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AN OVERVIEW OF KEY IMPROVEMENTS BY THE NIGERIAN METEOROLOGICAL AGENCY FOR THE MODERNISATION OF METEOROLOGICAL SERVICES IN NIGERIA

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ABSTRACT
Nigerian Meteorological Agency (NiMet) is posed to be a world class provider of Weather and Climate services for safety and sustainable national socio-economic development and also to observe Nigerian Weather and Climate and provide Meteorological, Hydrological and Oceanographic services in support of national needs and international obligations. NiMet has made and is still making tremendous efforts to ensure the delivery of timely, accurate and quality weather information for the development of all the socio-economic sectors of Nigeria. This is through the densification of the observations networks, acquisition of the relevant and latest weather instruments, weather monitoring systems and training of technical and operational personnel on data capturing, data dissemination system, calibration, installation and maintenance of the acquired equipment .This is aimed at giving an insight to the efforts made and is being made by NiMet towards the modernization of all its meteorological services. The information contained in study was obtained from NiMet through visits to some of the synoptic stations and also from documented sources.

Keywords: Innovation, Nimet, Meteorological Services, socio-economic sectors

INTRODUCTION

According to the National Oceanic and Atmospheric Administration (NOAA), about 80% of global economic activity is directly or indirectly affected by the weather, and about 10% of global Gross Domestic Product (GDP) is directly affected by the weather (Dutton, 2002). Moreover, Dutton (2002) conducted a qualitative analysis and concluded that in the United States, climate-sensitive areas account for 39.1% of US GDP. Lazo (2011) provided an empirical methodology for estimating industrial activities and found that those directly affected by the climate accounted for 3.4% of US GDP and that the impact on the household sector was $31 billion. Therefore, if weather and climate information is used properly, our society will be able to maintain socioeconomic value beyond mere disaster prevention. Furthermore, if this information is used more actively, high added value may be generated. However, analyses have shown that even though 90% of businesses are affected by weather and climate events, only 30% of them respond to such threats (Amado and Adams, 2012). Accordingly, the global society is attempting to strengthen weather services in the public sector (Vaughan and Dessai, 2014, Diaz and Joseph,2019) and is discovering various customized weather services through linkages with the private sector (Ubong et al., 2019, Newman et al., 2019) Thus, the market for weather services is becoming increasingly active (Howard,2020 and Freedain and Zillman, 2002) and various types of weather services and weather service companies are being established (Pettifer,2015, Freedairn and Zillman, 2002).

As such, with the availability of weather and climate information, the risks for corporations can be minimized and the scale of profit generation can be accelerated (Freedairn and Zillman, 2002). Indeed, in the global market, weather and climate information are being used as essential business decision-making tools in the industry with the application of weather risk management concepts. Countries and companies are generating profits or reducing losses by developing various solutions that analyze both weather and industrial big data (Georgeson et al., 2017 and Trocolli, 2008). Moreover, the fields of application are comprehensive, the forms are highly diverse, and the weather service sector is expected to continue to grow

National Meteorological and Hydrological Services all over the world have essential roles to play in environmental disaster prevention and mitigation. These roles are realized through delivery of quality and reliable public weather services, provision of weather forecasts, issuing timely warnings on hazardous weather, and carrying out outreach activities to enhance public awareness of weather challenges (Lee and Hilda, 2010). The interpretation and application of weather information as well as collaboration with various disaster relief organizations to minimize loss of lives and properties also constitute part of the essential roles. In the current 21st century, the destructions caused by natural disasters such as earthquakes, volcanic eruptions and landslides are still on the rise throughout the world. However, in some places, the destructive impacts of weather-related hazards have been harnessed over the years. In Hong Kong, for example, over the past five decades, owing to consistent utilization of authentic meteorological information in her national activities, the recorded statistics of destroyed properties caused by tropical cyclones including human injuries have fundamentally declined (Lee and Hilda, 2010).

The improvement of meteorological services in Nigeria has been one of gradual process since then, driven mainly by growing environmental challenges, user requirements and available technical support over the years, as a result of the evolving trend in information and communications technology (ICT). For example, the severe drought of 1969 to 1973 raised significant concerns, which led to the meeting of Heads of Government of the West Africa; subsequent call for better understanding of weather and climate of the region and its variabilities (Adefolalu, 2006). Following this call, coupled with the recognition of meteorology as corner piece for nation building, efforts were doubled to improve on the state of the weather observing network of stations in the country; as well as the transformation of the Department of Meteorological Services into a semi-autonomous Agency with a legal framework and corporate headquarters building.

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MATERIALS AND METHODS

The materials used in the study are basically from the Directorates of Weather Forecasting Services (WFS), Applied Meteorological Services (AMS) and Engineering and Technical Services (ETS) of the Nigerian Meteorological Agency. These Directorates were purposively selected because they are directly related with analysing climate data, issuing of forecast, dissemination of forecasts and predictions and the procurement, installation and maintenance of meteorological instruments. Content analysis from the interviews conducted with the heads of the relevant units of the Agency was used and also relevant information was extracted from the Agency's Publications and Bulletins.

METEOROLOGICAL SERVICES IN NIGERIA

The observation and collection of Nigerian meteorological data started in 1892 as an agricultural station under the then Public Works Department. It was about forty years later that a full-fledged Meteorological Department was established in the country. The Nigerian Meteorological Department started operations in 1937 as the main agency responsible for all forms of weather-observations in the country. Several ministries have supervised the Department's activities, including the Ministry of Communications in 1952, Transport in 1953 and the present Ministry of Aviation. The movements of the Department from one Ministry to the other over the years are without doubt, connected with the multi-sectoral relevance of the data they generate. Today, there is the Nigerian Meteorological Agency, a parastatal of the Ministry of Aviation.

COVERAGE, SCOPE, USERS, AND USES OF METEOROLOGICAL STATISTICS

As the study of the weather and climate, Meteorology has to do with the understanding of the physical, dynamic, and chemical state of the earth's atmosphere, and the interactions between it and the underlying earth's surface. To effectively monitor the weather, the Nigerian Meteorological Services Department maintains a network of weather-observation stations across the country. Over the years the work-load of these stations have increased tremendously, first as the number of airports increased and second, as it became appreciated that greater spread and number of stations are needed to generate representative data on the meteorological characteristics of the country.

The data collected from these stations are processed and the resulting information have operational applications for a wide range of socio-economic activities. Thus, meteorological statistics have several users which include large-scale farmers, foresters, fish farmers, the Civil and Military Aviation Departments, marine and other shipping firms, land transport establishments such as the railways in temperate zones, the construction industry, utility and energy distribution agencies, mining and energy extraction agencies, manufacturers and the general public. Some of the key areas where the interpretation of meteorological information is relevant, are described below.

i. Agriculture: Meteorological data are useful in planning farm schedules such as seed and seedling planting, fertiliser application, irrigation, crop monitoring (especially against pest infestation) as well as harvesting and storage of farm produce. They are also useful in livestock keeping and frost protection.

ii. Forestry: Meteorological data are also important in the forestry sector for the timing of tree planting and watering (particularly in the arid and semi-arid areas), in the prevention of loss of valuable timber species and wildlife arising from fire hazards and severe drought through early warning system

iii. Fishery: In fishery, meteorological data are useful as a guide in the establishment of fish ponds where rain is the main source of water. They are also significant in fishing on large bodies of water, particularly oceans and seas. Meteorological data provide early warnings on fogs and wind characteristics which are critical in the choice of fishing sites and timing.

iv. Aviation Industry: Meteorological data also provide useful information for aircraft landing and take-off, decisions on route changes, de-icing and likely inconveniences and discomfort arising from altitudinal changes in flight.

v. Marine Rigs: Meteorological information helps ships' captains plan their routes, cease operations and evacuate their cargoes when necessary to protect their equipment.

vi. Land Transport: Meteorological data are also relevant in providing information about temperature and rainfall and other weather parameters that can affect land transport. In temperate zones, information on snow fall, ice removal from rail lines are given prominence, and are significant in planning the movement of vehicles.

vii. Construction: Civil engineering works are affected significantly by weather and climatic characteristics. Thus, meteorological data are relevant for planning and decision making in the construction. The use of meteorological information in this sector is, however, still very low in Nigeria. It is only the information on rainfall dynamics that is being used in the decision making in physical construction sites, particularly in concrete reinforcement and similar works.

viii. Utilities & Energy Production: As electricity production in Nigeria is mostly hydro, any data that aids the knowledge of water flows and water levels in the dams are of particular relevance. Meteorological data are particularly vital in this regard. They aid in monitoring water level in most hydroelectric power stations and the expected seasonal variations as well as long-term changes that may occur and which may have adverse effects on water levels. Lack of such data can result in erratic supply of electricity. Meteorological information which forecast thunderstorms also provide early warning to the PHCN officials to switch off their plants to avoid possible damage.

NIGERIAN METEOROLOGICAL AGENCY AND ESTABLISHMENT OF THE LEGAL FRAMEWORK

With the defunct of the Nigerian Meteorological Services Department and emergence Nigerian Meteorological Agency (NIMET) in June 2003, as a parastatal of then Federal Ministry of Aviation (now Transportation), an Act of the National Assembly (NIMET Establishment Act No. 23 of 2003) was established. The Act of the parliament was to provide legal framework to give impetus to meteorological services in the country. The Agency was set up among other things, to carry out weather observation in Nigeria, as well as collect, process and disseminate all meteorological data and information within and outside the country. Furthermore, the Agency has the mandate to ensure uniform standard of observations of all meteorological phenomenon in the country, as well as ensure that international standards and practices in meteorological operations are not compromised. Since the inception of the Agency in 2003, NIMET has remained successful in the continued modernization process of meteorological services in the country over the space of 14 years.

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The drivers of the modernization process inter alia are;

(i) Strong financial resources base provided by the Federal Government and through internally generated revenue (IGR) of the Agency,

(ii) Long-term and stepwise developments/investments that are centered at advancing science and technology with verifications and improvements, and

(iii) Long-term, sustainable human capital development to foster highly educated experts that are capable of handling cutting edge science and technology.

METHODS OF DATA STORAGE AND DISSEMINATION

After the preliminary quality checks on the observed data by the respective station/State/zonal meteorological inspectors, the data are transferred to the Climate Returns Section at Oshodi. Here the data are further subjected to more comprehensive quality checks before transferring them to their final repository in the National Climatological Archives Investigation Section. This section is responsible for storing the data in manuscript forms, kalamazoos, and supplying information on them on demand. It is located at the Meteorological Services Headquarters in Lagos. In addition to the foregoing, a few of the data have been microfilmed, while a substantial amount (particularly those of the synoptic stations) now exist in computerised form. The data base management software presently used for this is DATAEASE which is employed in the CLICOM (climate computing) system acquired by the Department in 1990. The system was developed by the World Meteorological Organisation (WMO) in 1984 to aid the standardization of the climate data storage and exchange within its member-countries. Data processing/analysis packages like LOTUS and INSTAT are also used at the computer centre. Dissemination of the data/information are in the form of preparation of publications or periodicals, namely:

Monthly Rainfall Summary (from January 1951).
Monthly Weather Report (from January 1949).
Annual Summary of Observations (from 1949).
Agro-Meteorological Bulletins (from August 1962).

Additional materials are published from time to time in two series of occasional publications:

Meteorological Notes.
Technical Notes.

THE IMPROVEMENT OF METEOROLOGICAL SERVICES IN NIGERIA

Nigerian Meteorological Agency (NIMET) is posed to be a World Class provider of Weather and Climate services for safety and sustainable national socio-economic development and also to observe Nigerian Weather and Climate and provide Meteorological, Hydrological and Oceanographic services in support of National needs and international obligations. The key mandate of the Agency is observing, analyzing, timely and accurate reporting of weather and climate information for socio-economic development and safety of lives and property. These are the operational structure for effective service delivery:

i. The Corporate Headquarters in Abuja is located at the National Weather Forecasting and Climate Research Centre Abuja
ii. National Weather Forecasting and Climate Research Centre, Abuja
iii. Fabrication workshop at NiMet Complex, Oshodi.
iv. WMO Regional Training Centre, Oshodi Lagos
v. 6 Zonal offices (Enugu, Ibadan, Kaduna, Kano, Maiduguri and Port Harcourt)
vi. 1 Central Forecast Office, Abuja
vii. 4 Independent Forecast Offices (Abuja, Ikeja, Kano and Port Harcourt)
viii. 54 Synoptic Stations spread all over Nigeria
ix. Instrument Calibration Laboratory, Abuja
x. 1 Agro-meteorological Experimental Farm (Oshodi, Lagos)
xi. 8 Upper Air Stations (Abuja, Enugu, Lagos, Kano and Maiduguri, Jos, Calabar and Yola)
xii. 30 Automatic Weather Stations (Received additional 37 by TAHMO)
xiii. 12 Marine Stations, Calabar, Eket, Niomr and Koko (operational). Eastmole, Aiyetoro, Warri, Onne, PH Wharf, Apapa, Bonny, Forcados.
xiv. 6 Radar stations (Abuja, Port Harcourt [Operational], Yola, Maiduguri, Kano and Lagos
xv. 4 Air Quality and Ozone monitoring station (Abuja, Lagos, Enugu, Kano

KEY IMPROVEMENTS AND INITIATIVES

The Agency has developed over time to become a World class meteorological agency. These are some of the innovations achieved:

i. Technology To improve the capacity to track hazardous weather system, provide early warning system to pilots and the general public and provide accurate and timely weather forecast, the Agency procured and installed 6 Doppler Weather Radar
ii. The Nigerian Meteorological Agency (NIMET) is equipped with EUMETSAT ground receivers at the main forecast offices
iii. The installation of Low-Level Windshear Alert System (LLWAS) at Lagos, Kano, Port Harcourt and Calabar and other Airports. The Low-Level Windshear Alert System (LLWAS) measures wind speed and direction at remote sensor station sites situated around an airport and can generate warnings when wind shear or micro-bust conditions are detected The LLWAS assists pilots during critical times when they must determine whether to attempt to land or take off in hazardous weather conditions.
iv. Upper Air Weather Measurements. The Nigerian Meteorological Agency presently operates a network of eight upper air stations across the country. These are located at Abuja, Calabar, Enugu, Jos, Kano, Lagos, Maiduguri and Yola. Upper Air Sounding (or Observation) is used for measuring weather parameters at different altitudes in the atmosphere. It uses a set of sensors, known as radiosonde, attached to a hydrogen-filled balloon and released into the atmosphere.
v. The Thunderstorm and Lightning detector device detects electrical discharges associated with lightning within a 200 nautical mile radius of the system.
vi. Integrated AWODS installed in 14 locations Key Innovations & Initiatives: Technology It measures cloud height, cloud base, runway horizontal visibility, wind speed, wind direction, temperature, pressure, precipitation, humidity, radiation, thunder and lightning. Presently, NIMET Provide daily Weather Forecasting Services to Liberia and Sierra Leone under our Technical Assistance Program.
vii. The Data Management, Information and Communication Technology (ICT) Unit designed to enhance data collection, processing, storage and application for product generation in the different areas of meteorology. Data Management

Infrastructure. The Data Management Center receives real time numerical and satellite data for processing, archiving and dissemination to various end users.

viii. NIMET also has a data buoy anchored off Lagos coast. Hourly marine weather data obtained from these stations are built into the production of daily marine forecasts.

ix. NIMET has complied with best practices by certifying its aeronautical meteorological services : ISO 9001:2015 certified (the first African Country to have achieved that) NiMet is remodeling the fabrication and calibration laboratory in readiness for ISO : 17025 certification

x. NIMET, recently signed an MoU with a Dutch Consortium- TAHMO for the installation of a robust network of 1000 AWOS in Nigeria for hydrometeorological monitoring. Under this partnership, the Agency, on 8th October, 2017 received 37 Units at no cost to the Nigerian Government. These Units are being immediately installed across the country (34 in universities) to significantly increase the density of NIMET's observatories and quality of services.

xi. During the last Africa Hydromet Forum in Addis Ababa, 12th-15th September, 2017 NIMET signed a Memorandum of Understanding (MoU) With an Austrian Partner- UBIMET, with the core aim to establish a long-term commercial partnership between the Parties for the purposes to enhance and tailor the quantity and quality of weather services and products for end-customers in Nigeria and NIMET's areas of responsibility. As part of this collaboration, UBIMET is currently installing 8 Lightning Detection System across the country to help monitor and issue Early Warning Systems (EWS) for extreme weather events.

xii. NiMet is making plans to have collaborations with the Austrian Meteorological and Geodynamics Headquarters.

xiii. Nigerian Meteorological Agency (NiMet) formed a partnership, 2021 with the Earth Networks, a global provider of weather intelligence. The agreement includes a five-year collaboration to build the Nigeria Total Lightning and Mesoscale AWS Network (NTLMAN) for early warning of severe weather. The partnership was commemorated during a live virtual Memorandum of Understanding signing ceremony from Abuja and Germantown, Maryland. under the agreement, Earth Networks and NiMet will deploy and operate a comprehensive early warning lightning detection network in Nigeria and jointly co-market new sources of weather and lightning data to public and private industries in Nigeria. Precision weather stations and lightning sensors will be hosted at NiMet locations and maintained by NiMet staff. In addition to the network equipment, Earth Networks will also provide training and development for NiMet staff regarding use of comprehensive weather data, including real-time and historical lightning data, weather observations, sensor forecasts and live storm-tracking and alerting.

xiv. As part of the Agency's preparedness towards effective service delivery, the Agency entered through an MOU a collaboration with the Nigerian Maritime Administration and Safety Agency, NIMASA.

xv. The Nigerian Meteorological Agency in collaboration with the Institute of Agricultural Research Zaria (IAR) has embarked on the downscaling of the 2021 Seasonal Climate Prediction (2021 SCP) and its Roving Seminar.

In recognition of the need to step-down SRP vital information to grass root end users in the country, NIMET in collaboration with MARKETS II, a USAID funded project, organized an EA training of trainers across the country as part of the Agency's mandate to contribute to the Federal Government Agenda on reviving Agriculture for maximizing output and achieving food security and robust economic development The SRP step down workshops took place in 18 States during the 2017 Growing Season.

NIMET, in October, 2017 signed an MoU with the West African Service Centre on Climate Change Adaptive Land Use-WASCAL to increase observation stations density as well as developing refined tailor-made weather/climate services in the country. Fallout of this noble collaboration, West African Science Service Center on Climate Change and Adapted Land Use (WASCAL) has donated 10 number AWOS (Automatic Weather Stations) which are to be integrated in the NIMET's existing observatories for improved services.

The overall spirit and objective of the MoU was to reach an agreement that brings mutual commercial benefit to both Kukua and NIMET. In addition, this Agreement brings benefit to Nigeria as a whole through both economies and societies. In pursuance of this collaboration the parties agree on the following Key Principles:

a. Kukua and NIMET will collaborate for the enhancement of weather information across Nigeria.

b. Automatic Weather Stations will be installed at telecom tower sites and maintained under the responsibility of Kukua and NIMET.

c. NIMET will be a designated provider of ISO Standard Certifications regarding instrument precision and data

Despite the current giant stride to increase the number of observation stations across the country, due to the vast landmass of Nigeria, the number of these stations are grossly inadequate to address the challenges of climate variability and change. In light of the aforementioned, NIMET is collaborating with the 34 Universities to install and maintain standard weather observation stations across the length and breadth of the country. The data to be co-generated and co-shared for research and development in the Country.

The Agency is in collaboration with other Partners

i. International Institute Of Tropical Agriculture (IITA): Climate Smart Agricultural Practices

ii. International Fund for Agriculture (IFAD)-CASP Project On Climate Smart Agriculture and Farmers Associations Across The Country

iii. Federal Ministry of Agriculture

iv. Institute of Agricultural Research, ABU, Zaria, Agricultural Insurance Organizations and Companies and Other Community Based Organizations/Non-Governmental Organizations interested in Weather/Climate Services

The Nigerian Meteorological Agency (NIMET) have commenced the process of rescuing and digitizing its weather observational data stored in paper form. The data records spans for over a hundred years in some stations. The National archive is located in Lagos (former headquarters of NIMET) and to some extent, is in relatively good condition. Unfortunately, many archives are in poor condition and not well organized and managed. The Nigeria Meteorological Agency has the responsibilities of securing this endangered national resource and is therefore looking for the best data rescue and digitization methods, including the most modern equipment that will be most effective and efficient to adopt in this rescue project.

The various stations from which the data come include:

Rainfall stations	224
Agromet stations	167
Synoptic stations	42
Upper Air stations	5
Climate stations	13
Marine	3
Ozone	1
Background pollution monitoring (BAPMON) station	1

Methods of taking weather observations can be in the following forms:

[a] Direct reading of the basic meteorological elements from their respective measuring instruments at predetermined intervals.

[b] Extracting the elements' values from autographic charts wound round clock-driven devices, e.g. temperature, pressure, etc.

[c] Visual observation of the parameters by the observer, e.g. cloud amount.

[d] Estimating the parameters' values from satellite pictures.

[e] Deriving the parameters' values from some of the observed basic ones.

There are three principal types of climatological observatories:

Synoptic Stations are manned by full-time professional observers maintaining continuous weather watch and making hourly instrumental observations for periods up to 24 hours daily. Temperature, humidity, pressure, rainfall, sunshine and, in some cases, wind are recorded autographically. Evaporation, radiation and soil temperature are observed at most synoptic stations.

Agricultural Stations are manned by part-time observers making twice daily instrumental observations of temperature, humidity, evaporation, wind, radiation and soil temperatures. Some of these elements are recorded autographically.

Climatological Stations are manned by part-time observers making once or twice daily instrumental observations of temperature and humidity. On 1st July 1965, the numbers of stations operational were:

Synoptic Stations	28
Agricultural Stations	53
Climatological Stations	62

The density of stations over much of the country is inadequate and the present development objectives for the basic network is 2 stations per degree-square (1/2500 square miles) with locally increased densities in areas of particular agricultural and hydrological importance.

Conclusion

Although a vast amount of meteorological data covering a period of more than 100 years exist in Nigeria, there is considerable scope for improvement. Most of what need to be done revolve around funding (The Agency's Internal Generated Revenue is still undergoing expansion). More funds would have to be made available to the agency to:

[a] increase the density of its observation stations to the World Meteorological Organisation standards.

[b] resuscitate abandoned observation stations. There has been a drastic reduction of observing stations.

[c] acquisition of more computers to speed up the data processing at various levels, and reducing damages to which the single-copy paper media are exposed.

[d] build capacity in the areas of modern applied meteorological practices and data management. This is needed for the purpose of upgrading the quality of data particularly at the collection level.

[e] improve communications facilities, mobility of meteorological inspectors to effectively supervise the observing stations.

[f] recruit more technical staff are needed to enhance better transfer and dissemination of information. This will also facilitate the publication of special reports on the analysis of meteorological data.

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