accordingly, UNMA has a focal person within its Public Weather Service section to that effect. Efforts to enhance the usage of CAP are underway to onboard different partners including Red Cross and media. This CAP is coordinated through the Public Weather Service (PWS) of UNMA. There is a need for additional training of UNMA staff on the implementation of CAP.

Summary score, recommendations, and comments for Element 6

Element 6 receives a score of 3 at the CHD scale. This reflects: *"Weather-related warning service with modest public reach and informal engagement with relevant institutions, including disaster management agencies."*

Key recommendations include:
- UNMA faces challenges in developing flood threshold capacities and lacks a pollution monitoring bulletin, underscoring the need for specialized training in flood forecasting and air pollution monitoring. Enhancing staff skills in dynamic modelling tools will facilitate the operationalization of flood monitoring bulletins, while training in air pollution monitoring is essential for launching a dedicated division.
- There's also a broader need for comprehensive training in issuing warnings and advisories, coupled with efforts to sensitize stakeholders on utilizing the Common Alerting Protocol (CAP) to ensure messages effectively reach and impact the community. Partnering with other Uganda authorities that issue CAP message can be explored. Improving message clarity and public understanding is critical. In addition, the development of a comprehensive and accessible weather warning mapping tool would enable the public to grasp the overall weather situation at a glance.
- The deployment of automated tools for publishing (public) nowcasting information, leveraging the observation capabilities of the three weather radars, is urgently needed. This advancement would maximize the equipment's potential, significantly enhancing weather prediction and monitoring capabilities. Especially, since society is heavily impacted by severe rain by means of, for example, traffic congestion by changing road conditions.
- Moreover, air pollution monitoring is part of UNMA's responsibility, however, an observation network and trained staff for interpreting the data is absent. These two elements are essential for launching a dedicated division.

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.

Presently, Uganda has not yet achieved level 1 for National Framework for Climate Services (NFCS) implementation[27]. UNMA is actively developing a national framework for weather, water, and climate services for Uganda, supported and facilitated by ICPAC[28]. The national framework will be guided by the principles outlined by the World Meteorological Organization's (WMO) Global Framework for Climate Services (GFCS) guidelines.

UNMA's Directorate of Applied Meteorology, Data, and Climate Services (DADCs), under a director's leadership, coordinates the processing, managing, and archiving of climate data. This directorate is pivotal in coordinating the development and dissemination of climate-related information and products. Utilizing Climsoft, a user-friendly and accessible Climate Data Management System (CDMS), UNMA enhances its climate data archiving capabilities. Seven staff members have been trained to use Climsoft, acknowledging the need for continuous training due to its periodic updates.

The integration of Climsoft with existing automatic weather stations and weather buoys (located in the vast water bodies of Uganda, including Lake Victoria and Lake Albert) has not been explored. UNMA lacks the technical capacity to undertake the integration of the various observations systems.

For the non-automated, manned stations, data transfer from station to UNMA could be improved, and eventually be replaced by automated systems. At present, the senior zonal officers receive the data through telephone calls snapshots of the 10-day record send by observer to the senior zonal officer using WhatsApp. A better (temporary) option would be using a smartphone application to key in the data at the observation point, followed by immediate validation and quality control at UNMA Head Office. A smartphone application is preferred since PCs are not always available at the observation stations.

To enhance climate services, UNMA has initiated User Interface Platforms (UIPs), ensuring the efficient delivery of Early Warning Services (EWS) to stakeholders at national and sub-national levels. Four (4) UIP's are currently active. Participating stakeholders include government ministries (e.g., Ministry of Agriculture, Animal Industry and Fisheries, Ministry of Energy and Mineral Development, Ministry of Works and Transport); the Kampala City Council Authority (KCCA); the Department of Disaster Preparedness and Management; District Local Governments; and Farmers at Parish level).

UNMA has an ongoing collaboration with Makerere University, which has yielded the Weather Information Dissemination System (WIDS). The system allows the public to access weather and climate information through a USSD interface on mobile phones.

UNMA's demonstrates commitment to leveraging technology for improved climate service provision. UNMA's ambition relates to improving seasonal climate forecasting for agricultural purposes, the aviation industry, health, and infrastructural development.

UNMA hosts a wealth of manually recorded historical weather and climate data from the British Colonial and East African Community eras. A dedicated data rescue and digitalization program is recommended to facilitate the accessibility of these data for scientific research and model improvement.

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[27] 2023 status NFCS. https://wmo.int/sites/default/files/2023-10/NFCS%20Status%20as%20of%2013%20Oct%202023%20Table.pdf

[28] https://www.icpac.net

Furthermore, since 2017, UNMA publishes a yearly State of the Climate Uganda report on the climate over the prevailing year in comparison to climatology. UNMA participates in the WMO State of the Climate by submitting a climate summary (text and figures) drawn from the national annual state of the climate report. The annual state of the climate of Uganda report can be found on UNMA's website.

Summary score, recommendations, and comments for Element 7

The summary score for element 7 is 2 on the CHD scale, representing "*Basic Capacity for Climate Services Provision*".

To optimize climate services support and development are needed in every area of the value chain for Uganda. Significant improvements can be achieved by focusing on:

- Governance: Further strengthen national governance mechanisms to facilitate coordination for climate services; further streamlining contributions from UNMA to national adaptation planning.
- Data basis: Development of a comprehensive historical weather- and climate data rescue program within the framework of improving climate models and services.
- Basic system improvements: Facilitate a robust observation network, data collection, data management, and monitoring and forecasting systems as they are essential for the production and delivery of accurate climate information and services. Data communication between stations, including buoys, and UNMA servers is a priority.
- Further strengthening interaction between climate service users and providers (here UNMA), as has been developed under the National Climate Outlook Fora (NCOF) and Sub-National Climate Outlook Fora (SNCOF), (see element 10). These interactions are critical for co-producing and tailoring services to meet the specific needs of decision-makers, as well as ensuring effective decision support and feedback.
- Interaction should lead to development of decision-support products and services that cater to the diverse needs of users and anticipate climate adaptation measures.
- To facilitate adequate resources for climate services its recommended to improve monitoring and evaluation of socio-economic benefits, aimed at the cost-benefits of networks, data management, monitoring, and forecasting systems, rather than just the potential climate impacts on economic sectors.
- Capacity Development: Provide continuous technical advisory services and training programs to address the capacity development needs for both climate service provision and utilization.

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.

In Uganda, the Directorate of Water Resources Management (DWRM) oversees the integrated and sustainable management and development of the country's water resources, operating under the Ministry of Water and Environment (MWE) as one of its three directorates.
DWRM plays a crucial role in the integrated and sustainable management and development of the country's water resources. DWRM collaborates with the Uganda National Meteorological Authority (UNMA) to utilize precipitation data, including radar data, for various hydrological applications.

UNMA is tasked with generating past, present, and future forecasts of rainfall and temperature to assist in a range of planning and response activities. These forecasts include nowcasts, daily, 10-day, monthly, and seasonal projections, which are invaluable for hydrological planning and management. However, a significant challenge is that UNMA's meteorological forecasts currently lack the spatial resolution needed to accurately predict specific hydrological conditions, such as river water flow and soil moisture levels.

At present, the development and implementation of hydrometeorological modeling and forecasting across different temporal and spatial scales remain underdeveloped. This is largely due to limited collaboration between UNMA, DWRM, and the Directorate of Water for Development (DWD). Enhancing collaboration, fostering mutual understanding, and building synergies among these agencies is highly recommended. Joint training exercises for meteorologists from UNMA and hydrologists from DWRM and DWD are suggested to improve mutual understanding. Moreover, developing joint information products that effectively translate hydrometeorological data into actionable insights for disaster risk reduction practitioners will significantly enhance preparedness and response efforts related to weather and climate events.

8.2. SOPs in place to formalize the relation between Met Service and Hydrology Agency, showing evidence that the whole value chain is addressed.
Currently, there are no SOPs or cooperation agreement in place to formalize the relation between UNMA, DWRM and DWD.

8.3. Data sharing agreements (between local and national agencies, and across international borders as required) on hydrological data in place or under development.
UNMA manages a comprehensive archive of climate data through Climsoft, a Climate Data Management System (CDMS), whereas the Directorate of Water Resources Management (DWRM) utilizes HYDATA for maintaining hydrological data. A proposal, supported by the Green Climate Fund (GCF), aims to develop software and applications that would integrate meteorological and hydrological databases into a unified hydrometeorological database. The successful implementation of this initiative is anticipated to allow DWRM to effectively utilize meteorological observations from both manned and automatic weather stations. These observations would serve as vital inputs for hydrological models, enhancing the accuracy and effectiveness of water resource management and planning.

8.4 Joint projects/initiatives with hydrological community designed to build hydrometeorological cooperation.
During the (sub)-National Climate Outlook Forums (NCOFs and SNCOFs), DWRM is a major stakeholder in the collaborative production of advisories for the water resources sector.

In 2018, a project endorsed by the URCF / IFRC enabled one staff member from UNMA and another from DWRM to attend a Global Flood Awareness System (GloFAS) training event at the University of Reading in the United Kingdom. This initiative highlighted the importance of global collaboration and knowledge exchange in disaster readiness and response.

Currently, UNMA and DWRM are engaged in an eight-year collaborative effort aimed at fostering resilient communities and the restoration of wetland ecosystems and their catchments in western and eastern Uganda. Additionally, both organizations are key participants in the 'Water at the Heart of Climate Action' project, underscoring their commitment to addressing climate change impacts on water resources.

These joint endeavors underscore the potential for enhancing the partnership between UNMA, DWRM, and the Directorate of Water for Development (DWD) in producing hydrometeorological information. Such collaboration is crucial for mitigating the risks associated with extreme weather and climate events, through the integration of climate and hydrology information services, thus reducing vulnerabilities across communities.

Summary score, recommendations, and comments for Element 8

The summary score, based on UNMAs suggestion, for this element is 1 on the CHD-scale, reflecting *"No or very little meteorological input in hydrology and water resource management."*

It is important to recognize the intentions for collaboration vs the actual exchange of data and development of mutual information products, as at this moment.

Recommendations:

- Initiate joint training and/ explorative work session on integration of meteorological and hydrological observations, data management, modelling and public awareness raising. A combined effort including stakeholders on early warning and disaster preparedness and responds is advised upon.
- It is advised to develop synergy and collaboration from the bottom up, rather than via governmental policy reform.
- It is advised to actively seek further international support to facilitate such developments within UNMA, including in partnership with KNMI, as the Peer Advisor.

Element 9: Product dissemination and outreach

9.1. Channels used for user-centered 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?).

In Uganda about over 80% of the people have access to radio, less have access to TV. Access to mobile or fixed internet is commonly 25% in 2023 and increasing rapidly[29]. Uganda was home to 2.05 million social media users in January 2023, equating to 4.3 percent of the total population. A total of 30.55 million cellular mobile connections were active in Uganda in early 2023, equivalent to 63.8 percent of the total population.

UNMA, while not owning a television station, collaborates with the National Broadcaster, Uganda Broadcasting Corporation (UBC), and other local TV stations like Bukedde and Star TV to disseminate weather information on a six-hourly and daily basis. Broadcasts are not guaranteed, but daily publications are present at UNMA's YouTube channel[30]. UNMA operates a modest studio at the NMC in Entebbe with some editing capabilities, though broadcasts require enhancements, including updated icons for clearer public presentation and understanding.

A key partnership with Makerere University facilitated the development and operationalization of the Weather Information Dissemination System (WIDS)[31], a platform designed to deliver real-time, accurate weather information via web and mobile USSD interfaces to a broad spectrum of stakeholders.

Additionally, UNMA engages in extensive outreach through local FM radio stations nationwide and workshops in partnership with NGOs and other government agencies. A comprehensive email database allows the distribution of weather and climate forecasts, ranging from 6-hourly updates to seasonal forecasts, to technical officers across Uganda.

The institution's website, www.unma.go.ug, serves as a hub for accessing weather and climate early warnings. Moreover, UNMA actively utilizes social media platforms, including Twitter, WhatsApp, and Telegram, to ensure broad dissemination of forecast products to the public.

In 2023, UNMA was active on social media platforms:
- SMS have been sent to 6000 people representing central and local management.
- WhatsApp groups
- X (256 subscribers)
- Facebook (386 subscribers)
- YouTube (453 subscribers).
- Pre-recorded weather forecast for phone (has a cost, and thus, limited use).
- Toll free number.

9.2. Education and awareness initiatives in place.

For public awareness and education related to weather, climate (change) and societal effects UNMA actively engages in public communications. UNMA has initiated the Popularizing Meteorology in Schools (POMs) program. This outreach initiative targets both secondary and primary schools, aiming to foster interest in meteorology among students by highlighting the field's significance and potential career paths for a next generation of meteorologists.

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

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[29] https://datareportal.com/reports/digital-2023-uganda
[30] https://www.youtube.com/@ugandameteo
[31] https://www.wids.unma.go.ug

The institution is committed to inclusivity, tailoring its training programs to support marginalized communities, including a focus on gender inclusivity. UNMA is making strides in accessibility by translating climate early warning products into local languages and to develop understandable icons for indigenous populations. However, gaps remain in adequately serving individuals with hearing impairments and visual disabilities. To bridge this gap, there's a recognized need for UNMA to either hire or train specialists in these areas to ensure comprehensive support and accessibility for all community members.

The climate crisis is far from "gender neutral". Women and men are affected differently by weather and climate, and therefore need gender-sensitive information and services, as WMO Secretary-General Celeste Saulo mentioned in a keynote address. Women and girls are disproportionately affected by climate change and weather-related disasters. In addition, we know that they have less access to climate information, early warnings, agricultural advisory services, mobile phone technology and financial credit.

Summary score, recommendations, and comments for Element 9
Element 9 receives a score of 2 on the CHD scale. This reflects: *"Traditional communication channels and a basic dedicated website is used to disseminate forecasts and basic information."*

While UNMA has made significant strides in outreach and awareness, there remains a critical need to refine forecasts into formats easily understood by all stakeholders. Current dissemination channels fall short of effectively delivering early warning information. To address this, support is essential for establishing regional/district meteorologists in each district, ensuring climate and weather early warnings are effectively communicated, correctly interpreted, and utilized at the community level. Additionally, the development of user-friendly apps for alert dissemination represents a vital step forward in enhancing the accessibility and impact of early warning systems.

Urgent development needs include:
- Enhance broadcast capabilities by updating presentation icons for clearer public understanding and consider establishing UNMA's own television broadcast channel or more robust video production facilities.
- Expand the outreach through local FM radio stations and further develop partnerships with NGOs and government agencies for wider dissemination of weather information. Establishing regional/district meteorologists in each district as contact points.
- Increase the use, quality and frequency of social media communications and digital platforms to disseminate weather forecasts and early warnings. Explore the development of a comprehensive app for easier dissemination of alerts and weather information directly to the public's smartphones. However, increased communication efforts should be backed by increased levels to now- and forecasting, as the information quality will be leading in achieving higher appreciation of UNMA's services and efforts.

On education and training:
- Address inclusivity gaps by translating climate early warning products into more local languages and developing specific outreach strategies for individuals with hearing and visual impairments.

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.
The Uganda National Meteorological Authority (UNMA) proactively involves the users of weather and climate information through the National Climate Outlook Forum (NCOF) and Sub-National Climate Outlook Fora (SNCOF), held annually since 2022 in September, strategically before the onset of the rainy season. These forums gather experts from various government ministries, departments and their agencies, development partners, the private sector, and farmer representatives. The NCOF and SNCOF sessions serve as a platform for stakeholders to review outcomes from the previous rainy season, assess potential implications, and formulate advisories for the upcoming season based on UNMA's forecasts. Development partners, including the Uganda Red Cross Society, World Food Program (WFP), FAO, and USAID, often provide financial support for these forums. Nonetheless, the allocation of resources for organizing NCOFs and SNCOFs remains variable and subject to availability.

To reach last-mile users, UNMA conducts quarterly Parish Weather Clinics (PWCs), targeting smaller administrative units known as parishes, which typically comprise populations not exceeding 6,000 individuals. PWCs facilitate direct interaction between UNMA staff and local community leaders, including political figures, religious authorities, elders, and retirees, focusing on the accessibility, interpretation, and application of weather and climate information. Currently, the PWCs are financed by the Government of Uganda (GoU. However, the sustainability of GoU funding is uncertain, often impacted by shifting governmental priorities.

10.2. Independent user satisfaction surveys are conducted, and the results used to inform service improvement.
UNMA conducts annual independent user satisfaction surveys of the general public to gauge the effectiveness of its services and identify areas for enhancement. One or two surveys are typically conducted via basic questionnaires, primarily in English, to capture a broad spectrum of user experiences and expectations. Qualitative feedback is also gathered during the PWCs, NCOFs, SNCOFs.

However, these feedback mechanisms are recognized as insufficient to provide a robust feedback loop. The 2022 survey revealed a significant rise in demand for weather and climate information, especially from the public-, agriculture-, and aviation sectors. More specifically, the public is increasingly demanding for more accurate and reliable forecasts (across timescales) that are more area specific. To address this need, UNMA would be required to run high resolution (e.g., 3km) NWP and climate model output to aid forecasting thereby underscoring the need for UNMA to refine and broaden its offerings to meet these evolving requirements.

PA KNMI advises to explore international collaboration and centralized NWP facilities (global and regional levels) as a first step to improve forecast capacity at UNMA. For its current WRF model, the resolution can be adjusted, if UNMA was provided with sufficient computing power, as the latter is the limiting factor within UNMA. Stepping away from decentralized, inhouse computing facilities and rely totally on international facilities is a matter of governmental policy and national regulations, issues to be addressed in the coming years.

UNMA has the ambition to introduce quarterly customer satisfaction surveys. In the current state, UNMA lacks the computing resources to produce model output needed to generate area-specific forecasts.

10.3. Quality management processes that satisfy key user needs and support continuous improvement.
In 2018, UNMA achieved ISO 9001:2015 certification for its Aeronautical Meteorological services, initially focusing on Entebbe International Airport. There is now a need to extend this quality management scope to include additional regional airports like Arua, Kasese, Gulu, Jinja, Soroti, and Kabalega, as well

as to cover applied meteorology, data, and climate services, and the NMTS. The certification mandates UNMA to conduct regular surveillance audits to address Non-Conformities (NCs) and improve service quality continually. The forthcoming external surveillance audit is scheduled for March 2024, marking an opportunity for UNMA to enhance its standards further.

Summary score, recommendations, and comments for Element 10

Element 10 receives a score of 3 on the CHD scale, reflecting "Services development draws on regular dialogue with major stakeholders."

It is recommended that:
- UNMA continuous and guarantees its intensive stakeholder interaction (PWCs, NCOFs, SNCOFs). Financial support therefore should be secured via GoU or development partners.

- The concept of the NCOF has regional potential, both as a concept for neighboring countries and within a regional version (Regional Climate Outlook Forum) with the context of the East African Society.

- The expansion of the implementation of a Quality Management System needs to be accelerated over the coming years due to interdependence of the various processes. Extending ISO 9001 certification for its aeronautical meteorological services to regional airports (Arua, Kasese, Gulu, Jinja, Soroti, and Kabalega) could be a first step.

- UNMA has the ambition to intensify customer satisfaction surveys will be of little use if UNMA does not have the means to follow up on requests, demands improved service delivery. It's the lack of resources that is hampering a higher service quality, not the willingness.

Annex 1 Consultations (including experts and stakeholder consultations)

- The following stakeholders have been consulted, either directly or indirectly: Ministry for Environment, Office of the Prime Minister – Department for Disaster Preparedness and Management, the Uganda Civil Aviation Authority, the Greater Entebbe Fishers Development Initiative, the Uganda Red Cross Society / International Red Cross Foundation, Uganda National Farmers Federation.
- CREWS East-Africa project was consulted on planned activities and investment planning between SOFF investment phase in Uganda.
- Consultation of WMO in WISBOX-WIS2.0 matter will continue.
- KNMI experts have been consulted on peer review findings and recommendations.
- Communications with SOFF peer reviewers for the neighboring countries will continue after completion of this report.

Annex 2: Urgent needs reported.

UNMA needs development support throughout the complete value chain of providing reliable and accessible weather and early warning services, within the context of SOFF/GBON and in more general terms. The following urgent needs have been identified:

- The current legal framework and funding from the Government of Uganda (GoU) do not enable sufficient cost-recovery services for UNMA. Adequate funding and cost-recovery mechanisms would provide UNMA with additional resources, ensuring sustainability of operations and the development of value-added services tailored to end-user needs. The critical role of weather and climate services, including early warnings and nowcasting, is not adequately reflected in UNMA's financial allocations, given Uganda's high socio-economic vulnerability to extreme weather events.
- The ongoing debate regarding UNMA's semi-independent status and potential reintegration into the Ministry of Water and Environment generates uncertainty, also among staff and management. The change of status could affect international collaborations and investments. Maintaining UNMA's status is recommended to ensure independence in weather and climate observations, at arms length from political influences.
- Understaffing and challenges in recruiting skilled personnel pose a significant threat to UNMA's development and quality assurance of data and services across nearly the entire data observation chain. Significant efforts related to SOFF/GBON may not be fully leveraged due to these challenges and should be considered. Special attention is needed for station operations, network and sensor maintenance, calibration, data management, and UAS operations. UNMA's internal training capacity may be insufficient to tackle this challenge. Targeted international projects should aim to address these critical training needs to ensure sustainability.
- Gender equity, particularly at the management level, requires continuous attention. Women and girls are disproportionately affected by climate change and weather-related disasters, therefore need gender-sensitive information and services.
- UNMA's observation system faces critical gaps that compromise the efficiency of nowcasting and early warning services, including the absence of a lightning detection system and insufficient capacity to utilize data from three operational weather radar stations. Additionally, there has been no operational upper air sounding system since 2016.
- A significant limitation for GBON is the semi-automatic nature of the surface weather observation system, which completely relies on manual data transfer, preventing 24/7 near-real-time data transfer. None of UNMA's stations are connected to the Global Telecommunication System (GTS), WIS, or WIS 2.0.
- UNMA lacks an integrated data management system for storing, processing, and automatically disseminating observation data for further use.
- There is a need for a comprehensive digitalization and data rescue program for UNMA's historical climate records.
- While customer engagement is effectively organized through initiatives like the Uganda National Climate Outlook Forum, rapidly increasing customer demands exceed UNMA's current service capabilities. Communication strategies could be enhanced for greater user-friendliness, and mobile applications for weather forecasts and warnings should be further explored, especially for the agriculture and fisheries sectors.
- Implementing a new automated forecast verification system with multiple scores is crucial for continuously improving forecast accuracy.
- The capabilities for weather forecasting and early warnings are basic. There is a need to develop impact-based forecasting and enhance seasonal climate predictions. The computing hardware, software and capacity should be balanced to the updated data collection capability and the required computing power.

However, considering the constraints on human resources and UNMA's dependency on the GoU's staffing limitations, it may be beneficial to outsource computing power and the development of tailored meteorological products to specialized centers abroad, rather than expanding in-house computing and server capacity, and developing a modern forecasting workstations and automated systems within UNMA. Similarly, options for maximizing the autonomous operations of the AWS network should be considered.

- Regional cooperation with other NMHSs, strategic partnerships, and peer advisory cooperation are strongly recommended to enhance knowledge exchange, resource distribution, and calibration capabilities.
- Strengthening strategic cooperation with academic institutions, governmental agencies, and NGOs, particularly in disaster preparedness, is highly encouraged, both at national and regional levels.
- UNMA is strongly encouraged to increase its involvement in international cooperation programs. Donors are advised to build further on the work already accomplished, attentively consider UNMA's priorities, and ensure that a significant portion of the available funding is directly allocated to UNMA.

The Royal Netherlands Meteorological Institute (KNMI), as UNMA's SOFF peer advisor, is committed to supporting UNMA in strategic and operational development and the modernization of its systems.

Annex 3 Information supplied through WMO

Peer adviser KNMI acknowledges the numerous lists of references provided by SOFF in templates and guiding material throughout the Readiness phase, including information and guidance given in the CHD data inventory and review sheet for Uganda.

Annex 4 List of materials used

The peer adviser KNMI utilised the following materials:

- Materials and documents provided by the Uganda National Meteorological Authority (UNMA).
- Online material included as references to this document.
- Web pages of the Government of Uganda and UNMA.
- Reflections and inputs provided by the Ministry of Water and Environment (e.g. related to hydrological services).
- Interview data, in person contributions and personal communication and reflections provided during the drafting of this report.