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Kampala, Uganda

WED

21°C

Mostly Clear

0.2%

SUN	MON	TUE	WED	THU	FRI	SAT
27°	27°	26°	21°	23°	21°	18°
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A VALUE FOR MONEY AUDIT REPORT ON THE RELIABILITY OF METEOROLOGICAL INFORMATION BY UGANDA NATIONAL METEOROLOGICAL AUTHORITY (UNMA)

A REPORT BY THE AUDITOR GENERAL

DECEMBER, 2018

THE REPUBLIC OF UGANDA

OFFICE OF THE AUDITOR GENERAL

The reliability of meteorological information produced by Uganda National Meteorological Authority (UNMA)

A Report by the Auditor General

December, 2018

AUDITOR GENERAL'S MESSAGE

24th December 2018

The Rt. Hon. Speaker of Parliament
Parliament of Uganda
Kampala.

VALUE FOR MONEY AUDIT REPORT ON THE RELIABILITY OF METEOROLOGICAL INFORMATION PRODUCED BY UGANDA NATIONAL METEOROLOGICAL AUTHORITY (UNMA)

In accordance with Article 163(3) of the Constitution, I hereby submit my report on the audit undertaken on the Reliability of Meteorological Information Produced by Uganda National Meteorological Authority (UNMA).

My office intends to carry out a follow-up at an appropriate time regarding actions taken in relation to the recommendations in this report.

I would like to thank my staff who undertook this audit, Dr Alex Nimusiima the Consultant from the Department of Geography, Geo-Informatics and Climatic Sciences of Makerere University, and the staff of the Uganda National Meteorological Authority (UNMA) for the assistance offered to my staff during the period of the audit.

John F.S. Muwanga
AUDITOR GENERAL

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ABBREVIATIONS

AMSS	Automatic message switching system
CAA	Civil Aviation Authority
CAM	Commissions for Aeronautical Meteorology
CMM	Marine Meteorology
EAC	East Africa Community
EAMD	East African Meteorological Department
EWS	Early Warning System
GPS	Global positioning system
GTS	Global Telecommunication System
HROM	Human Resource Operations Manual
ICAO	International Civil Aviation Organization
ICT	Information Communication Telecommunications
IPCC	Inter-Governmental Panel on Climate Change
ISO	International Organization for Standardization
JJA	June, July, and August
MAM	March, April, and May
MWO	Meteorological Watch Office
NARO	National Agricultural Research Organization
NMC	National Meteorological Centre
NWP	Numerical Weather Prediction
QMS	Quality Management System
UNBS	Uganda National Bureau of Standards
UNDP	United Nations Development Programme
UNMA	Uganda National Meteorological Authority
USAID	United States Agency for International Development
WMO	World Meteorological Organization

EXECUTIVE SUMMARY

Most activities done by people, particularly outdoor activities, have to be done with weather in mind and therefore it is critical to provide meteorological services that support relevant national needs, such as: protection of life and property, safeguarding the environment and contributing to sustainable development. In the recent past, the impacts of climate change, such as: unreliable rains, increased frequency of floods, landslides, drought as well as disease outbreaks and epidemics like malaria and cholera, among others, have been rampant.

In Uganda, meteorological services are provided by Uganda National Meteorological Authority (UNMA) which is a semi-autonomous government institution and a Government's authoritative voice on weather and climate.
UNMA is mandated to promote, monitor weather and climate as well as provide weather predictions and advisories to Government and other stakeholders for use in the sustainable development of the country and these services are guided by the World Meteorological Organization (WMO) standards, International Civil Aviation Organization (ICAO) standards, the National Climate Change Policy 2015, and UNMA Act 2012.

The Office of the Auditor General undertook a value for money audit to assess the measures put in place by the Uganda National Meteorological Authority (UNMA) to produce and disseminate accurate, timely and comprehensive meteorological information that meets the information needs of users. In order to achieve this, the audit assessed the procedures used by UNMA to carry out weather observations and whether they were in a manner prescribed by World Meteorological Organization standards; the process of data processing, analysis and storage and whether it was in accordance with the recommended best practices; and the appropriateness of the dissemination mechanisms employed by UNMA to ensure that weather and climate products and services are received by the different stakeholders in a timely manner.

The study covered two financial years 2016/17 and 2017/18 and focused on functioning manual and automatic weather stations.

KEY AUDIT FINDINGS

1. At the time of the audit, only Entebbe synoptic station was observing and reporting meteorological data every hour as required by WMO.
The other synoptic stations were only operating 12 hours during daytime and thus failed to observe the main standard hours of times of 3 am (0000z) and 9 pm (1800z).

2. UNMA has not had a governing board since February 2017. This Board is responsible for recruiting and appointing staff and formulation of Meteorology Regulations.17.

3. Except for the weather equipment at Entebbe synoptic station that was calibrated in January 2017, none of the equipment in all the other sampled stations had been calibrated in the two year period (FY 16/17 and FY 17/18).

4. Most weather parameters were being observed and reported on by synoptic stations as required by WMO. However, both Agromet and Hydromet stations were not observing and reporting on some key parameters required by WMO.
For the Agromet stations, the parameters not observed and reported on included soil temperature, soil moisture and evaporation; all the Hydromet stations inspected lacked data on river water level, river discharge, suspended sediment in river and water quality.

5. Except for Entebbe aerodrome station that reported aerodrome warnings and wind shear warnings as required by ICAO, all the other four aerodrome stations that is Soroti, Gulu, Kasese and Arua did not observe and report on these parameters.

6. By audit time, no weather radars had been installed, only 29 (56%) of the 52 manual weather stations installed were functional, 43 automatic weather stations had been installed and were functional though not reporting on a regular basis.

7. By audit time, UNMA did not have a data backup system as required by WMO and of the required weather parameters, only records for 2 parameters, namely: rainfall, and temperature, had been partially digitalized at 80% and 40%, respectively.
In addition, less than 10% of the original manual weather records had been scanned.

8. Seasonal climate outlooks were not being received by the farmers on a quarterly basis. In addition, the fishermen, especially on Lake Victoria, were not receiving weather alerts.

KEY RECOMMENDATIONS

a) UNMA should liaise with the relevant authorities to ensure that the appointment of the board members is fast-tracked to facilitate recruitment of substantive staff at all levels.

b) UNMA should prioritize calibration of its key equipment by setting aside a budget for this purpose, pursuing regional collaborative arrangements with neighbouring states for possible partnerships a n d also in the long run set up calibration laboratories.

c) UNMA Management should continue to plan and budget for the required equipment and instruments and also liaise with relevant authorities to ensure that stations are equipped with essential equipment and instruments.

d) UNMA should develop maintenance and replacement plans for the existing weather stations, especially rainfall stations, and ensure that regular maintenance is carried out.

e) Staff in the data processing unit need more specialised training on the use of the CLIMSOFT so that they can be in position to perform troubleshooting and regular maintenance of the software instead of relying on hired experts.

f) UNMA should prioritize digitisation and scanning of original weather records by planning and budgeting for scanners, staff and data backup systems.

g) UNMA should develop and implement a robust dissemination mechanism that will ensure all District production officers and other users receive weather and climate information in time.
For instance, UNMA needs to work directly with farmer associations and fishermen groups to ensure that meteorological information is received by the individual persons in time.

OVERALL AUDIT CONCLUSION

Whereas meteorological services remain important in the sustainable development of the country and in reducing the environmental hazards that Uganda is currently facing, UNMA still faces challenges of inadequate essential equipment, uncalibrated equipment, limited coverage and functionality of stations and lack of high speed processing facilities, among others.

The measures put in place by UNMA to produce and disseminate accurate, timely and comprehensive meteorological information are still inadequate and, therefore, UNMA's strategic objectives are likely not to be achieved.

CHAPTER ONE

01

The reliability of meteorological information produced by
Uganda National Meteorological Authority (UNMA) | A Report by the Auditor General

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Today humans largely depend on weather information to aid in their decision making. According to Muchetu (2014), most activities done by people, particularly outdoor activities, have to be done with weather in mind[1]. It is critical to provide meteorological services that support relevant national needs, such as: protection of life and property, safeguarding the environment, contributing to sustainable development , promoting long-term observation and collection of meteorological, hydrological and Climatological data, including related environmental data, promotion of indigenous capacity building, meeting international commitments and obligations and contributing to international cooperation[2].

According to the UNMA Act 2012, Meteorology is the science of the atmosphere that embraces both weather and climate and is concerned with the physical and chemical state of the earth atmosphere. Meteorological data has been defined as facts pertaining to the atmosphere such as wind, temperature, precipitation, air density and other phenomena that affect air operations[3].

The Government of Uganda (GoU) has always recognised natural resources (including weather and climate) as a basic factor in the country's national development process. The day to day management and harnessing of all natural resources are largely dependent on the state of the environment, weather and climate which are important factors in the social and economic development of the country since they have major influences on the developments of all other sectors of the economy[4].

1.2 MOTIVATION

Many Government investments are being carried out without incorporation of meteorological aspects which affects the viability of such investments in the short and long run causing social and economic losses[5]. In Uganda, the impacts of climate change such as unreliable rains, increased frequency of floods, landslides, drought as well as disease outbreaks and epidemics like malaria and cholera, among others, have been rampant in the recent past. These aspects have significant implications for agriculture, food security, soil and water resources[6]. Climatic changes affect the other Sustainable Development Goals (SDGs)[7] and often make it more difficult to achieve them.

World Meteorological Organization (WMO) to which UNMA is a member is a co-custodian of SDG 13 on climate action[8]. UNMA is required to play a stronger role in protecting life and property and in building weather and climate resilience through the provision of timely, accurate and reliable meteorological information[9].

1 Assessment of the Reliability of World Weather Online Forecasts for Kadoma Community
2 Uganda National Meteorological Authority (UNMA) Strategic Plan July 2017 – June 2021 multiply country's data problems - Daily monitor-Monday April, 24th 2017.
3 https://www.thefreedictionary.com/meteorological+data
4 https://www.unma.go.ug/index.php/about-unma/who-we-are
5 MWE sector performance report 2016, page 127.
6 Impacts of Climate Change in Uganda.
7 Known as the Global Goals, are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity.
8 SDGs, Contributions of WMO Community
9 SDGs, Contributions of WMO Community

Despite the need for timely, accurate and reliable weather and climate information, Uganda National Meteorological Authority (UNMA) has continued to encounter several challenges while executing its mandate of promoting, monitoring weather and climate as well as providing weather predictions and advisories to Government and other stakeholders for use in the sustainable development of the country. Some of the challenges experienced by UNMA include understaffing at all levels, inadequate meteorological infrastructure, limited computing facilities to run operational weather and climate models, limited library resources, lack of calibration laboratories, inadequate weather equipment and instruments and limited data archiving capability, among others.

As a result, Uganda's meteorological systems do not adequately meet the needs of its citizens for simple access to past weather and climate data, present conditions and hazards, or detailed and accurate forecasts of future weather.[10]

In light of the challenges noted above, an independent assessment was undertaken by the Office of the Auditor General to assess the measures put in place by Uganda National Meteorological Authority (UNMA) to produce accurate, timely and comprehensive meteorological information that meets the information needs of users.

1.3 DESCRIPTION OF THE AUDIT AREA

1.3.1 General description

Uganda National Meteorological Authority (UNMA), a successor of the Department of Meteorology (DoM) of the Ministry of Water and Environment (MWE), is a semi-autonomous government institution under the MWE and Government's authoritative voice on Weather and Climate. UNMA was established on 24th January 2014 following the enactment of the UNMA Act 2012. UNMA's mandate is to promote and monitor weather and climate as well as provide weather predictions and advisories to Government and other stakeholders for use in the sustainable development of the country. UNMA provides meteorological services to the different sectors of the economy, including the aviation industry, air defence, and environmental monitoring, water resources management, agriculture, transport, tourism and disaster management, among others[11].

In order to provide meteorological services, UNMA has installed 52 manual and 43 automatic weather stations across the country. The 52 manual weather stations include 12 synoptic stations, 23 agromet stations and 17 hydromet stations which are manned by weather observers. An automatic weather station (AWS) is an automated version of the traditional weather station, and is used either to save human labour or to enable measurements from remote areas. Automatic weather stations report in real time or save the data for later recovery.

1.3.2 Legal Framework

Meteorological services are guided by the National Climate Change Policy 2015, UNMA Act 2012 and the East Africa Community Meteorological Data Policy. The Policies and Act also provide the institutional structure to produce and deliver meteorological services.

UNMA'S mandate is to promote, monitor weather and climate as well as provide weather predictions and advisories to Government and other stakeholders for use in the sustainable development of the country.

10 Meteorological Early Warning System to Build Resilience to Climate-Induced Shocks
11 UNMA strategic plan July 2017 – June 2021, Paragraph 2.1 page 5

1.3.3 Vision and Mission

Vision

UNMA's vision is to be a centre of excellence on weather and climate services for sustainable development of Uganda[12].

Mission

UNMA's mission is to contribute to overall national development through the provision of quality customer focused cost effective and timely information for weather and climate services to all users[13].

1.3.4 Strategic Objectives

Uganda National Meteorological Authority (UNMA) has set the following strategic objectives[14] on which to focus its operations and maximise the use of available resources.

a) To improve the quantity and quality of meteorological services to customers by strengthening the observing network, National Meteorological Centre (NMC), data and information exchange according to WMO (World Meteorological Organization) and International Civil Aviation Organization (ICAO) standards.

b) To build a skilled and motivated workforce through good human resource management practices.

c) To promote greater awareness of the benefits of using meteorological services, information and products for public safety and socio-economic planning [through workshops, print media, and talk shows.

d) To improve the accuracy and reliability of forecasts and advisory services to customers through the development of climate prediction and short-term weather forecasting capability.

e) To achieve a sustained increase in revenue generation besides earnings from services for the public good to facilitate implementation of other strategic objectives.

1.3.5 Functions of Uganda National Meteorological Authority (UNMA)[15]

a) Establish and maintain a system for rapid exchange of meteorological and related information.

b) Establish a network of stations for taking, recording and transmitting meteorological observations as well as hydrological and other geophysical observations related to meteorology.

c) 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.

d) Apply technology to aviation, marine transport, water resources management, agriculture, health, national defence and security, disaster preparedness and other development activities.

e) Research and train in meteorology and related fields and coordinate national, regional and international aspects of research and training.

f) Establish a framework under which aeronautical meteorological services are paid for at commercial rates by end users.

g) Establish and maintain a total quality management system in operations while providing the necessary data essential for the environmental impact assessment.

h) Monitor the state of the atmosphere in Uganda at different times and spatial scales, analyse, document and disseminate weather and climate trends and their implications on socio-economic development.

11 UNMA strategic plan July 2017 – June 2021, Paragraph 2.1 page 5
12 UNMA strategic plan July 2017 – June 2021, Paragraph 4.1 page 25
13 UNMA strategic plan July 2017 – June 2021, Paragraph 4.2 page2 5
14 UNMA strategic plan July 2017 – June 2021, Paragraph 5.12 page 27
15 Uganda National Meteorological Authority Strategic Investment Plan 2018/2019-2022/23, Page 102 Appendix 3.

i) Build the capacity at local government level for the implementation of climate and weather programmes through regional offices.
j) Promote the use of weather and climate information services in development planning; build strategic partnerships with national and international agencies, academic institutions, civil society organisations, cultural and other institutions at various levels in the management of climate and weather programmes.
k) Mobilise resources to support climate and weather programmes and activities.
l) Participate in the review, formulation and implementation of weather and climate policies and programmes.
m) Interpret, review and recommend appropriate changes in the climate and weather policies as well as international instruments.
n) Promote, guide and coordinate the implementation of policies and programmes.
o) Manage and exercise authority over the National Climate Data Bank.
p) Set and implement national standards in observation of weather and climate whose data is to be forwarded to the National Data Bank.
q) Supervise any other weather and climate observers whose data is to go into the National Data Bank.
r) Assist the government to meet its international obligations in conservations and other international agreements related to weather, climate and climate change.
s) Observe, record and transmit meteorological observations as well as hydrological and other geophysical observations related to meteorology and for the purpose establish a network of stations.

1.3.6 UNMA Funding

UNMA operated as a subvention between the financial years 2014/15 and 2015/16. However, starting from the Financial Year 2016/17, the Uganda National Meteorological Authority was granted a vote status with the responsibility of providing weather and climate forecasts and advisories for all socio-economic needs of the population[16]. For the period under review (FY 16/17 and FY 17/18), funding of UNMA was only from Government of Uganda. Table 1 below illustrates the budgeted, allocated and released funds.

Table 1: UNMA budget allocation for financial years 2016/17 and 2017/18

Funding	2016/17	2017/18
Approved Budget (UGX Billion)	22.612	29.55
Releases (UGX Billion)	21.5	25.36
Spent (UGX Billion)	18.65	24.51
% of budget released	95.10%	85.8%
% of budget spent	82.5%	82.9%
% of release spent	86.8%	96.6%

Source: Gou IFMS

16 Ministry of Water and Environment Sector Performance Report 2016, page 126 and 2018

In addition to the above Government funding, UNMA also received donor funding in form of benefits in kind. For instance, the German Federal Ministry for Economic Cooperation and Development (BMZ) through its implementing agency GIZ and United States Agency for International Development (USAID) have supported UNMA through a project known as Strengthening Meteorological Products, Services and Use in the Agriculture and Water Sectors where 23 automation weather stations (AWS) were procured and installed, computers and IT infrastructure for data processing and management have been provided and also upgraded the dilapidated data archive room to international standards[17]. The United Nations Development Programme (UNDP) through the project known as Strengthening Climate Information on Early Warning Systems (Sciews) has also provided UNMA with 20 automatic weather stations and upgraded over 20% of the hydro meteorological systems[18].

1.3.7 Organisation Structure[19]

UNMA is headed by the Executive Director who reports to a Board and the Permanent Secretary of MWE. The Executive Director is assisted by five directors responsible for applied meteorology, data and climate services; weather forecasting services; networks and observations; training and research; and Finance and Administration as shown in the UNMA organogram in **Appendix I**.

1.4 AUDIT OBJECTIVE

To assess the measures put in place by the Uganda National Meteorological Authority (UNMA) to produce and disseminate accurate, timely and comprehensive meteorological data that meets the information needs of users.

1.5 AUDIT QUESTIONS

i) Does UNMA observe and generate accurate and timely data in a manner prescribed by World Meteorological Organization standards?

ii) Is data processed, analysed and stored in accordance with the recommended best practices (World Meteorological Organization standards)?

iii) Has UNMA put in place appropriate mechanisms to facilitate dissemination of and access to meteorological information promptly?

1.6 AUDIT SCOPE

The study covered two financial years 2016/17 and 2017/18 focusing on timeliness, accuracy and comprehensiveness of meteorological information produced by Uganda National Meteorological Authority. Functioning manual and automatic weather stations installed and managed by Uganda National Meteorological Authority were considered for this study.

17 Strengthening Meteorological Products, Services and Use in the Agriculture and Water Sectors
18 Modernization of the hydrological monitoring and forecasting system
19 UNMA approved organisational structure

CHAPTER TWO

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The reliability of meteorological information produced by
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CHAPTER TWO

AUDIT METHODOLOGY

The audit was conducted in accordance with the International Organization of Supreme Audit Institutions (INTOSAI) Performance Auditing Standards and the Office of the Auditor General (OAG) VFM audit manual. The standards require that the audit is planned in a manner which ensures that an audit of high quality is carried out in an economic, efficient and effective way and promptly.
The specific methods described below were used during the audit execution to address the audit objective.

2.1 SAMPLING

Using random sampling, the audit team selected 18 out of 29 functioning manual weather stations and 14 out of 43 automatic weather stations to give an equal opportunity to each station to be selected in the sampling process. Of the 18 functioning manual weather stations, 9 synoptic, 6 agromet and 3 hydromet stations were considered for the study.

2.2 DATA COLLECTION

The study relied on review of documents, interviews, focus group discussions and field inspection to obtain the necessary information to answer the audit questions as detailed below:

a) Does UNMA observe and generate accurate and timely data in a manner prescribed by World Meteorological Organization standards?

The audit team reviewed the WMO standards, UNMA operational manuals, East Africa Committee Handbook for Meteorology, daily weather observation slips, synoptic registers, weather summary forms, dekadals forms, rainfall cards among others to understand how the weather observations are carried out and whether real time and weekly reporting is done. The list of documents reviewed is in **Appendix II**.

Interviews were conducted with the Manager Network Stations, Director Forecasting Services, weather observers and the Data Centre Manager to understand the weather observation processes and measures put in place to ensure that data observed and generated is accurate.

In addition, focus group discussions with fishermen of Lamu landing site in Masaka district and Kigungu landing site in Wakiso district and farmer groups in Mbale and Iganga were carried out to ascertain whether the information produced by UNMA was received on the timely basis and level of accuracy.

The audit team further inspected 18 of the 29 functioning manual stations (9 Synoptics, 3 Hydromets and 6 Agromets stations) and 14 of the 43 automatic weather stations to confirm their existence and assess their current functioning condition. List of inspected stations is in **Appendix IV**.

b) Is data processed, analysed and stored in accordance with the recommended best practices (World Meteorological Organization standards)?

The audit team inspected the National Meteorological Centre, the Directorate of Applied, Data and Climate Services and also interviewed staff in the data processing unit and archives to understand the different data processing tools and software and storage facilities used by UNMA.

In addition, the team reviewed WMO T.D NO 485 Guidelines on global data processing and forecasting to establish whether data processing and analysis was carried out in accordance with World Meteorological Organization standards.

c) Has UNMA put in place appropriate mechanisms to facilitate prompt dissemination of and access to meteorological information?

Interviews were conducted with the Manager Network Stations, Director Forecasting Services, weather observers and the data centre manager to understand the different dissemination channels used by UNMA to ensure that weather and climate products/services are received by the different stakeholders in a timely manner.

In addition, interviews and focus group discussions were carried out with district production officers, agricultural extension workers, fishermen of Lamu landing site in Masaka district and Kigungu landing site in Wakiso district and farmers in Mbale and Iganga to assess the appropriateness of the dissemination mechanisms used by UNMA to ensure that the farmers and fishermen receive the meteorological information in time and whether the meteorological information is accurate and comprehensive to enable farmers and fishermen take timely and accurate decisions. The list of Interviewees is in **Appendix III**.

CHAPTER THREE

03

The reliability of meteorological information produced by
Uganda National Meteorological Authority (UNMA) | A Report by the Auditor General

CHAPTER THREE

SYSTEMS AND PROCESS DESCRIPTION

3.1 ROLES AND RESPONSIBILITIES OF KEY PLAYERS

There are number of players with different roles in the processes of identification and registration of persons. Key among these includes:

3.1.1 UNMA Board

The UNMA Board is the governing body of the Authority appointed by the Minister of Water and Environment under Section 5 of the UNMA Act 2012. The Board is responsible for approving annual plans and budgets for the Authority, monitoring the implementation of the Authority's plans and programs, overseeing the proper management of finances and assets of the Authority, regularly reviewing the Authority's structure, staffing levels, emoluments and terms and conditions and approving senior staff appointment[20].

3.1.2 The Executive Director

The Executive Director is a secretary to the Board and also acts as the Accounting Officer for the Authority. He/she is responsible for submitting mandatory reports to WMO, providing strategic direction to implementation of UNMA functions in accordance with UNMA Act, WMO Instruments, conventions, protocols and Memoranda of Understanding (MOUs) with stakeholders, assuring timely delivery of meteorological services and products to the users at national, regional and international levels in line with existing standards, policies and legal frameworks.

3.1.3 The Directorate, Weather Forecasting Services

The Directorate is responsible for the collection and distribution of real-time weather information from all outstations in the field as well as producing daily public and aviation forecasts. This Directorate generates products to serve the interests of different clients and these include daily advisories and forecasts for aviation, public weather service forecasts issued through radios, print media, television, cell phone SMS, sharing weather data with the rest of the globe through the Global Telecommunication System (GTS)[21] of the World Meteorological Organization (WMO) and maintaining a good telecommunication system to exchange real-time weather information rapidly across the World.

3.1.4 The Directorate of Applied, Data and Climate Services

The Directorate is responsible for preparing the national climatological, agro-meteorological, hydro-meteorological and environmental data bank, providing general and user specific agro-meteorological and hydro-meteorological bulletins to various users, liaising and providing technical support to various users of agro-meteorological and hydro-meteorological information and to foster collaboration on environmental issues with other authorized government departments and other related institutions carrying out research in climate variability, climate change, interaction of weather to humans, plants, soils, livestock, and environment.

20 Uganda National Meteorological Authority Act 2012
21 Co-ordinated global system of telecommunication facilities and arrangements for the rapid collection, exchange and distribution of observations and processed information within the framework of the World Weather Watch.

3.1.5 The Directorate, Networks and Observations

The Directorate of station networks and observations is responsible for ensuring that equipment and telecommunications for rapid national data exchange are operational and meet the required WMO standards and procedure to fulfil national and international obligations; planning the development and expansion of meteorological and climatological station networks; maintaining operational standards for climatological, agro-meteorological and rainfall stations; developing and maintaining a Quality Management Framework for the provision of weather, climate data and related services.

3.1.6 The Directorate of Finance and Administration

The Directorate is responsible for the business support functions such as finance and accounts, administrations and human resources, procurement and supplies as well as public relations divisions.

3.1.7 World Meteorological Organization (WMO)[22]

The roles of WMO include facilitation of worldwide cooperation in the establishment of networks of stations for the making of meteorological observations as well as hydrological and other geophysical observations related to meteorology and to promote the establishment, and maintenance of centres charged with the provision of meteorological and related services.

Other roles of WMO are to promote the establishment and maintenance of systems for the rapid exchange of meteorological and related information; promote standardization of meteorological and related observations and to ensure the uniform publication of observations and statistics internationally; further the application of meteorology to aviation, shipping, water problems, agriculture and other human activities; promote activities in operational hydrology and to further close cooperation between meteorological and hydrological services; and to encourage research and training in meteorology and, as appropriate, in related fields and to assist in coordinating the international aspects of such research and training.

3.1.8 International Civil Aviation Organization (ICAO)

To define and elaborate concepts for aeronautical meteorology service provision consistent with the identified operational requirements including the functions and processes necessary to provide quality-assured, cost-effective aeronautical meteorology services and information supporting the global air traffic management system. Identifying the scientific and technological capabilities necessary to fulfil the identified operational requirements; develop and maintain ICAO Provisions necessary for meteorological service for international air navigation.

22 Guidelines on the role, operation and management of National Meteorological and Hyrological Services

3.2 PROCESS DESCRIPTION FOR PRODUCING METEOROLOGICAL INFORMATION

The meteorological information production process can be divided into two parts, the short term forecasting process and the long term forecasting process.

Part 1: Short term forecasting Process at the National Meteorological Centre Data Observation

Data for short term processing is mainly from the synoptic stations. Data observation and collection is done every 30 minutes for 24 hours by the observers at these weather stations (especially at aerodrome stations). All the synoptic stations are required by WMO to make observations at four significant hours that are universal, i.e. 9am (0600z), 3pm (1200z), midnight (1800z) and 3am (0000z). The observers record all the weather elements at these hours and transmit the data to the National Meteorological Centre (NMC) in Entebbe. In addition, for aerodrome stations, these are also required to make upper-air observations twice-daily observations with the aid of inflatable weather balloons (radiosondes) to understand the weather at different levels of the atmosphere that affects aircraft safety.

Data processing

Observed data from synoptic stations is sent by the observers to the communication department at National Meteorological Centre (NMC) for processing and analysis using smartphones, emails and sometimes telephone calls. The communicator at NMC checks for consistencies and accuracy of the information which is then sent to the Automatic Message Switching System (AMSS)[23] for sharing with the regional centre (Regional Telecommunication Hub) as well as other global centres at the universally agreed times. The communication department then receives data from other areas of the globe through the AMSS which is given to forecasters to guide in the production of the forecasts. In addition, the observers at aerodromes also prepare a Meteorology Aviation Report (METAR) every 30 minutes to guide the forecasters in producing the various forecasts needed for the aviation industry.

Forecasting

Forecasting is done for the general public, aviation industry and any other customer that may request for specific information. The forecaster on duty produces Terminal Aerodrome Forecast (TAF), trend forecast as well as en-route forecast to the Civil Aviation Authority (CAA) for briefing the pilots. The Synagie system, Messir Vision, charts of real-time data, model charts and analyses from global centres are used in the production of these products. The forecaster also produces the daily weather forecasts for public consumption by analysing the current weather and the systems that are likely to affect the weather in the next 24 hours.

Dissemination of the short term forecast

Meteorological data for aviation is sent to CAA at half-hourly intervals through a digital platform that relays data in universally accepted formats. When data is required as a result of specified operationally significant changes in the meteorological conditions, special observations and reports are made whenever such changes occur between routine observations. Observational data are combined into a report for dissemination at the local aerodrome or beyond depending on their use. The reports are presented in two forms, i.e. as local routine and special reports in abbreviated plain language intended for dissemination and use at the aerodrome of origin or as an aerodrome routine meteorological report (METAR) and aerodrome special meteorological report (SPECI)[24] intended for dissemination and use beyond the aerodrome of origin.

23 Standard ICAO ground-to-ground communication system for the exchange of air traffic control messages within the Aeronautical Fixed Telecommunication Network between airports.

24 Report issued when there is significant deterioration or improvement in airport weather conditions.

Local routine and special reports are supplied to Air traffic services (ATS)[25] units which use them together with any information obtained from their own duplicate displays (e.g. wind, height of cloud base, or runway visual range (RVR)[26] displays of automatic meteorological observing systems) or supplementary visual observations taken by ATS personnel, in order to provide the required OPMET information to aircraft taking off or landing. These reports are supplied to aircrafts by ATS units, or an air-ground data link, or directed transmissions and/or through broadcasts.
The daily forecast for the general public is shared with radio stations and televisions through the public weather service section at NMC.

Part 2: Long-term forecasting Process at the Directorate of Applied Meteorology, data and climate services

Observations

For long-term forecasting data is also received from synoptic stations as well as the hydrometeorological stations that observe twice a day at 0900z and 1200z, and from agrometeorology stations that observe three times every day at 9am, 12pm and 3pm. The observer fills in an observation slip every after an observation, and at the end of the month they fill in a weather summary form which is delivered to DADCS. There is also a number of rainfall stations across the country that observe only daily rainfall and prepare a rainfall card that is delivered at the end of the month to DADCS. The senior weather observer carries out quality control checks for errors and inconsistencies before they are sent to DADCS for further processing and analysis.

Data entry and processing

Data comes from synoptic stations, agrometeorological stations and hydro-meteorological stations, rainfall stations. Returns are brought on a monthly basis using a weather summary form (form 10) that includes all parameters recorded every day at two hours, that is, 9 am and 3 pm. Synoptic stations also produce metars (hourly observations) in a synoptic register which is also brought at the end of the month to DADCS. After checking for errors by a senior weather observer at DADCS, one copy is stored and the other taken for digitisation by the data entrants. All parameters are entered into the system, but sorting is normally done for the parameters that are in high demand such as rainfall, temperature and humidity. The Directorate then summarises the data in the form of averages, means, totals and also determine the highest temperature, rainfall and humidity.

Data analysis and product generation

After data has been entered into a system by the data processing unit, the senior meteorologists carry out data analysis to generate ten-day bulletins (dekadals), monthly bulletins and seasonal forecasts. Ten-day rainfall totals are analysed for all the stations in the country to produce the status of rainfall in the last ten days. The Weather Research Forecast (WRF) model[27] is then run at a 10km resolution to provide the forecast of the following ten days. The past dekade analysis and the ten-day forecast are then packaged together into a dekadal bulletin for public consumption. The monthly updates are also produced using WRF but at a lower resolution of 30km due to low computing power. Three seasonal forecasts are issued in a year; March to May (MAM), June to August (JJA) and September to December (SOND).

25 Service which regulates and assists aircraft in real-time to ensure their safe operations through preventing collisions between aircraft, providing advice of the safe and efficient conduct of flights and conducting and maintaining an orderly flow of air traffic.
26 Distance over which a pilot of an aircraft on the centreline of the runway can see the runway surface markings delineating the runway or identifying its centre line.
27 Next-generation mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting applications

The forecasts give advisories on likely weather conditions and impact on various sectors such as wildlife, energy and agriculture. The seasonal forecast is generated using both statistical and dynamical models. The dynamical model is run on a regional basis (Great Horn of Africa, GHA) to produce a general outlook of the seasonal forecast for the entire region. Statistical methods use station data from synoptic stations to downscale the forecast from the regional basis to the national level for the different climatological zones.

Product dissemination

The agrometeorological bulletin and monthly updates are sent to farmers through email contacts of District Production officers, Chief Administrative Officer, the District chairpersons, sub-county chiefs and community development officers, NGOs, academia and Civil Society who are expected to disseminate this information to the grass route people. The downscaled seasonal forecast is published in newspapers, radio and television and also sent to emails of the contacts in their database.

In addition, the Authority has been receiving some grants to translate the seasonal forecasts into local languages and then the information is packaged onto compact disks (CDs) and sent to various radios in the different regions for dissemination. Currently, about 35 local languages have been translated for the main seasonal forecasts of March to May and September to November.

The authority also conducts awareness workshops for farmers' groups as well conducting radio talk shows to further disseminate the information.

CHAPTER FOUR

The reliability of meteorological information produced by
Uganda National Meteorological Authority (UNMA) | A Report by the Auditor General

CHAPTER FOUR

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

With support from the Government and Development partners, UNMA has been able to register some achievements, namely[28]:

a) Enactment of an enabling law and the establishment of UNMA Act that empowers UNMA to recruit staff and appoint Board members.
b) Provision of aeronautical services to the Civil Aviation Authority (CAA).
c) Automation of meteorological data exchange system from weather stations to National Meteorological Centre and other regional and global centres that provides routine collection and automated dissemination of observed weather, climate and water-related data and products, as well as information discovery, access and retrieval services.
d) Compliance with WMO requirement of upgrading staff from class IV to class III which is the minimum education qualification required by the World Meteorological Organization for staff carrying out meteorological observations.
e) Attained ISO 9001-2008 certification that is crucial in building public confidence in service delivery more so when it comes to professions like weathercasting.

Despite these efforts, it was observed that UNMA still faced challenges in executing its mandate of promoting, monitoring weather and climate as well as providing weather predictions and advisories to the users, government and other stakeholders for use in sustainable development of the country as detailed below:

4.1 TIMELINESS OF METEOROLOGICAL INFORMATION

Observation hours

Paragraph 1.1.2 of the manual on the global observing system (Volume II) regional aspects (Revised edition 1995) requires all surface synoptic stations included in the regional basic synoptic network to make surface observations at four main standard times of observation, that is, 3am (0000z), 9am (0600z), 3pm (1200z) and 9pm (1800z) and at four intermediate standard times of observation, that is, 6am (0300z), midday (0900z), 6pm (1500z) and midnight (2100z). Any surface station that cannot carry out the full observational programme should give priority to the carrying out of the observations at the main standard times.

Furthermore, paragraph 4.3.1 of the International Standards and Recommended Practices for Meteorological Service for International Air Navigation 2007 requires routine observations from aerodrome stations to be made throughout the 24 hours each day and such observations shall be made at intervals of one hour or if so determined by regional air navigation agreement at intervals of thirty minutes.

Through review of documents for the 9 selected synoptic stations over the two years period, audit noted that only Entebbe synoptic station observed and reported throughout the 24 hours as required by WMO. The other 8 synoptic stations were operating 12 hours during day but also had failed to observe the main standard hours of times of 3 am (0000z) and 9 pm (1800z).

The half service observation and reporting at synoptic stations was due to the low technical staffing levels to carry out observations at these main standard hours. The low staffing level was attributed to the absence of the governing board.

28 Section2.2 of the UNMA strategic Plan July 2017 –June 2021, page 6

Since February 2017, UNMA has not had a governing board that is responsible for recruiting and appointing staff, formulating of meteorology regulations, approving annual plans and budgets, as well as their monitoring and implementation. In addition, the office facilities of some synoptic stations that the audit team visited such as Makerere, Kasese, Soroti, Masindi, Tororo could not allow night time meteorology observations since the premises were distant from the weather observatory, posing a security threat to the weather observers.

Through review of the Strategic Investment Plan 2018/2019-2022/23, UNMA's plan was to have a staff establishment of 298 to efficiently manage and run its operations. However, the audit team observed that only 198 were filled leaving 100 (34%) vacant positions. Furthermore, staffing levels at the different stations were below the minimum staff requirement as illustrated in Table 2 below.

Table 2: Staff levels at UNMA Synoptic Stations

	Weather Stations	Staff required	Current staff level	Staff gap	% Staff gap
	SYNOPTIC STATIONS				
1	Gulu	6	2	4	67
2	Soroti	6	3	3	50
3	Mbarara	6	2	4	67
4	Kasese	6	3	3	50
5	Masindi	6	3	3	50
6	Entebbe	6	7	-1	-17
7	Makerere	6	5	1	17
8	Jinja	6	2	4	67
9	Tororo	6	3	3	50
TOTAL		**54**	**30**	**24**	**44**

Source: Interviews with zonal officers and manager networks stations

The 12 working hours of synoptic stations and the low levels of technical staff negatively affect the quantity and quality of meteorological services to be provided to different users as night observations such as visibility and cloud height cannot be observed and recorded.
In addition, these stations cannot provide meteorological data at night to global weather centres which is useful in the production of the different forecasts.

The synoptic stations at aerodromes such as Soroti, Gulu, Arua and Kasese face a risk of not being recognised by international organisations like ICAO which affects government plans of uplifting these aerodromes to international airports (NDP II[29], Vision 2040[30]).

29 Uganda Second National Development Plan II (2015/16 to 2019/20) Pages 106 and 300
30 Uganda Vision 2040, Page 63

Management Response

Most of the observations made by the audit team reflect the true picture on the ground. The Minister of Water and Environment already submitted the names of the proposed Board to cabinet having addressed cabinet's concerns.

Conclusion

The synoptic stations did not observe and generate timely data as prescribed by WMO. Therefore synoptic observations could not be made throughout the 24 hours.

Recommendation

UNMA management should liaise with the relevant authorities to ensure that the appointment of the board members is fast-tracked to ensure that over a set timeline, the required staff are recruited at the various levels.

4.2 ACCURACY OF OBSERVATIONS

Calibration of equipment and instruments

Paragraph 3.1.1 of the Guide to Meteorological instruments and methods of observations 2010 requires all stations to be equipped with properly calibrated instruments and adequate observational and measuring techniques. In addition, Paragraph 2.1.3.2 of the same Guide requires all temperature measuring instruments to be issued with a certificate confirming compliance with the appropriate uncertainty or performance specification, or a calibration certificate that gives the corrections that must be applied to meet the required uncertainty and that temperature-measuring instruments should also be checked at regular intervals. Furthermore, paragraph 4.9.3 requires calibration of reference and standard instruments to be performed at least every 12 months and over the full range of the reference application for the instrument. This is to ensure that the instruments are measuring to the required accuracy as set by WMO.

Physical inspection of 18 sampled manual stations and interviews with the manager network stations revealed that only Entebbe synoptic station had weather instruments which had been calibrated over the two year period; however, the calibration certificates had expired as at April 2018. Furthermore, UNMA had not developed calibration schedules for the different stations and certificates confirming compliance were not in existence.

In addition, upon the review of the MWE Ministerial Policy Statements for financial years 2016/17 and 2017/18 the audit team noted that UNMA had planned to establish two meteorological calibration laboratories (mobile and stationery) to calibrate the meteorological instruments in the country. The team noted that UNMA budgeted UGX 250,000,000 for the procurement of tool boxes, calibration equipment and spare parts in the FY 2016/17; however, no funds were released by the Ministry of Finance, Planning and Economic Development for this activity. Upon further review of UNMA's budget for FY 2017/18, the audit team noted that UNMA did not include calibration equipment and laboratories and therefore no funds were released.

The non-calibration of meteorological equipment was attributed to lack of functional calibration laboratories whose equipment is expensive and requires specialized staff. In addition, UNMA did not prioritize the procurement of calibration equipment in the year 2017/18.

Failure to calibrate weather instruments annually increases measurement uncertainty which affects the accuracy and precision of the measurements of these instruments.

Management Response

Most of the observations made by the audit team are factual. UNMA is working with Uganda National Bureau of Standards (UNBS) to calibrate the various meteorological instruments, however, due to limited capacity, currently, only mercury based thermometers are being calibrated.

In addition, UNMA is also currently working with other regional centres, such as the Kenya Meteorological Department to calibrate the instruments, however, it is very expensive and not sustainable. To establish a calibration laboratory with requisite capacity is estimated to cost about UGX 1Bn.

Audit Comment

Whereas management explained that only mercury based thermometers have been calibrated, calibration certificates were not availed to the audit team for verification. In addition, we note that mercury based equipment have since been outlawed by the World Meteorological Organization.

Conclusion

UNMA did not equip its stations with calibrated equipment as required by WMO. The continuous use of uncalibrated equipment affects the accuracy of observations made, thus the reliability of forecasts predicted.

Recommendation

UNMA should prioritize calibration of equipment and purchase of spare equipment in its budget and also liaise with all relevant authorities to ensure that all weather stations are equipped with properly calibrated instruments. In addition, UNMA should harness regional collaborative arrangements with other neighbouring states so as to take advantage of the synergies that arise from such partnerships. In the long run, UNMA should set up calibration laboratories as stipulated in its strategic plan.

4.3 COMPREHENSIVENESS OF METEOROLOGICAL INFORMATION

4.3.1 Weather parameters observed and reported

Paragraph 1.3 of the Guide to Meteorological Instruments and Methods of Observation 2010 requires elements such as present weather, past weather, wind direction and speed, cloud amount, cloud type, cloud-base height, visibility, temperature, relative humidity, atmospheric pressure, precipitation, snow cover, sunshine and/or solar radiation, soil temperature and evaporation to be observed at a station making surface observations.

Paragraph 2.3.1 of the Guide to Agricultural practices 2010 Edition requires the observing programme at agrometeorological stations to include observations of some or all of the following variables characterizing the physical environment: solar radiation, sunshine and cloudiness, air and soil temperature, air pressure, wind speed and direction, air humidity and soil moisture, evaporation and precipitation.

Furthermore, ICAO annex 3 requires all aerodromes to provide observed or expected existence of wind shear which could adversely affect aircraft on the approach or take-off path or during circling approach between runway level and 500 m (1,600 ft) above that level and aircraft on the runway during the landing roll or take-off run.

Review of the weekly summary forms and the monthly weather return reports of the 9 synoptic stations and interviews held with weather observers at these stations revealed that most parameters required by WMO were being observed and reported though some synoptic stations failed to report on evaporation and cloud cover.

Upon the physical inspection of selected agromet stations, the audit team noted that these stations lacked essential equipment and instruments to observe and report soil temperature, soil moisture and evaporation, yet these are very important observations for agronomic applications. For instance, Soil temperature directly influences crop growth and also the physicochemical and life processes in plants. In addition, in scheduling irrigation, the estimation of moisture content is the basic requirement. The inspected hydromet stations were not observing and reporting all the parameters required by WMO. For instance, Kyejonjo hydromet station only observed and reported rainfall for the two year period under study. All the inspected hydromet stations lacked data on river water level, river discharge, suspended sediment in river and water quality. Details are shown in Table 3 below.

Table 3: Parameters not observed at some of the UNMA stations

WEATHER STATIONS	PARAMETERS NOT OBSERVED	CAUSES
Agromet stations		
Kituuza	Soil temperature, soil moisture cloud height, evaporation	Lack of essential equipment such as soil thermometers, grass minimum thermometers, tensiometers, soil moisture sensors, evaporation pans, gunberan and theodolite
Kawanda	evaporation, wind speed and direction, Max temperature, soil temperature, soil moisture	Lack of essential equipment such as soil thermometers, grass minimum thermometers, tensiometers, soil moisture sensors, evaporation pans, wind vane, Maximum thermometers
Namulonge	soil temperature, soil moisture, evaporation, cloud height	Lack of essential equipment such as soil thermometers, grass root thermometers, tensiometers, soil moisture sensors, evaporation pans, gunberan and theodolite
Hydromet stations		
Wadaelai	Wind direction, wind speed, evaporation, radiation. Since 2016 to date, the station has not observed sunshine hours and Atmospheric Pressure. Lacked data on river water level, river discharge, suspended sediment in river and water quality	No technical staff Lack of essential equipment such as sunshine recorder, barometer, evaporation pan
Kyejonjo	Since 2016 only Rainfall data was being observed. No data on other Parameters. Lacked data on river water level, river discharge, suspended sediment in river and water quality	Non functioning stevenson screen Absence of essential meteorological instruments
Entebbe	Since 2016, No data on Max temperature, Min temperature, sunshine hours, Atmospheric Pressure. Since May 2017 no Wind data, evaporation was observed. Lacked data on river water level, river discharge, suspended sediment in river and water quality	Lack of functioning maximum and minimum thermometers, sunshine recorder, barometer, Broken down evaporation pan and wind vane
Synoptics		
Tororo Synoptic	Since 2016, Wind speed, humidity, cloud cover and evaporation were not being observed	Lack of essential equipment to observed and report these parameters
Entebbe Synoptic	Since 2016, sunshine hours, evaporation, cloud height were not observed	Lack of essential equipment to observed and report these parameters
Jinja Synoptic	Since 2016, Cloud height, evaporation were not observed	Lack of essential equipment to observed and report these parameters
Makerere Synoptic	Since 2016 evaporation, soil temperature, cloud height were not observed	Lack of essential equipment to observed and report these parameters

Source: Weekly summary forms and monthly weather return reports

Of the 9 synoptic stations, 5 are categorized as aerodrome stations, namely: Entebbe, Soroti, Gulu, Kasese and Arua. Except for Entebbe synoptic station that reported aerodrome warnings and wind shear warnings as required by ICAO, the other four stations were not observing and reporting these parameters. Soroti, Gulu, Kasese and Arua stations were also not providing briefing services to the flight crew/flight operations personnel, whenever requested.

Physical inspection and interviews held with weather observers of Soroti and Gulu synoptic stations revealed that terminal aerodrome forecasts (TAFs) were not being produced due to lack of communication equipment like the automatic message switching system (AMSS) and other important tools like the synagie system and the messir vision.

The absence of agrometeorological data such as soil temperature, soil moisture and evaporation denies farmers relevant information to take critical decisions in agriculture production, crop growth and harvest, therefore, directly affecting national planning, policy formulation and strategic decision-making and research in meteorology. In addition, hydro-meteorological data is critical for hazard analyses and planning and its non-availability could result in severe weather, with heavy precipitation that could bring unexpected hydro-meteorological hazards, such as, flash floods and landslides causing significant injuries, deaths, infrastructure damage and transportation paralysis.

Furthermore, the lack of key aviation related equipment like Synagie system and Messir vision at Soroti, Arua and Kasese makes these aerodrome stations not conform to ICAO standards, therefore, it affects their upgrading into international airports as stressed in NDP II[31] and Vision 2040.

Management Response

The audit observation is appreciated. Most of the instruments are open-field-based and are subjected to very harsh conditions which lead to their fast deterioration and damage. Some effort is being made towards the maintenance, repair and replacement of the equipment but the current budget cannot cope with the need. Management has developed and costed a maintenance Strategy where maintenance of meteorological equipment requires an annual provision of at least 20% of the value of the installations.

Conclusion

UNMA did not observe all weather parameters as required by WMO. Therefore, the information needs of end users such as farmers, water sector and fishermen could not be met. The aerodrome stations did not conform to ICAO standards and this will affect their upgrading into international airports as envisaged in NDP II and Vision 2040.

Recommendation

UNMA should continue to plan and budget for the required equipment and instruments and also liaise with relevant authorities to ensure that stations are equipped with essential equipment and instruments. Priority during budgeting should be given to key equipment, such as , Synagie system and Messir vision for Soroti weather station and the other aerodromes of Gulu, Kasese and Arua so that they are upgraded to conform to ICAO standards.

31 Uganda Second National Development Plan, Page 300

4.3.2 Coverage and functionality of Stations

Section 4 (b) of UNMA Act requires the Authority to establish networks of stations for taking, recording and transmitting meteorological observations as well as hydrological and other geophysical observations related to meteorology. Section 4.4 of the Uganda National Climate Change policy 2015 requires the optimum number of synoptic stations to be 16, climatological (hydromet and agromet) stations 60, rainfall stations 1,000, upper air stations 2 and radar stations.

The review of the weather station status report 2017 and interview held with the manager of network stations and installation revealed that the established stations were below the optimum number as per Uganda National Climate Change policy 2015. Details are shown in table 4 below:

Table 4: Numbers of meteorological stations run by UNMA

Category	Optimum number	Established number	% of establishment
Synoptic	16	12	75%
Climatological stations (Hydromet & agromet)	60	40	67%
upper air stations	2	1	50%
Radar	2	0	0%
Rainfall	1,000	100	10%

Source: Uganda National Climate Change policy 2015 and interview with Manager Networks

Further review of the MWE Ministerial Policy statement 2017/18 indicated that the UNMA targeted to have 44 functional stations out of the 52 manual weather stations, 60 automatic weather stations (AWS) installed and one weather radar procured and installed. However, the audit team noted that only 29 (56%) manual weather stations were functional, 43 automatic weather stations had been installed, and no radar had been installed by 30th September 2018.

In addition, through review of the contract documents and interviews with the procurement officer , it was established that the procurement of the radars was ongoing and the contract had been signed on the 14/6/2017 for Radar 1 and delivery was expected to be within 6 months. The procurement officer also informed the audit team that the procurement process for the second radar was under administrative review because of procurement irregularities resulting from failure to follow evaluation criteria and hearing had been scheduled for 24/5/2018.

On physical inspection, the audit team observed that only one upper air station had been established at Entebbe but also failed to provide measurements on a daily basis due to lack of key equipment to produce hydrogen that is used to fill the balloon. The balloon is fitted with weather equipment such as radiosonde and is sent to the atmosphere to capture atmospheric conditions at different heights.

On interface with UNMA automatic weather reporting system, the audit team observed that some automatic weather stations were not regularly reporting on the observation and analysis of real-time data. For instance, out of 43 automatic weather stations, 31 (72%) stations did not report data between the 17th May – 24th May 2018. In addition, out of the 14 sampled automatic weather stations, the audit team further noted that 11 automatic weather stations had irregular reporting patterns as shown in **Appendix V**.

The limited coverage of stations was due to the high investment costs required for their establishment, failure to develop maintenance plans for established rainfall stations and irregularities in the procurement of the radars. Further, the irregular reporting patterns by automatic weather stations was mainly attributed to unreliable internet connectivity that cannot support the transmission of observed data to the server .

The limited coverage and functionality of stations directly affects the quantity of meteorological data captured in the entire country which affects the forecast products that are generated, therefore, limiting the country's ability to monitor, detect and predict climate variability and climate change. The absence of vital weather equipment, like the weather radar, limits the accuracy of the forecasts given, especially for rainfall. The radar provides real-time information on rainfall and is an important tool in forecasting rainfall even within a short time like 30 minutes for a specific area or region.

Management Response

By 10th December 2018, 38 out of 43 AWS were reporting in real time and the remaining 5 were not reporting due to irregular mobile network signals. In addition, the 1st Radar is scheduled for shipment in January 2019 and the delay for its installation has been attributed to land regularization of the Radar installation site. For the 2nd Radar, the contract was signed.

Audit Comment

We note the management response of 38 AWS functioning as at 10th December 2018. We would like to emphasise that part of the observations are made at a point in time in cases where systems are expected to be fully operational throughout. To test the functionality of the AWS, the audit team interfaced with the AWS reporting system and noted that 31 AWSs were irregularly reporting between the 17th- 24th May 2018. The delivery of radar 1 was expected to be done by 14/12/2017 (within six months from contract signing of 14/6/2017).

Management has since explained that delivery should be completed by January 2019. Management's plan of procuring the radar within six months was unrealistic, given the technicalities involved in the procurement and contract management process that is, assembling, shipment and installation.

Although management explained that the contract of radar 2 had been signed, the audit team was not provided with this document for verification.

Recommendations

a) UNMA should implement the maintenance strategy to achieve the purpose for which it was developed for.
b) The procurement of the two planned weather radars needs to be fast-tracked.
c) UNMA should ensure continuous and reliable internet connectivity for the automatic weather stations to ensure regular reporting.

4.4 METEOROLOGY DATA PROCESSING AND STORAGE

According to WMO technical document no. 137 (2007), data from manual stations should be collected and captured on-site and recommends a diurnal digital transfer to the NMC. For data entry, WMO (2007) recommends a system that checks the constraints and data type for each parameter before it ingests the values into the database.

WMO (2007) further recommends that all paper records should be stored in a controlled environment to avoid deterioration and possible destruction by temperature and humidity extremes, insects, pests, fire, flood, accidents or vandalism. It further recommends that before archiving, the records should be captured in microfilm or, preferably, in electronic image form through a digital camera or scanner.

Currently, UNMA is using CLIMSOFT software version 4[32] to enter and store climatic data in a computerized form; this software can detect a few errors such as a wrong reading which can be corrected by the data entrant before it is stored in the database. However, at times, this software fails due to technicalities because the responsible UNMA staff in this section lack the requisite capacity to troubleshoot the issues leading to expert outsourcing whenever the need arises.

At the time of audit inspection (September 2018), the audit team noted that of all the weather parameters required to be digitalized, only 2 parameters, that is, rainfall and temperature had been digitalized at 80% and 40%, respectively. Through document review and an interview held with the Director, Applied Data and Climate Services, the audit team further noted that UNMA had embarked on scanning its manual weather records which dated as far back as 1920; only 10% of these records had been scanned. The low level of scanning was attributed to the limited number of scanners and unskilled personnel in the Directorate. Failure to scan and back up the original weather records could result in loss of data in case of system failure which affects historical records leading to inaccurate future predictions.

Management Response

UNMA plans to acquire additional data software for data management and backup and this requires USD 50,000.

Audit Comment

Since the climsoft version4 used by UNMA enables data management and back up, and management has not fully utilized its functions, it is more prudent for UNMA to focus on using climsoft software to its full capacity rather than putting its limited resources to the purchase of additional software.

Recommendations

a) Staff in the data processing unit need more specialised training on the use of the CLIMSOFT so that they can be in position to perform troubleshooting and regular maintenance of the software instead of relying on hired experts.

b) UNMA should prioritize digitalization and scanning of original weather records by planning and budgeting for scanners, staff and data backup systems.

32 Software suite for storing climate data in a secure and flexible manner and for extracting useful information from the data

4.5 METEOROLOGY DATA ANALYSIS AND PRODUCT GENERATION

4.5.1 Meteorology products generation

WMO (2007) defines seven levels of forecasting that are recognized globally as (1) nowcasting which is a description of current weather parameters and 0 to 2 hours description of forecasted weather parameters (2) very short-range weather forecasting which is forecasting up to 12 hours of weather parameters (3) short-range weather forecasting which is beyond 12 hours and up to 72 hours description of weather parameters (4) medium range weather forecasting which is beyond 72 hours and up to 240 hours description of weather parameters (5) extended range weather forecasting which is beyond 10 days and up to 30 days description of weather parameters, usually averaged and expressed as a departure from climate values for that period and (6) long range forecasting which is forecasting from 30 days up to two years that includes monthly updates and seasonal forecasts and (7) climate forecasting which is forecasting beyond two years.

ICAO and WMO require aerodrome meteorological stations to produce a number of products for the aviation sector. These include Terminal Aerodrome Forecasts (TAFs), landing and take off forecasts, Enroute forecasts, Area forecasts for low-level flights, SIGMET[33] information, AIRMET[34] information air traffic operating below flight level 100, Aerodrome warnings and Wind shear warnings, among others.

Through interviews with the Director, weather forecasting services, the audit team noted that UNMA produces short range weather forecasting up to 2 days, monthly forecast of 30 days, 90 days forecast (seasonal), and climate change projections from various parts of the country. However, medium range forecasts and extended range weather forecast that are key for agricultural planning as well as recreation activities planning, were not being produced.

Although the Entebbe station is equipped with aerodrome facilities, this station does not produce aerodrome warnings and wind shear updates. Consequently, the UNMA aerodrome stations are not providing all the aviation products as required by ICAO. In addition, aerodrome stations such as, Soroti, Kasese, Gulu and Arua are not prioritized because of the ocassional aviation activities that take place there and UNMA considering them as normal synoptic stations.

Shortage of staff in the forecasting section is responsible for the failure to produce the medium range and extended range weather forecast because the few forecasters concentrate on the aviation forecasts as well as short-range forecasts.

Planning weekly activities that depend on weather is affected because of lack of reliable forecasts at medium and extended ranges. People resort to consulting global modelling centres that do not normally capture local features that affect our weather.

Upgrading the airfields of Kasese and Arua as highlighted in NDP II[35] and Vision, 2040[36] will not be achieved because of not prioritising them during the budgeting process.

33 Weather advisory that contains meteorological information concerning the safety of all aircraft.
34 Concise description of weather phenomena that are occurring or may occur along an air route that may affect aircraft safety.
35 Uganda Second National Development Plan, page 300
36 Uganda Vision 2040, page 63

Management Response

Although we need to recruit 10 meteorologists for NWP at NMC Entebbe; procure cluster super computers, and aviation weather stations such as the Automatic Weather Observing Stations (AWOS)[37] at all aerodromes each at approximately USD 200,000; and digitalize climate forecasting and the pilot briefing system at all aerodromes, we are limited by the current vote ceiling.

Audit Comment

We note that there are ceilings and this practice is not about to be abolished in Government; however, UNMA needs to actively engage in soliciting the necessary support given that some of the equipment is critical and necessary if UNMA is to effectively execute its mandate and also remain relevant and the preferred and sought after source for meteorology data by the various users; but in its current situation, users will always seek for this information from other more reliable sources as the audit revealed.

Recommendations

a) There is a need to recruit more staff in the forecasting section of UNMA so that all the meteorology products can be generated for public use.

b) Prioritise buying aviation equipment at the different aerodromes in the country if the aerodromes are to be upgraded into international airports.

4.5.2 Numerical Weather Prediction (NWP) and Modelling

WMO recommends the use of NWP in short-midterm forecasting to supplement the already existing procedures at the NMCs. Best practices in dynamical as well as statistical modelling have been used in the production of monthly forecasts, seasonal forecasts and climate forecasts in the different parts of the globe.

Through interview with the Director, forecasting services, the audit team observed that the use of NWP in short range forecasting is minimal with only one person running the WRF model for short-range forecasting and therefore the WRF model was not run on a daily basis. On physical inspection at NMC, the audit team observed that there were no computers dedicated for running the NWP models and the two computers available were being shared with other members of staff in other sections. Furthermore, the audit team observed that UNMA had procured a server at NMC which has a storage capacity of 16TB, memory of 128GB and processing speed of 2.67GHz that could solve the computing challenge, but this faced a challenge of continuous internet connectivity affecting the running of the weather models that require boundary data which is downloaded regularly from global centres using the internet.

For long term forecasting, the use of modelling was equally minimal, for example, only two people in the Directorate of Applied Data and Climatic Services (DADCS) were running WRF model to produce dekadal forecasts, as well as Monthly forecasts and for seasonal forecasts, the dynamic model was run regionally at ICPAC with statistical models used for downscaling of the forecast to the national level.
The audit team also noted that the products of monthly and seasonal forecasts were given a regional level or zonal level because the few staff involved in statistical downscaling can only run the models up to regional or climatological zone level.

37 Fully configurable airport weather system that provides continuous, real time information and reports on airport weather conditions.

There is a shortage of staff with skills to run NWP models, for example, only one person at NMC was running the WRF model for operational purposes. Internet connectivity which was irregular at NMC affected the running of the models which require regular downloading of boundary data from global centres.

The forecasts given are on a regional basis, for example, Lake Victoria basin that is comprised of a number of districts, yet NWP can be used to give an area specific forecast that is more beneficial for decision making.

Management Response

In addition to the audit observation, two more staff have since joined the NWP team at NMC though the optimum number of the specialised NWP team required is 10 for NMC and 5 for DADCS. Capacity building of staff including attachment at regional and global centres, are estimated to cost USD 50,000 annually.

Audit Comment

Whereas efforts have been taken by UNMA to increase the number of staff to 3 at NMC, this remains low compared to the required number of 10. The DADCS still remains understaffed with only 2 staff to run the WRF model. Although UNMA indicated that it needs USD 50,000 annually for capacity building, the audit team noted that a capacity building strategy had not been developed from which costing could be made.

Conclusion

Whereas UNMA uses Climsoft software, a software recommended by WMO for data processing and analysis, it still has challenges in data storage and product generation due to inadequate skilled personnel, processing equipment and unreliable internet connectivity to run the Numerical Weather Prediction model in both short range and long term forecasting. Delayed digitalization and scanning of historical meteorological information for storage will affect the process of preserving historical data which could be at risk of being lost due to deterioration of manual weather records.

Recommendations

a) UNMA should develop and implement a capacity building strategy that, among others, spells out the specialised groups required to run the Numerical Weather Prediction model at NMC and modelling at Directorate of Applied Data and Climate services.
In addition, UNMA should also liaise with the already existing partnerships with national, international and regional institutions to actualize the capacity building strategy.

b) UNMA should enter into service level agreements with internet providers to ensure that regular internet connectivity is maintained for models to run uninterrupted on the server.

4.6 DISSEMINATION OF FORECASTS

Paragraph 5.1.4 of the guide to agricultural practices 2010 edition requires dissemination of weather forecasts to agricultural users to be quick, with the minimum possible time lag following their formulation. The weather forecasts must, therefore, be not only timely but also very accurate. In addition, paragraph 5.1.3 (h) of UNMA National strategic plan requires the timely issuance of seasonal climate outlooks on a quarterly basis for the entire country.

Furthermore, Paragraph 6.1.1 of Manual for aeronautical meteorological practice requires Suitable telecommunication facilities to be available at aerodromes to ensure rapid communications between meteorological offices and stations, and to allow these offices and stations to supply the necessary OPMET information to ATS units (control towers, approach control, etc.), operators and other aeronautical users at the aerodrome.

Interviews with the District production officers and agricultural extension workers of Tororo, Iganga and Apac revealed that seasonal climate outlooks were not being received on a quarterly basis. Particularly, Tororo district production officer indicated that it last received an outlook in October 2017 and for Iganga district the seasonal forecasts are always received mid-season after the farmers have planted. District production officers and Agricultural extension workers interviewed indicated that the ten-day forecast (dekadals) and monthly climate bulletins were not being received and yet they are important in the short-term forecast on the weather parameters that enable farmers to make decisions on a daily basis.

On physical inspection of Soroti Meteorological station, the audit team observed that the station lacked telecommunication facilities to access the World area forecast system (WAFS) products from World Area Forecast centres (WAFCs). As a result, the station could not supply the necessary OPMET information to ATS units (control towers, approach control, etc.), operators and other aeronautical users at the aerodrome.

The audit team noted that NMC was producing weather alerts for fishermen, especially on Lake Victoria, but these were not reaching the fishermen. For instance, through focus group discussions held with the fishermen at Kigungu landing site in Wakiso and Lamu landing site in Masaka, it was revealed that weather alerts and forecasts were not being received by the fishermen before commencing and during the fishing activities.
In addition, the fishermen indicated that the weather information received from radio and television stations mainly focused on rainfall and sunshine, yet wind direction and strength is what directly affects their movements on the lake. The fishermen further indicated that the format and language used in the forecasts were difficult to understand and this makes the usability of this information impossible.

The audit team noted that DADCS was producing seasonal weather forecasts for the farmers and disseminating them through the District production officers. However, through focus group discussions held with farmers in Iganga district and Mbale district, it was noted that farmers in Mbale were receiving seasonal weather forecasts through the agricultural extension workers while those of Iganga were not receiving any forecasts and depended on their indigenous knowledge to make agricultural decisions like when to start planting.
The farmers in Mbale district further indicated that the weather information received is sometimes accurate but not representative and preferred weather information concerning their district and more particularly their sub-counties.

The inaccessibility of weather information and seasonal forecasts by the end users was due to the lack of a robust dissemination mechanism that can efficiently send weather and climate forecasts to all district production officers, fishermen and farmers across the country and the low internet connectivity especially in rural districts.

In the absence of the seasonal outlooks and the dekadals, farmers in affected districts will not access vital weather and climate information that is necessary for making agricultural decisions and therefore affecting overall productivity of agricultural outputs in the Districts and the Country at large. Lack of weather alerts and forecasts by the fishermen and other lake users will lead to increased loss of lives on lakes.

Management Response

UNMA is partnering with other institutions in the dissemination of seasonal forecasts namely GIZ, World Vision, Care International, Save the Children and Oxfam. UNMA is working with 54 climate champions from World Vision and USAID in 19 districts. Establishing a feedback strategy is a good strategy but requires adjustments to recruit meteorologists at Local Government levels since UNMA is centralized. UNMA in collaboration with partners is currently disseminating quarterly seasonal climate forecasts to assist easy uptake and easy planning.

Audit Comment

Whereas UNMA partners with a number of institutions to disseminate seasonal forecasts, it has not developed a dissemination strategy that ensures that the daily weather alerts, ten day and monthly forecasts are received by the farmers and fishermen in time.

Conclusion

UNMA did not put in place appropriate dissemination and feedback mechanisms to ensure that all end users receive meteorological information in timely manner. Therefore, the purpose for meteorological information remains unachieved if it cannot be accessed and used by the stakeholders.

Recommendations

a) UNMA should develop and implement a robust dissemination mechanism that ensure that the different stakeholders receive information in time. For instance, UNMA can explore closely working with community groups through the already established Local Government structures to ensure that the forecasts reach the farmers and fishermen in time.

b) UNMA needs to work with the Uganda Communications Commission (UCC) so that a code can be given by the telephone companies at a free cost where fishermen can request or receive the required information on their phones.

c) UNMA should implement a feedback mechanism to allow production officers and extensions workers to log in complaints and suggest areas of improvement. Weather information should be disseminated in the simplest form possible (local language simple to read and interpret) especially to the communities.

OVERALL CONCLUSION

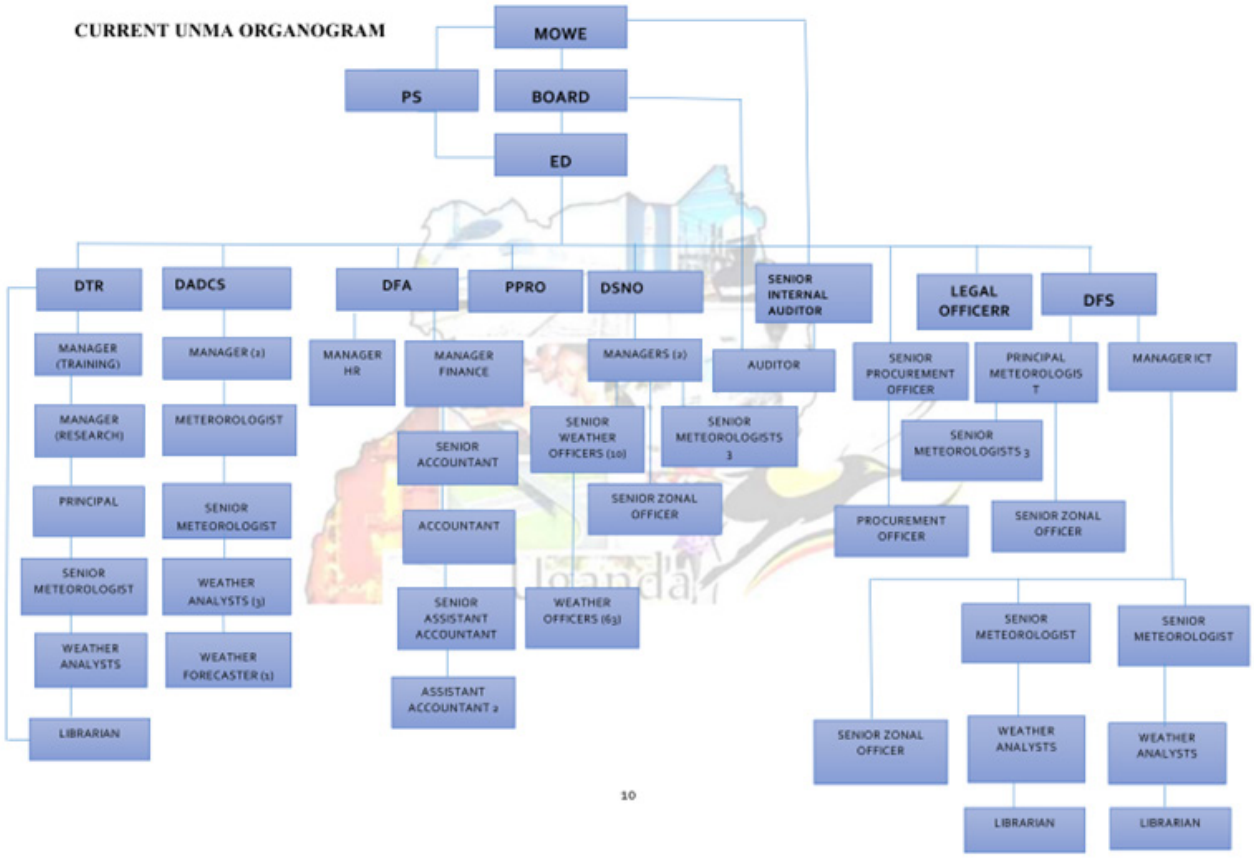
Whereas meteorological services remain important in the sustainable development of the country and in reducing the environmental hazards that Uganda is currently facing, UNMA still faces challenges of inadequate essential equipment, uncalibrated equipment, limited coverage and functionality of stations and lack of high speed processing facilities among others.

The measures put in place by UNMA to produce and disseminate accurate, timely and comprehensive meteorological information are still inadequate and therefore, UNMA's strategic objectives are likely not to be achieved.

GLOSSARY OF TERMS

TERM	MEANING
Agrometeorological station	Manual weather station that provide meteorological data for agricultural and/or biological purposes and make other meteorological observations under the programmes of Agrometeorological Research Centres
Automatic weather stations	Automated version of the traditional weather stations which consist of weather-proof enclosure containing the data loggers, rechargeable batteries, telemetry and the meteorological sensors with attached solar panels mounted upon masts
Calibration	Process of configuring an instrument to provide a result for a sample within an acceptable range
Dekadals	Ten day weather forecasts
Digitalization	Preservation of historical climate data recorded on papers and fragile media into computer compatible form
Hydrometeorological station	Manual weather station that conduct meteorological and hydrological observations of weather conditions and the condition of oceans, seas, rivers, lakes and marshes
Manual weather station	Simple weather station comprising a range of conventional instruments housed in a Stevenson screen to enable basic weather data to be collected daily
Meteorology	Scientific study of the atmosphere that focuses on weather processes and forecasting
Meteorology aviation report	Routine weather report issued at hourly or half-hourly intervals describing meteorological elements observed at an airport at a specific time.
Numerical weather prediction	Method of weather forecasting that employs a set of equations translated into computer code and use governing equations, numerical methods, parameterizations of other physical processes
Seasonal Climate Outlook	A monthly newsletter that summarises climate outlooks for the next three months
Synoptic weather station	Manual weather station with instruments which collect meteorological information at synoptic time 00h00, 06h00, 12h00, 18h00 (UTC) and at intermediate synoptic hours 03h00, 09h00, 15h00, 21h00 (UTC)
Terminal Aerodrome Forecast	Concise statement of the expected meteorological conditions at an airport during a specified period (usually 24 hours)
Weather observer	A person who records weather conditions every day at scheduled times, compile the information into meteorological messages according to international codes and transmit it to different centres.
World Meteorological Organizations	United Nation system's authoritative voice on the state and behaviour of the Earth's atmosphere, its interaction with the land and oceans, the weather and climate it produces and the resulting distribution of water resources.

Appendix I: UNMA Organogram



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Appendix II: Documents Reviewed

DOCUMENTS REVIEWED	PURPOSE
The UNMA Act, 2012	To know the legal framework of UNMA to support the provision of the meteorological services.
UNMA Strategic Plan	To obtain the strategic objectives of UNMA and the planned activities over the period of the strategic plan. Establish whether the development plans and budget reflect proposed investments.
MWE Ministerial Policy statements 2014/15,2015/16, 2016/17 and 2017/18	To find out the planned activities and budgeted amounts for the Authority for the specific periods.
UNMA Regulations	Ascertain the laid down procedures to operationalise the UNMA Act in as far as observation, processing, analysis, storage and dissemination of meteorological data and information is concerned.
UNMA Organogram	Ascertain the staff positions as per the approved structure; and determine the filled and unfilled positions.
UNMA Strategic Investment Plan 2017	To obtain long term planned activities and strategic objectives.
UNMA status network report 2017	To assess the performance of the weather stations and the different challenges encountered.
The Uganda National Climate Change Policy 2015	To understand the policies and regulations of the entity. How the meteorological authority supports the data processing unit of UNMA.
MWE Sector performance reports 2015, 2016 and 2017	To understand the contribution of UNMA in the sector, achievements and challenges faced.
Communication strategy	To know the awareness campaigns and the different communication channels used to transmit data and dissemination meteorological products.
Operational Manuals	To understand the guiding principles and how the observations for the different parameters are carried out.
Procurement Plans & Procurement Reports	To know what procurements were planned for and if they have taken place.
Board Minutes	To know board resolutions that concern the Management of meteorological information and the Authority at Large.
East Africa Committee Handbook of Meteorological Instruments 1975	To understand the terms and conditions each member state is required to meet and the extent to which they have been met.
Daily observation slips, synoptic registers, weather summary forms, monthly station reports, rainfall cards, dekadal forms	To find out the parameters observed at each station and understand how the observations are recorded.
Guide to Meteorological observation and instruments	To know the standards that UNMA is required to comply with.
WMO TD.NO. 1376: Guidelines on climate data management	To understand the best practices in meteorological data management.
WMO TD.NO. 485: Guidelines on Global data processing and forecasting	To understand the best practices in meteorological data processing and forecasting.

Appendix III: Interviews conducted

ORGANISATION	INTERVIEWEE	REASON FOR INTERVIEW
UNMA	Executive Director	To gain an in-depth understanding of the operations of the authority, the staffing of the authority, roles and responsibilities of the authority, the critical processes managed by the authority, the relationship between the authority and other stakeholders, progress made in execution of the authority's mandate, challenges faced by the authority and possible solutions.
	Manager Data centre	To understand the roles and responsibilities of the unit staff, the progress made in operationalising the Act, challenged faced and possible solutions.
	Manager Networks and observations	To understand the roles and responsibilities of the Directorate of Networks and Observations, the challenges they face to carrying out observations, the status of equipment calibration, the reasons for the irregular reporting of AWS, the maintenance and installation plans and current status of network stations across the country.
	Senior Weather observers & weather observers	To understand the roles and responsibilities, staffing levels, qualifications, reporting guidelines and frequency, means of reporting, the types of weather stations, the instruments and the parameters in place and the maintenance of the various instruments as well as challenges faced in undertaking the activities of weather observatory.
DISTRICTS	District Production Officers	To ascertain whether they received the seasonal forecasts in time and whether they understood the information therein; the training they have received from UNMA, whether the dissemination mechanisms are the most appropriate and if they receive dekadals and monthly forecasts.

Appendix IV: Weather Stations inspected

Weather stations	Date of Inspection
Mbarara synoptic station & Automatic weather station	06/06/2018
Gulu synoptic station & Automatic weather station	11/06/2018
Kitgum Agromet station & Automatic weather station	11/06/2018
Masindi Synoptic station & Automatic weather station	12/06/2018
Bushenyi agromet stations	06/06/2018
Kasese Synoptic station & Automatic weather station	06/06/2018
Kyejonjo Hydromet station	05/06/2018
Mubende Hydromet station	05/06/2018
Soroti Synoptic station & Automatic weather station	18/10/2018
Entebbe Hydromet station & Automatic weather station	30/03/2018
Makerere synoptic station & Automatic weather station	20/03/2018
Tororo synoptic station & Automatic weather station	03/04/2018
Entebbe synoptic station & Automatic weather station	30/03/2018
Jinja synoptic station & Automatic weather station	03/04/2018
Kituuza agromet station	22/03/2018
Naro Ntawo agromet station & Automatic weather station	22/03/2018
Kawanda agromet station & Automatic weather station	23/03/2018
Namulonge agromet station & Automatic weather station	23/03/2018

Appendix V: Sample size

SAMPLE SIZE OF WEATHER STATIONS	Population	Using Yamane Taro Sampling method Sample size= N/(1+N* e2)
AUTOMATIC WEATHER STATIONS (All Functioning)	43	14
MANUAL WEATHER STATIONS (Functioning)		
Synoptic	12	
Hydromet	8	
Agromet	9	
Total functioning Manual stations	29	12
		The sample size using a Stratified Sampling method
Synoptic		12/29*12= 5
Hydromet		8/29*12 =3
Agromet		9/29*12 =4
Where N: = Population		
e2 = probability of error = 5%		
Note: The Sample size does not include non - functioning stations since they do not generate weather observations		

Appendix VI: Reporting patterns of sampled Automatic Weather Stations

Months	Automatic weather stations	2016	2017	2018
January	Makerere Mubende	 1st – 30th No data on other parameters except Rainfall		1st -12th No data on all parameters 1st -8th No data on other parameters except Rainfall
February	Mubende Kasese	1st -28th No data on all parameters except Rainfall 21st -30th No data on all parameters		
March	Mubende Mbarara	1st -30th no data on all parameters except for Rainfall	Other parameters reported except rainfall on 22nd, 24th, 26th and 27th	
April	Tororo Makerere	1st -19th No data on all parameters 1st-19th No data on all parameters	30th No data reported except rainfall	
May	Tororo Entebbe Makerere Mubende Kyenjojo Kasese Mbarara Kabale Jinja Soroti Lira	 From 1st-30th No data on the parameters reported from two stations 1st-19th No data reported on all parameters	1st-30th No data on all parameters except rainfall	17th -24th No data on all parameters
June	Makerere Mubende Kasese	 From 1st-30th no data on all parameters reported from two stations	1st-2nd no data reported on all parameters except rainfall	

July	Makerere Mubende Kasese	 From 1st -31st No data on all parameters reported	17th -18th rainfall data not reported	
August	Mubende Kasese Jinja	1st -31st no data reported 1st -13th no data reported		
September	Tororo Makerere Mbarara Jinja Soroti Lira Mubende Kasese	20th -29th no data reported on all parameters 1st - 6th, 20th 30th 1st - 12th, 20th -30th no data on parameters reported		
October	Mubende Kabale	22nd -25th 1st -17th no data reported		
November	Mubende		16th - 25th, 29th -30th No data reported on parameters	
December	Makerere Mubende Kyejonjo	 1st -6th no data reported	25th - 26th, 28th -30th No data reported on parameters 1st -31st no data reported	

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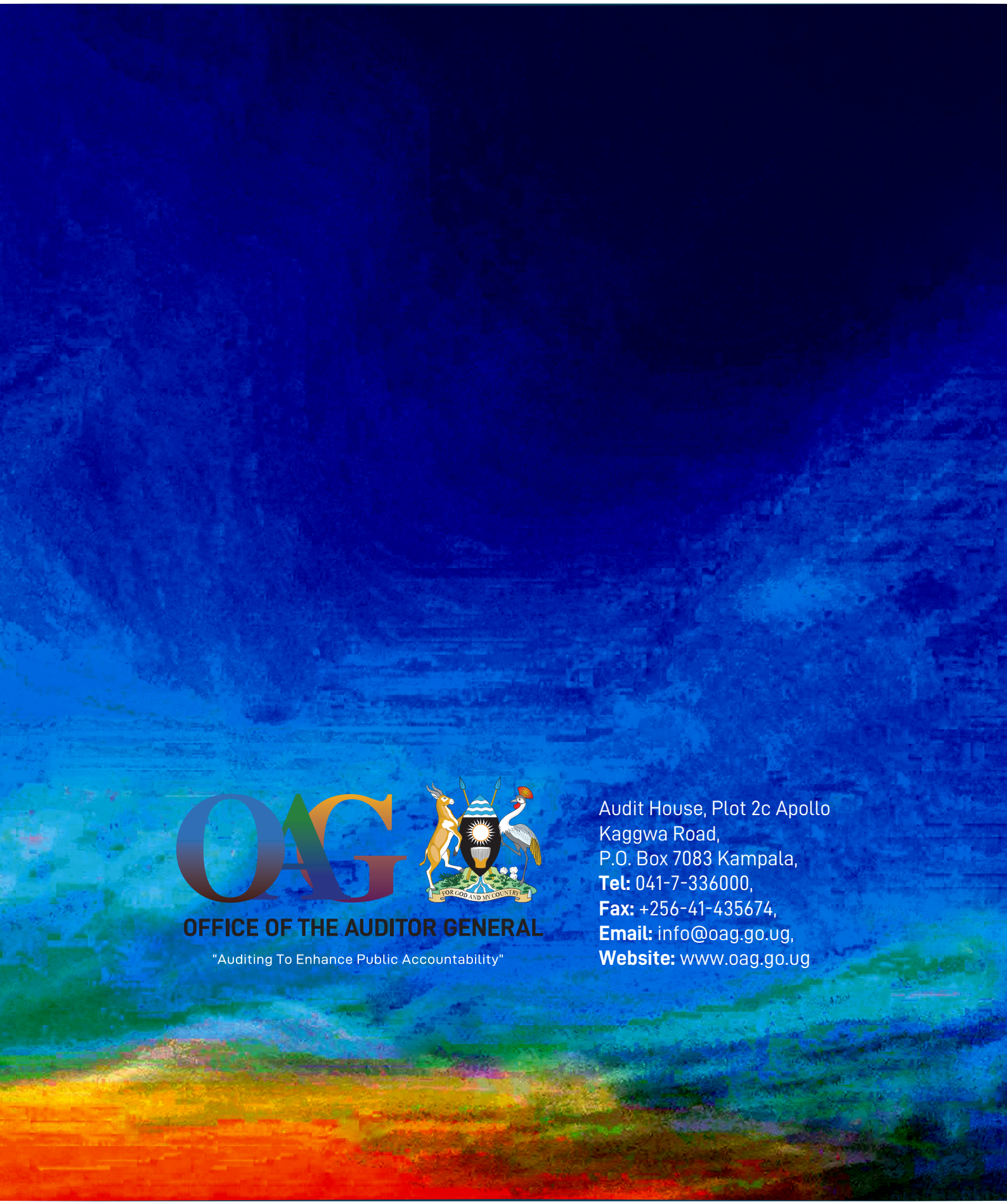

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