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Meteorological Services for Disaster Risk Prevention and Mitigation in Nigeria

Okhakhu Poly Alens
Department of Geography and Regional Planning, Ambrose Alli University, P.M.B. 14, Ekpoma-Nigeria
Email:drpolycarp@gmail.com

Abstract
This study examines the place of meteorological services in disaster risk prevention and mitigation in Nigeria. It discusses the types, establishment requirements and limitations of meteorological stations in the country. The study also examines the climatic features of 'Regions A and B' and their related hazards. It observes, inter alia, that owing to existence of few meteorological stations which are poorly instrumented and maintained by corporate interests and government, derivation of authentically adequate climate information required for accurate weather predictions and spatial planning becomes a major challenge in the country. This situation has given rise to vast inundation of some settlements, displacement of people, destruction of agro-products, and aviation disasters in Nigeria. Premised on the findings, the study recommends that effective meteorological observations should be carried out in the country by using standard weather instruments. The weather information obtained from the observations should be used by a body of specialists for authentic atmospheric prognostications and spatial planning alongside other suggested measures necessary to prevent and mitigate climate-induced environmental disasters in Nigeria.
Keywords: meteorological, services, disaster, prevention, mitigation

Introduction

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 (Marjorie, Scott, Thomas and Paul, 2009; Lee and Hilda, 2010).

In this study, three essential meteorological approaches are proposed to help curb the occurrence of natural disasters which are climate-triggered in Nigeria. The first approach argues in favour of strengthened socio-economic and political infrastructures against the prevailing extreme climatic forces specifically torrential precipitation and gusty winds. The second approach encourages continual scientific researches and advancements in weather observations, monitoring and predictions by experts through the application of both manual and automatic meteorological apparatuses. The final approach focuses on the readiness of the public to respond quickly to hazardous weather warnings either by relocating to safer environments or directly avoiding the prevailing weather onslaught by staying indoors in well protected weather-resistant buildings.

Prior to the utilization of weather reports, the observed meteorological conditions referred to as 'meteorological fields' could be simulated artificially with the assistance of computers (Roger, 1986). The purpose of this simulation is to provide clearer pictures and comprehend how critical or mild such atmospheric conditions have been at the locations covered. Where the simulated conditions are dangerous and might induce violent winds and rainstorms which could destroy settlements and associated infrastructure on the earth's surface, public weather warnings are issued immediately cautioning the inhabitants of the locations against such impending hazards. If, on the other hand, the atmospheric conditions are interpreted as mild and tranquil, restraint against such cautions

is advised by the national meteorological agency.

This background suggests that atmospheric prognostication should form a very significant aspect of this current discourse which should be encouraged holistically if we must conceive a meaningful panacea to mitigate climate-induced environmental disasters in Nigeria. Also, consistent efforts must be made to accumulate essential climate information both in past and current years in Nigeria. The information gathered should be pooled and carefully used for reliable predictions of atmospheric conditions in the country. A reliable measure to achieve this objective is to strengthen the technical conditions of the existing private and government-owned weather stations as well as establish new ones in Nigeria including the digital types that are space-borne.

Nigeria lies approximately within latitudes 4^0N and 14^0N and within longitudes 3^0E and 15^0E. It is bordered in the north, east and west by the countries of Niger, Cameroun and Benin, while the Gulf of Guinea, which is an arm of the Atlantic Ocean, forms the southern boundary (Iloeje, 1982; Udo, 1987). The climatic implication of this location in West Africa is two-fold. First, it shows that Nigeria is widely exposed to the influence of approaching desert winds, sandstorms, and high radiation from the north. Second, the location presents the country as a geo-political entity which is receptive of abundant precipitation induced by the tropical maritime winds that ascend from the Gulf of Guinea in the south. Effective management of these essential climatic resources by experts would lead to beneficial development as well as prevention of climate-spurred environmental disasters such as thunderstorms, flooding, surface denudation, landslides and rockfall in Nigeria.

A previous study carried out by Okhakhu (2010) revealed that the utilization of inadequate climate information for environmental planning and inaccurate prognostications of the state of the atmosphere resulted in widespread climate-induced inundation of cities, mud-flows on the streets, ravine formation on the highways, destruction of farm produce, impaired visibility on the roads and in airports, and collapse of several buildings in Nigeria. Also, standard meteorological stations which could provide authentic climate information for public consumption are inadequate in the country. In addition, adequate meteorological prognostications are partly retarded in the country owing to few practising meteorologists. Challenges related to inadequate funding on the part of government and corporate bodies, presence of few experts, and poor maintenance of installed apparatuses have weakened the institutional efficacy and viability of meteorological services in Nigeria.

Meteorological services in contemporary countries of the world are coordinated by meteorological stations under the specialist management of central national agencies. In Nigeria, for example, the Nigerian Meteorological Agency (NMA) carries out this essential service. In reality, it is not genuine to accept holistically that all weather reports from both private and government-owned meteorological stations throughout the country are completely pooled and documented at the NMA. Besides, most rural areas in the country do not have functional meteorological stations. Even when weather satellites reports are utilized to cover these areas, realistic land-based weather stations are required to verify the authenticity of these reports. This situation reveals a major weakness with regard to documentation and provision of accurate climate information for utilization in weather prognostications for disaster prevention in the country.

In Nigeria, current scientific studies on effective meteorological services for preventing frequent occurrences of environmental disasters are non-existent. Most often, inadequate weather reports which do not indicate the exact location, period, and time of occurrence of weather hazards are broadcast in televisions and radios by the NMA. It is against this background that this current study examines the place of meteorological services for disaster risk prevention and mitigation in Nigeria.

Research Objectives

The specific objectives of this study are to:

a. examine the types of meteorological stations in current climate studies;
b. itemize the standard requirements for the establishment of meteorological stations;
c. assess the challenges of meteorological stations in Nigeria;
d. examine the climatic characteristics of 'Regions A and B' and their related hazards;
e. assess the implications of the findings for disaster risk prevention and mitigation in Nigeria.

Research Methods

This study used primary data and documented information. The primary data were obtained from oral discussions held with some specialists who had participated in previous relief missions in Nigeria. Relevant inferences were thereafter drawn from the discussions. A central aspect of this study is on atmospheric prognostication. The concept enables the weather conditions of the past and current years to be vastly

understood, and the future to be predicted with a view to preventing the occurrence of environmental disasters. In this regard, application of inaccurate weather statistics is out of the focus. Relevant information was derived from published textbooks and journals on climatology. The final input formed the documented literature used in the current study. Based on the objectives of the study, the cause-effect analytical approach was adopted in the discussions.

Types of Meteorological Stations in Contemporary Climate Studies

Specially established stations on and above the earth's surface where weather observations, measurements and documentation are regularly carried out are referred to as meteorological stations. These stations have both conventional and automatic weather instruments. The conventional instruments are operated manually by part-time and professional weather observers while the automatic instruments are self-operational (Ayoade, 2004). The sources of energy for automatic weather instruments are solar and wind powers including dry cell batteries. In the current scientific age, functional meteorological stations are established on level earth's surface, stationary weather ships at the seas, suspended balloons in the air, and mounted satellites in outer space. In fact, weather satellites have the capacity to provide instantaneous atmospheric reports which are required urgently for planning aviation and other strategic activities in any country. This instantaneous function of weather satellites nullifies the prolonged medieval philosophy of 30-35 years of weather observations.

Based on the number of weather elements measured, frequency of measurement, status of the weather observer whether professional or amateur, nature of available instruments, and the levels at which the data generated are needed for human application, five types of meteorological stations are recognized in contemporary climatology. These are synoptic, agricultural, digital, climatological, and rainfall.

Synoptic Stations

These are weather stations that are managed by full-time professional weather observers who are either called climatologists or meteorologists. Personnel such as gardeners, messengers, stations' clerks and security guards are also involved in the managerial team. Standard weather instruments which assist in measuring the most conventional weather variables such as precipitation, temperature, humidity, sunshine, wind-speed, pressure, and evaporation are installed in the stations. The weather instruments are regularly maintained by meteorological engineers. Most of these weather stations are owned and sponsored by governments of countries, states, airport authorities, research institutes, universities, and some concerned corporate establishments.

Continuous and planned weather observations, measurements and documentation are carried out in the weather stations. The observed weather data and reports are accurate, spatially comprehensive and authentically reliable for different human applications. Also, meteorological training of different categories of students is carried out in the stations under the perfect guidance of assigned professionals. No doubt, the synoptic weather stations are regarded as authentically standard and functional in all dimensions (Ayoade, 2004).

Agricultural Stations

These weather stations have few meteorological instruments such as Class B evaporation pans, grass and soil thermometers, hygrometers, sunshine recorder, rain gauge, and anemometer. These instruments are used for observing, processing and recording evaporation, grass and soil temperatures, humidity, sunshine, precipitation, and wind speed. The relevance of these weather variables in implementing vital agricultural activities on the earth's environment has been discussed by Akinbode (2002) and Ayoade (2004).

Agricultural weather stations are managed by part-time weather observers, and are established and owned by agricultural research institutes, river basin development authorities, facilities of agriculture in universities, multi-national corporations, agricultural plantations, and private firms. Daily weather observations which are carried out by weather observers in the stations are often not as accurate, continuous and reliable as observed in standard synoptic stations. Also, there is a limitation associated with the maintenance of weather instruments. These technical lapses notwithstanding, the observed weather data and reports from the stations are often of immense value to regular agricultural activities being carried out on the environment by different organizations.

Digital Stations

These are the most recent weather stations which were established towards the end of the 20th century by meteorological scientists in Canada, Russia, the USA, Belgium and Sweden under private, corporate and government sponsorships. The instruments installed in the meteorological stations are genuinely automatic and characteristically digitized. They derive their energy from solar panels, hydrological and wind turbines, and automatic high-powered dry cell batteries. The instruments used for weather observations and documentation are

devised integrated sensored televisions and cameras. Most of the instruments are long-lasting, and through the use of highly sensitive sensors, they are able to penetrate all the different zones of the earth's atmosphere with a view to gathering essential weather data for multi-dimensional human applications (Okhakhu, 2014).

These recent meteorological stations are mobile in nature. Characteristically, they are in forms of gift boxes with small handles to carry. Others are like small laptop computers which provide easily readable weather statistics and charts. The instruments are able to observe and record all known weather elements such as precipitation, temperature, sunshine, wind speed, wind direction, humidity, and radiation. Others include cloud cover, evaporation, pressure, and soil temperature. The weather data and reports from these digital apparatuses are generally comprehensive in nature, accurate, and reliable for daily, weekly and monthly weather forecasts and for other purposes. Examples of these digital weather stations are the Vantage Pro 2 devised by Davis in the United States of America. Orbiting weather satellites which weather data are reliably adequate for predictions and national planning are also categorized as digital weather stations. As a result of the nature of weather instruments in the stations, they are highly expensive to establish and maintain.

Climatological Stations

These weather stations are known for their specific functions which include observation and recording of precipitation, temperature, humidity and winds. By their functions, we can reliably say that rain gauges, thermometers, hydrometers, wind vane and anemometer are the meteorological instruments installed in the stations.

Part-time weather observers are employed in the weather stations. The weather observations and documentation carried out are fairly accurate and reliable while their reports are also representatives of the exact atmospheric processes and patterns observed. The maintenance of installed meteorological instruments is regular, cheap, and well planned by the stations' part-time work force.

Most of the weather stations found in colleges and secondary schools which were formerly under the supervision of European missionaries in Africa and specifically in Nigeria are realistic examples of climatological stations. Some ministries such as agriculture and natural resources, works, aviation etc have well established climatological stations. This is true because their common activities require the statistical knowledge and accurate information of the processes at work in the atmosphere to be successfully realized.

Rainfall Station

This weather station has only the rain gauge as its instrument. The station maintains and uses it to observe and measure the rainfall amount at the site where it is established. Two part-time workers are employed in the station. One carries out the daily weather readings at 10.00am and 4.00pm while the other partner serves as a security guard. This weather station is relatively small in area configuration when compared to either the synoptic or climatological station. As a result of this feature, its weather reports are often spatially encompassing, accurate and authentic for predictions in carrying out agricultural, mining, commercial, hydrological, energy, and transportation activities in a defined geographic entity.

Researchers at the graduate levels particularly in Climatology and Meteorology Programmes in the Universities always set up this type of weather station to obtain first-hand weather data within a period of 3-6 years in the absence of such data in the study area. In fact, this weather station is easy to establish, cost-effective in management, and transferable from one site to another if the need arises.

Considering the meteorological stations above, the synoptic type would be recommended for establishment in Nigeria. This weather station is selected because it has all the standard weather instruments for observing, measuring, and documenting the commonly occurring weather essentials. Also, the station has professional weather observers whose functions revolve around providing regular weather information, instrumental maintenance and efficient training of students etc. Its cost of establishment is relatively cheap compared with the digital station.

Requirements for the Establishment of Meteorological Stations

For functional meteorological stations to be set up at any location on the earth's surface, a number of factors must be considered. These are itemized in this part.

The selected physical site must be a level surface which can conveniently accommodate the meteorological station. If the surface undulates, planned human efforts should be employed to make the necessary corrections.

The specific environment where the meteorological station is established should be free from obstructions posed by tall trees, high-rise buildings, and steel towers. The reason for this objective is to ensure a friction free atmospheric circulation around the meteorological station. Given this condition, the installed instruments can observe and measure the different weather elements conveniently.

The selected site where a meteorological station is established should be open and free to continuous atmospheric process and circulation. In other words, a meteorological station must be sited in an open environment where weather processes are operational and naturally occurring without any form of interruption.

Physical sites or surfaces which are sloping, hilly, swampy and mountainous in nature should not be used for the establishment of meteorological stations. Accurate and reliable weather data cannot be obtained from such weather stations if sited on these unstable surfaces. Also, pruned and adequately manageable grass should be planted on the level surfaces of mete orological stations. The grass would help prevent instantaneous surface evaporation and maintain the ecological equilibrium of the weather stations.

Fenced perimeters with protective wires measuring 12m by 10m are recommended for standard meteorological stations. Complete weather instruments which include both conventional and self-operational types should be installed by meteorological engineers in meteorological stations.

A functional technical management with responsible security is needed in the weather station because of the variety of expensive meteorological instruments installed. Also, boxes of spare parts should be regularly acquired and stored in a secure place where they await future utilization in the weather station. These objectives call for adequate funding on the part of government, corporate organizations and private interests.

Finally, routine inventory of fixed weather apparatuses, proper monitoring, and maintenance of the instruments should be carried out by experts managing the weather stations. This objective would help sustain the stations for a number of years.

In Nigeria, all these suggestions should be applied in order to have standard meteorological stations which are capable of providing essential up-to-date climate information for continuous planning aimed at preventing and mitigating environmental disasters. The climate information would also be needed for vital planning in all the sectors of the country, particularly in aviation, agriculture, commerce, water management, crude oil exploration and exploitation, road and housing constructions, military training, tourism development, and daily administration of towns and cities (Okhakhu, 2014).

Challenges of Meteorological Stations in Nigeria

Over the years, established meteorological stations in Nigeria have been disrupted by a horde of physical and human challenges. First, most of the selected sites where weather stations are set up in Nigeria are not suitable level surfaces. In fact, the current urge by young Nigerians to erect houses and harness the vast natural resources such as iron-ore, bauxite, limestone and crude oil on and beneath the Nigerian environment has resulted in various forms of environmental degradation, subsidence and physical warping. Subsequently, natural plains are changed either to sloping, hilly or unstable landscapes. Meteorological stations established on these degraded earth's surfaces cannot observe and measure weather variables accurately.

Dysfunctional weather apparatuses are deliberately installed in some meteorological stations in Nigeria. This development is a direct consequence of inadequate capital provision by the government, employment of unskilled personnel in the weather stations, and prevalence of a culture of corruption which breeds ineptitude in most administrative offices in Nigeria. Faulty meteorological instruments, right from the point of installation, are liable to observe and produce spurious and inaccurate weather reports. Inaccurate meteorological data and information when used in prognostication studies, particularly in agriculture and aviation, are destined to yield poor and disastrous results. The current poor agro-yields and observed plane crashes in the aviation industry in Nigeria are examples of related consequences of direct utilization of unreliable weather reports amidst undetected mechanical faults in airplanes.

Most of the instruments in meteorological stations in Nigeria such as rain gauges, evaporation pans, wind-vanes, anemometers, barometers, thermometers, hygrometers, and sunshine recorders etc are inadequately maintained. Also, meteorological engineers are few in the country. This problem situation is exacerbated by the prevailing extreme weather which wears away some of the instruments in meteorological stations. As a result of poor

security provision in most meteorological stations in the country, persistent instrumental destruction and theft have become common practices among vandals and thieves. Most meteorological stations in higher institutions of learning in the country always encounter these problems. Furthermore, inadequate funding poses a serious challenge to most weather stations. This leads to poor maintenance of weather instruments and replacement of worn-out parts. Consequently, the meteorological stations are left at the mercy of over-grown grass as well as finally abandoned to rust because they are not owned by private bodies.

In Nigeria, high-rise buildings, steel towers, communication masts, tall trees and over-grown grass always pose tremendous obstructions to free circulating atmospheric processes around meteorological stations. Accuracy and reliability of data gathering in meteorological stations sited in these locations are oftentimes in doubt. Such observed weather reports are neither good for prediction activities nor useful in climate change prevention and mitigation studies.

Climatic Characteristics of 'Regions A and B' and their Related Hazards.

Relevant climate studies carried out in past decades have identified the existence of four major climatic belts in Nigeria. These are sub-equatorial, tropical hinterland, tropical continental, and the high plateaux (Agboola and Hodder, 1979; Iloeje, 1982; Okhakhu, 2010). In the current study, based on the types of natural disasters we attempt to examine, these major climatic belts identified would be broadly synthesized into 'Regions A and B.' Region A consists of the sub-equatorial and tropical hinterland while Region B embodies tropical continental and the high plateaux.

Region A extends from the banks of the Atlantic Ocean in the south and terminates at the lower half of the middle belt of Nigeria. The region experiences heavy rainfall which lasts between 10 and 8 months within the year. The torrential rainfall is associated with extensively marked incidents of lightning and thunderstorms. As Iloeje (1982) argued, annual rainfall amounts between 3,200mm and 1,100mm have been recorded in the Region. It also experiences moderate temperatures which fluctuate from 23^0C to 32^0C on annual consideration. Mild sunshine, high humidity between 90% and 60%, moderate cloud cover, fluctuating pressure, and prevalence of gusty winds are other observed climatic features of the Region (Okhakhu, 2010).

Based on this climatic background, some climate-induced environmental hazards of different magnitudes would be anticipated in the southern and middle parts of Nigeria. These hazards include rainstorms, soil degradation, flooding, mudflows, landslides and rock falls. Others relate to over-flow of river banks, dark cloud cover, occurrence of gusty winds, tree-fall across the roads, rails and stream paths, chemical and biological weathering of infrastructure, and prevalence of a colony of insects in farm establishments.

The inevitable effects of these climate-induced hazards would be seen in the aspects of over flooded rivers and extensive coastal inundation, erosion of cultivated farm products, mud flows in the streets, submerged and collapsed buildings, and direct obstruction of road, sea and air transportation in the southern part of Nigeria. Furthermore, there might be incidents of traffic congestion on the roads and cancellation of air flights owing to poor atmospheric visibility induced by gusty winds, dark clouds and torrential precipitation. In extreme situation, plane crash and road carnage could occur, leading to the death of countless travellers. Severe landslides and rock-falls in some parts of the Western Region particularly around the Idanre Hills in Ondo State and Erin-Ijesan in Osun State could serve as serious limitations to agricultural activities. In the Eastern Part of the country where the soils are friable and extensively sandy, heavy precipitation could cause severe soil degradation leading to collapse of unstable buildings. Human displacement and occurrence of poor environmental conditions would be observed. In Agenebode in Edo State and parts of Benue State, the over flooded rivers particularly the larger River Niger and River Benue would experience low supply and presence of planktons which are required for fish breeding because of inadequate sunshine penetration. The consequence of this hydrological phenomenon would be reduced fish breeding and production in the river. The negative impact would be seen in poor means of livelihood of the users of these rivers, particularly in terms of reduced income, trade and decreased supply of proteins for healthy human lives. These vast consequences, as John (2012) and Lockwood (2012) argued, are aspects of climate change being currently examined by environmental scientists all over the world.

Region B extends from the upper half of the middle belt and terminates relatively at the upper Sahel Savanna demarcation. This broad Region is occasionally broken in parts by some pockets of highlands such as the Jos Plateaux, Biu, Mandara, and the Central Hausa Highlands. The Region experiences high sunshine, low clouds owing to reduced evaporation, and high diurnal temperatures between 29^oC and 43^oC. As a result of reduced

humidity which fluctuates from 65% to 35%, the broad belt receives low rainfall between 1,000mm and 250mm per annum (Agboola and Hodder, 1979; Udo, 1987). High and turbulent winds ranging from 82 km/hr to 250 km/hr are also observed in the vast region (Okhakhu, 2010). At the various geomorphic elevations identified in the Region, heavy rainfall with favourable temperatures is experienced.

Premised on these climatic variables, we could certainly predict a crop of natural hazards which would be anticipated in the Region to include gusty winds, sandstorms, wind erosion, mudflows, thunderstorms, drought and desertification, and presence of a colony of insects particularly mosquitoes, house flies, tse-tse flies and bugs. A number of adverse consequences would be anticipated in the Region owing to the variety of natural hazards itemized. These include weathering of properties, excessive dryness of the landscapes, erosion of cultivated farm products, and dust coverage of the environment in some locations. Occurrence of human diseases such as meningitis, malaria and typhoid, seasonal fluctuations of rivers and streams which affect river transportation and power provision, and flooding of the down towns as a result of torrential precipitation during the peaks of rainy season would be observed.

From reliable geomorphic, climatic and hydrological assessments, Nigeria is of higher elevations in the north than in the south (Iloeje, 1982; Ayoade, 2004). This makes the country a sloping geomorphic entity with most of her hydrological resources trickling down towards the south from the north. The recent flooding of Benue, Edo, Kogi, Anambra, Delta, Bayelsa and Rivers States in Nigeria owing to torrential precipitation and the sudden release of water from the dams in Cameroun illustrates this geomorphic descent. As would be seen in the next phase, these natural hazards can be controlled and prevented through timely and prudently directed weather prognostications using recent climate information and dependable strategies.

Meteorological Services for Disaster Risk Prevention and Mitigation in Nigeria

Meteorological services concern the continual processes of observing, gathering, recording and publishing essential meteorological variables on precipitation, temperature, humidity, winds, clouds, etc which are entirely associated with a demarcated climatic region or place. In this consideration, authentic directives are given to the public using the radio and television media on the methods and principles regulating effective utilization of meteorological elements assembled by the central meteorological organization. In the case of Nigeria, we have the Nigerian Meteorological Agency (NMA) with headquarters in Lagos carrying out these important services through the radio and television media. In this section, we attempt to discuss the place of meteorological services in preventing climate-induced and other environmental hazards in Nigeria.

Essential climate data would have to be observed, collected, processed and documented using standard meteorological instruments under perfect meteorologists' management in Nigeria. This recommendation calls for the establishment of numerous meteorological stations throughout the country by our government. In this way, a dense network of climate information accumulation and documentation would be established. The climate information required in this regard includes rainfall, temperature, winds and winds speed, humidity, pressure, cloud cover, evaporation, radiation, and sunshine. These climatic parameters could be utilized by meteorologists or climatologists to issue early weather warnings on areas in the country which might be prone to climate or weather-induced hazards on different magnitudes. The best media to reach out to the public are through the radio, television, cell phones, enlightenments at the market, school and religious establishments, and the use of local criers.

The essence of these weather warnings is to sensitive the people to prepare adequately to counter the future adverse effects of such weather hazards or disasters. Adequate preparations in this consideration would include immediate relocation of people to safer and secure sites, provision and accumulation of food varieties with medicines, storage of clean water for human consumption, and invitation of security agencies to facilitate mutual safety of people with their properties. Cooking utensils are also needed while weather-resistant buildings should be erected before the occurrence of anticipated hazards to accommodate the displaced persons without undue procrastination by the agencies concerned. These recommendations represent the first phase in the preparation for preventing the negative effects of weather-induced disasters in Nigeria.

The second phase focuses on empirical strategies which could help mitigate the inevitable weather-induced hazards on the Nigerian environment. First, all the houses built and sited on steep slopes, river valleys, flood plains, coastal belts and estuaries should be vacated while their occupants deserve immediate evacuation to safer landscapes with secure buildings designed to resist the prevailing extreme climatic forces such as wind storms, torrential precipitation, floods and thunderstorms. In addition, vital economic goods and other allied wealth-producing industries particularly food, textiles, pharmaceutical, energy and water, should be secured and

protected. These measures require immense skills, adequate funds, technology, cooperation, persuasion and enlightenment between the people concerned and government agencies to be realized. These recommendations are necessary because the objectives of mitigation approach in meteorological studies are to reduce the hazards, protect human lives, secure income, and reduce the social, psychological and economic deprivations that follow the occurrence of disasters in a place or a demarcated region.

Disaster mitigation in meteorological studies requires the concerned efforts of specialists in different disciplines such as architects, hydrologists, structural, civil and mechanical engineers, physicists, physical planners, political scientists, sociologists, economists and climatologists. Also, government offices which are needed in this regard include public works, water corporations, town planning, meteorological agency, emergency planning, public health, and social affairs. In extreme disaster conditions, international agencies which have the capacity to manage and provide timely required means of human sustenance particularly food, water, medicines, temporal shelters and security are invited. The United Nations' relief agencies, the US and Swedish Red Cross Societies, and other relief agencies of the developed countries are renowned in their prudent efforts at disaster mitigation all over the world. In Nigeria, the efforts of its government, the citizenry, corporate bodies, philanthropic organizations, financial institutions, factories and industries, including individual contributions are needed in disaster management.

The above measures should be supported through prudent training of local craft-men and builders on hazard resistant design principles which would ensure safe construction of houses as well as bridges on primary and secondary roads. In fact, curriculum development in schools of architecture to explore full design implications is necessary in this regard. New buildings would have to be erected in some demarcated areas while the existing houses should be improved in accordance with the safe standard building codes for comfortable human habitation during and after the period of disaster occurrence.

In addition, functional legislation should be enacted while landuse planning should be enforced to ensure that the suggestions raised are carried out on the environment without hesitation. The law enacted should state clearly the kinds of standard building materials required at different locations within the seasons in Nigeria. While this legislation should minimize the level of corruption in the implementation of physical planning measures, it should also be relevant, realistic and closely related to the local conditions including the economic levels of poor families.

Reliable predictions of atmospheric conditions which might result in occurrence of environmental hazards should be carried out regularly, carefully and continually by meteorologists or climatologists. These predictions should provide effective coverage for the country. Where the hazards have occurred, detailed examination through hazard mapping approach is recommended. The data derived would make possible the assessment of the hazard magnitude and, perhaps, its frequency in the near future. The relevant strategies suggested in the study would be applied to remedy the challenging situation.

Weather predictions and issuance of impending disaster warnings represent the most significant parts of this current research. Atmospheric prognostication studies would enable the country to know and understand the different categories of hazards which might be anticipated at a particular period in certain locations within the year. Hazards like thunderstorms, sand-storms, flash floods, coastal sea surges, and landslides could be predicted accurately with regard to the period of occurrence based on the availability of rainfall, temperature, humidity, wind, and pressure data of the area. When this objective is realized, issuance of disaster warnings through the various mass media could be carried out in time by the central meteorological agency in the country. These recommendations would assist the people and their respective local governments to prepare adequately in anticipation of these natural hazards. The state and federal governments' efforts could be sought in this regard should the levels of disasters experienced be above the prompt control and direct management of the local governments.

Research Findings

Based on the preceding discourse, the following findings are made.

The study observes the existence of few meteorological stations in Nigeria which are inadequately funded, maintained and managed by few experts. This condition has given rise to derivation and release of inadequate and inaccurate weather reports from the weather stations. Effective prognostications of instantaneous and fairly long atmospheric conditions necessary for prevention and mitigation of environmental disasters become impossible in the country.

A prominent feature of this study is on reliable meteorological prognostication. It makes use of authentic weather information to predict current and future occurrences of hazards on the environment. Also, meteorological prognostication is relevant to strategic planning in all the sectors of the national economy. The study reveals a negligence of focus in this direction owing to few experts and poor management on the part of corporate organizations and government in Nigeria.

The study points out that based on its climatic characteristics, 'Region A' is likely to experience environmental hazards such as rainstorms, flash floods, soil degradation, mudflows, landslides and rockfall. Others include over-flow of river banks, dark cloud cover, gusty winds, tree-fall across the roads and railways, chemical and biological weathering, and occurrence of a colony of insects. These hazards would impact negatively on private erection of buildings, transportation in the atmosphere, at sea, and on the land, agriculture, social infrastructure, and mineral exploitation in the southern part of Nigeria.

Similarly, premised on its climatic features, 'Region B' would be directly prone to environmental hazards like gusty winds, high solar energy reception, sandstorms, wind erosion, thunderstorms, short period of rainfall, and a variety of insects. Consequently, excessive dryness of the landscapes, dust pollution of the environment, drought and desertification, heat wave, seasonal fluctuation of rivers, and human diseases as malaria, typhoid, cough, catarrh and meningitis would be experienced in the northern part of Nigeria.

High and turbulent winds ranging from 82km/hr to 250km/hr were observed in the extreme north of 'Region B.' These winds could be harnessed using relevant technology to provide clean wind energy for the people of the region. This energy would play a vital role in mitigating the harsh weather affecting the people as well as moderating the adverse impact of climate change. The study revealed that abundant precipitation is received annually in 'Region A.' This rainwater could be stored for future utilization in underground, surface, and overhead tanks. In locations where river-waters are increased in the south of the country, minor reservoirs could be established with a view to supplying cheap water to the people during the 'short August break.' In the reservoirs created, water treatment techniques like sedimentation, coagulation, filtration, coppering, chlorination and fluoridation could be applied by contracted or employed specialists in order to provide quality table and factory water for different uses.

Finally, the study notes that these environmental disasters observed in both regions could be prevented and mitigated when adequate meteorological information is utilized for reliable predictions which are necessary for strategic planning in all sectors of the country.

Policy Recommendations

The place of meteorological services in disaster risk mitigation in Nigeria over the years has not been adequately felt by Nigerians owing to a body of problems enumerated in previous sections. It is premised on this background that the following recommendations are made with a view to strengthening the responsive capability of meteorological stations and the NMA in the country.

New meteorological stations with standard instruments for weather observations should be established all over the different climatic and political regions of Nigeria. All higher research institutions within the country should benefit from this essential meteorological proposal. These established meteorological stations should be provided with functional security, standard spare parts and adequate funds for continuous performance and instrumental efficiency.

Meteorological stations should be established on level surfaces with free weather circulating atmosphere. Instrumental maintenance is necessary while continuous documentation of observed data is suggested to ensure effective data coverage of the country. It is through this medium that adequate climate information could be documented for utilization in prediction studies aimed at mitigation of hazards in the country. The services of some meteorological stations in Nigerian universities and the Nigerian Meteorological Agency are most required in this consideration.

The mitigation and management of weather-induced hazards require the combined efforts of government agencies, corporate organizations, industrial establishments, philanthropists, local societies, and the immediate communities where the hazards have occurred. Extreme disaster cases might require some foreign assistance, particularly in terms of provision of relief materials such as food, water, clothing, medical supplies, beddings, and mobile shelters to the displaced people. Some funds would have to be provided by the groups listed

aforementioned and should be rationally distributed to the victims of climate-induced hazards. These funds would enable the people to acquire other important family items which were not provided by the various relief agencies.

Torrential precipitation, high temperatures, gusty winds and dark clouds were identified as the causative factors of most environmental problems in Nigeria. This current research suggests the adoption of a policy of continuous climate data documentation throughout the country by most meteorological stations. The processed information would be used for prediction studies by meteorologists to issue authentic warnings on possible periods and locations these environmental disasters would be experienced. This suggestion when carried out would result in the prevention of different environmental hazards and their consequences identified in 'Regions A and B' within the country.

Finally, the abrupt release of excess water from the dams and reservoirs should be prudently coordinated nationally and internationally. In fact, formal discussions and exchange of hydrological information among the countries involved in the utilization of the River Niger waters in West Africa are most necessary in this regard. These strategies would help prevent or mitigate the enormous challenges which might befall the settlements found down-slope the river on higher elevation. The essential contributions of hydrologists, climatologists, hydraulic engineers, biologists, architects, economists, and political scientists should be registered in this regard. This is true because, these specialists have adequate knowledge of the workings of water in the dams, its volume, release, erosive capacity, politics involved in the discussions, and its final flow into the ocean in the south of the country.

Conclusion

The destructive effects of weather-related hazards have been gradually harnessed over the years in most developed countries of Europe, South-East Asia, and in the USA. Strengthened social infrastructure against the prevailing extreme climatic forces, improved meteorological services and adequate funding of climate studies among others have accounted for this favourable temperate condition. In Nigeria, the reverse has been the situation. This is why this current study examines, among other important objectives, the place of meteorological services for disaster risk prevention and mitigation in Nigeria.

The weather and climatic characteristics of Nigeria should be examined and monitored continually using standard meteorological instruments under proficient experts' coordination and management. This requires the establishment of new standard weather stations across the different climatic and political regions of the country with the objective of building a central climate data-bank. The types of weather stations which are suitable for these purposes and the requirements for their establishment are examined in the study. The anticipated environmental hazards in 'Regions A and B' and measures required to manage such prevailing challenges are further discussed. Of these measures, public awareness through the various media of the future dangers which might be posed by inadequately predicted atmospheric occurrences was robustly elaborated. Prompt human evacuation to safer environments and the construction of weather-resistant buildings to accommodate the people were also suggested. The role of government and corporate organizations in the provision of needed funds for meeting the immediate food and medical reliefs of the vastly displaced in the country was anchored. Training of meteorologists for effective monitoring of the Nigerian rural and urban atmosphere is the apex for all these suggestions to become realities. There is no doubt that a properly observed and monitored atmosphere using standard meteorological instruments would help guide against the occurrences of climate induced environmental disasters in the country.

The study clearly concluded, among other important meteorological issues that, strengthened socio-economic infrastructures against the prevailing extreme climatic forces and improved meteorological services premised on consistent adequate funding by both the government and corporate organizations, instrumental maintenance and authentic weather prognostications by experts through the mass media for public utilization would help prevent, control, and mitigate the occurrences of environmental hazards in Nigeria.

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