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# Climatic Implications of Environmental Development in Nigeria

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**Abstract**
This study which benefits from reconnaissance surveys and recent hydro-climatic and transport management literature, examines the climatic implications of environmental development in Nigeria. The study discusses the significant roles of weather and climatic elements in facilitating adequate environmental development in the areas of water provision, agricultural production and transportation in Nigeria. In reality, the study observes that essential weather and climatic elements which include solar radiation, rainfall, temperatures, humidity, wind, and soil moisture are not integrated and utilized in the planning and management of water resources, agriculture and transportation in Nigeria. This negligence led to minimized socio-economic benefits, inadequate water supply, poor agricultural production, road accidents, train derailments and airplane crashes in the country. Based on its findings, the study suggests, inter-alia, that adequate and sustainable water provision, food and cash crops production and efficient transport system could be realized in Nigeria on incorporation of essential climatic guidelines in the planning and management of these three significant sectors.
**Keywords:** Climate, Implications, Development, Water, Agriculture, Transport.

## Introduction and Research Problem

The development and prosperity of any country depend on the resourcefulness of the people and the land. The national use of the land includes water resources, agriculture, transport, industry, construction and housing, recreation and tourism, and scientific studies. Most frequently, weather and climate affect the development of these national activities to a great extent (Acheampong, 1988; Ayoade, 2004). As observed, climate determines the types of crops which are grown in some parts of a country at a given time. Also, the selection of agricultural soils based on favourable weather and climatic conditions could enhance immensely a country's food production (Phillips, 1989; Akinbode, 2002; Okhakhu, 2013). According to Adebayo (2000), the production of upland rice in Adamawa State in Nigeria has benefited from the advances in agricultural technology which involve the introduction of high yielding varieties, the application of fertilizers and provision of authentic extension services. In spite of these technological advances, the yield of the crop varies overtime and space in the state. Given that soil and management factors have improved and therefore become positive factors in the production process, climate, particularly precipitation, appears to be the major factor influencing the yield of rice in the state. In fact, scientific studies demonstrate that technology alone does not reduce the effect of weather on crop production but rather, a period of favourable weather directly interacts with technology to produce higher crop yield. Precipitation effectiveness indices are the major climatic controls of crop yield in the tropical savanna region. It is not only the total amount of rainfall that is essential but how effective the rains are in terms of occurrence, distribution, frequency, intensity, soil filtration, and availability as soil moisture (Adebayo, 1997; 2000).

The rainfall essentials should be observed consistently, measured carefully and documented where available using standard meteorological apparatuses which are effectively managed by meteorologists. In this regard, the authenticated rainfall statistics would be used by agro-scientists for effective planning of current and future agricultural operations in the delimited environments within the country. Incidents of drought, erosion of crops by floods, pest and disease invasions of farmlands and crop failure could be avoided. We could predict that the result of these planned agricultural operations would be abundant harvests and increased production in the selected areas of agriculture within Nigeria. This is one very important focus of this study.

Climate is the most important component of the natural environment. It affects geomorphic processes, soil formation phases, water resources, plant growth, surface development and human survival on the earth's surface (John, 2012). Natural organisms including man are greatly influenced by climate. No doubt the major essentials of life for mankind which include solar energy, air, water, food and shelter are climate dependent. The air we breathe into our body lungs is derived from the atmosphere, the water we drink and often use for different domestic activities originates from precipitation, and the food we eat for the preservation of lives has its origin in photosynthesis which is a process that is made possible by sunshine, carbon-dioxide, wind and moisture, all of which are natural attributes of climate. Man's clothing, housing requirements, scientific contributions and resistance to diseases are largely determined by the prevailing weather and climatic conditions. Also, weather and climatic conditions constitute relevant factors in the efficient sitting of buildings, choice of building materials, design and the air-conditioning of the structures (Smith, 1975; Okhakhu, 2014; 2016). According to Okhakhu (2014), the buildings put in place must be structurally safe and able to resist the exerted forces of the prevailing climate during their anticipated lifetime. It is essential to observe that most construction works which

 

are outdoor activities are directly affected by the prevailing weather conditions. Rains, thunderstorms, snow falls, dark cumulus clouds, gusty winds, sandstorms, and extreme temperatures all have adverse effects on construction activities. The estimates of the number of workable days for construction purposes are made using information gathered on the above weather variables. Otherwise, such construction activities would be disrupted timelessly leading to waste of precious materials including valuable working capital.

Nigeria is a humid tropical country which is located between the Atlantic Ocean in the south and the Sahara Desert in the north (Acheampong, 1988). It lies approximately within Latitudes $4^0$N and $14^0$N and within Longitudes $3^0$E and $15^0$E. 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 (Okhakhu, 2014; 2015). Nigeria's position in West Africa has three essential implications for assessment: first, it shows that it is naturally exposed to the influence of the harsh desert winds, hot-cold sandstorms and high solar radiation from the distant north; second, the location shows that it is a geo-political sovereignty which is regularly receptive of abundant precipitation induced by the tropical maritime winds that originate from the Gulf of Guinea in the south; finally, the position presents Nigeria as a unique country which is naturally endowed with rich geomorphic, hydro-climatic, vegetal, animal, mineral, micro-organic and fertile soil resources. These natural resources have stimulated different human activities in agriculture, forestry, mining, housing, river trading, health and tourism, thus leading to uneven urbanization with reduced socio-economic benefits in Nigeria. The main cause of these socio-economic challenges is inadequate planning of available natural resources without empirical integration of the prevailing weather and climatic conditions in the country. It is against this background that this current study examines how essential climatic elements can be used to facilitate adequate environmental development with specific focus on water resources, agriculture, and transportation which are very important to human existence and sustenance in Nigeria. Therefore, a review of the climate of Nigeria is most essential in this current scientific assessment.

**The Climate of Nigeria**

Nigeria has a tropical climate which is hot and wet throughout the year particularly in the south-east but in the west and north, a distinct dry season is experienced. As observed, the length of the dry season increases inland from the south coast. As a result of her latitudinal position in West Africa, Nigeria's net radiation, duration of bright sunshine, and the mean annual and maximum temperatures decrease from the north to the south. Temperatures and relative humidity remain fairly constant throughout the year in the south, but in the north, considerable seasonal change and wide diurnal range are observed. The mean monthly maximum temperature remains steady throughout the year at $35^0$C in Lagos and $32^0$C in Port Harcourt while the mean monthly minimum temperature hovers around $21^0$C in Lagos and $22^0$C in Port Harcourt. In the far northern city of Maiduguri, the mean monthly maximum temperature often exceeds $38^0$C during the hottest months of April and May while the mean monthly minimum temperature is below $22^0$C (Udo, 1987; Acheampong, 1988).

As Udo (1987) observes, two air masses, the equatorial maritime air mass and the tropical continental air mass dominate the climate of Nigeria. The former is associated with the rain-bearing south-west winds from the Atlantic Ocean while the latter is associated with the dry and dusty harmattan from the Sahara Desert. Two major seasons are recognized in Nigeria, and these are the rainy season and the dry season. The length of the rainy season decreases from nine months in the Forest South (March to November) to only four and a half months in the Sahel North (Mid-May to September). There is a modification of this pattern of rainfall in the south which has a double maxima regime with a short August Break in the rains. Four seasons are therefore recognized in the south of Nigeria. These are the long rainy season from March to early August, the short dry season in August, the short rainy season from September to early November, and the long dry season which occurs from Mid-November to February (Collins, 2010; Okhakhu, 2010; 2014).

In Nigeria, the rainfall is heaviest in the south-east which has more than 3,300mm per annum. Along the west coast, the rains decrease to 2,500mm per annum. There is a general decrease in rainfall away from the coast such that the far north has less than 510mm of rains within the year. Considering the global pattern of atmospheric pressure distribution, Nigeria's climate is dominated by the interactions between the pressure belts over the Sahara Desert and the South Atlantic Ocean throughout the year. During the northern hemisphere winter, a high pressure centre develops over the Sahara and the dry harmattan winds affect the entire West Africa. The extensive and generally diffuse zone of air convergence known as the Intertropical Discontinuity (ITD) moves towards the south of the country. The harmattan air is dusty and warm during the daytime but very cold and harsh at night owing to rapid radiational cooling through the cloudless skies. At this period, there is complete dryness and very low humidity prevails over the greater part of Nigeria. Relative humidity reaches 80% in the mornings in the south-east but fluctuates to 50% in the afternoons. In the north central and extreme north, the humidity values fall below 10% throughout the day. During the harmattan which blows for over three months in the north but rarely more than three weeks along the south coast, there is considerable fall in the relative humidity. Extensive bush fires which often destroy natural vegetal covers, farms, villages and houses are

 

most common during the harmattan. All over Nigeria, there are prolonged dry spells, and often the rains may cease completely. Also, evaporation and transpiration rates become very high in the far north of the country and these normally exceed precipitation on the average (Iloeje, 1982; Udo, 1987; Acheampong, 1988; Okhakhu, 2014).

At summer, the ambient pressure also remains uniformly high in the upper troposphere such that a thermally induced low pressure develops over the continental interior. The ITD then shifts its latitudinal alignment and moves to a position over the Sahara. The equatorial air mass then conveys abundant moisture from the Atlantic Ocean into the country, starting from the south coast through the middle belt to the far north. Along the south-east coast and the delta region, the annual rainfall total is over 3,000mm. In the west, the central and the northern parts, the rainfall values range from 760mm to 1,800mm. Over the Plateau region, the rainfall ranges from 1,250mm to over 1,500mm which is a reliable consequence of relief inducement. During this period, increased cloud cover is experienced all over the country and the hours of bright sunshine are considerably reduced particularly in the south-east (Acheampong, 1988; Ayoade, 2004; Okhakhu, 2014; 2015; 2016).

## Implications

### Weather, Climate and Water Resources

The sources of water all over the world include precipitation, surface and underground water bodies. Specifically, precipitation, rivers, seas and oceans constitute the greater proportions of these water bodies. In Nigeria, water is utilized both for domestic and industrial purposes. The domestic uses of water include washing, cooking, sanitation, spraying of house lawns, wetting of private gardens, bathing, and drinking. In the cities, water is used for cooling industrial machinery, environmental sanitation, cleaning of hospitals and maintenance of hygiene, production of potable water, scientific experiments in schools, establishment of fish, snail, crab, duck, alligator and crocodile ponds, production of assorted drinks in factories, creation of dams, and electricity generation in rivers. Adequate water sustenance in rivers through torrential rainfall during the peaks of rainy season facilitates river fishing, sand derivation for construction activities and the conveyance of goods with people among different places on the earth's surface. These occupations provide both domestic and foreign currencies to the citizens and governments of countries. The presence of rivers serves as a means of boundary demarcation between local places and sovereign countries. Streams, lagoons, rivers, seas and oceans form convenient natural habitats for micro-organisms, insects, birds, plants and animals across the world. The distribution of human populations, industrial establishments and facilitation of construction activities on the earth's surface are greatly enhanced and made possible by water resources. Of these hydrological resources, precipitation which is a natural resource and element of climate plays the most appreciable role in the natural and human environments.

Nigeria is a well drained country with a close network of rivulets, brooks, streams and rivers. The total length of streams and rivers is over 20,000km. Rivers Niger and Benue and few others have a potential discharge of some 10,000m3/sec (Acheampong, 1988). As of now, there is absence of accurate scientific assessment of the magnitude of Nigeria's surface water resources. However, reliable observations show that these water resources are unevenly spread and prone to seasonal and climatic variations. In the South-East of Nigeria, there is a dense network of streams and rivers. This hydrological network density decreases in the West and Central, and in the far North of the country. As observed, the streams and rivers in the Central and North of Nigeria often carry less water on their courses, and are easily depleted during the long dry season through excess evaporation and sustained infiltration. Also, physical observations at the Agenebode-Idah axis indicate the presence of numerous sand bars, mud, wood and rock debris in River Niger. As Ayoade (2004) rightly observed, the 1984 West African drought greatly threatened the existence of all rivers in Nigeria. Of course, the waters in the rivers were greatly reduced to the levels they could hardly carry locally made canoes with agricultural products from some locations to other locations within Nigeria (Okhakhu, 2014).

The climate of Nigeria shows that heavy rainfall occurs in the South-East which fluctuates in the West, Central, and in the far North. High atmospheric humidity with moderate temperatures is also observed in the South-East, West and in the Central parts of the country. In planning to attain sustainable water provision, electricity generation, construction of houses, roads, bridges, airports, seaports and environmental sanitation in Nigeria, the alternating lengths of rainy and dry seasons should be considered. While it is conveniently possible to carry out water provision and electricity generation activities during the rainy season, it is accurately suitable also to carry out all forms of construction works during the long period of the dry season which runs from November to March. During this season, the cost of environmental construction is minimized while the infrastructures put in place are realistically fortified for durable future utilization. Having observed the presence of mud, decayed woods and all forms of debris in Nigeria's rivers during the rainy season, a characteristic inducement of natural and anthropogenic pollution, aesthetic climatic principles suggest the dredging and overall cleaning of these rivers during the rainy season for easy navigation, tourism, scientific researches and other

 

associated activities respectively. These climatic principles are specifically suggested for the planning and management of surface water resources in Nigeria.

Authentic hydrological data based on the nature of geology and relief characteristics of Nigeria reveal that the country is deficient in ground water resources (Acheampong, 1988). Mitchell's (1961) study carried out before the dawn of climate change as revealed in Acheampong's (1988) work, established that Nigeria has about 9,500 billion litres of ground water which represent some 0.20% of the world's total. According to Acheampong (1988), over half of Nigeria is underlain by crystalline rocks of the basement complex. These rocks, he argues, are igneous and metamorphic, and are neither porous nor permeable except where there are weaknesses like fissures, joints, cracks and shelter belts that rain water can percolate directly downwards. As a hydro-geomorphic convention, ground water is found in the weathered basins lodged in the mantle. These zones allow water to percolate the subterranean water reservoirs in any country. In Nigeria, there are three distinct challenges associated with these subterranean water reservoirs. First, their subterranean locations are difficult for identification. Second, these water reservoirs are always prone to saline intrusion which makes the water readiness for direct human consumption impossible except where adequate treatments through filtration, sedimentation, coagulation, coppering, chlorination and fluoridation are carried out. Third, these underground water reservoirs are specifically recharged by the rain water which is derived from the troposphere. Therefore, any delay in rainfall occurrence, marked reduction in the rainfall amounts or the occurrence of drought within the rainy season may greatly affect the water recharge capacity of these underground reservoirs. Consequently during the dry season, established boreholes, hand-dug wells and natural springs may not yield sufficient water for domestic and industrial uses.

In planning sustainable water derivation activities from the subterranean reservoirs for animal, human and industrial consumption, and with specific regard to dam and borehole establishment in Nigeria, authentic statistics on the prevailing weather and climatic conditions must be observed, processed and documented by climatologists. Specifically, precipitation occurrences, fluctuations and cessations within the year must be obtained from different standard meteorological stations for utilization. Also, temperature values and the wind dynamics would have to be integrated in the planned water derivation and provision schemes. These elements of climate are essential because they determine the rate of water evaporation and diffusion into the atmosphere. The beneficial climatic principles provided by the climatologists in this regard should be accepted and incorporated into the entire physical, mechanical and electrical designs of the anticipated water projects. Where these essential meteorological guidelines are omitted, these proposed water projects may be deficient in water supply or disrupted timelessly by the prevailing extreme weather forces like thunderstorms, high temperatures and gusty winds. For example, boreholes must be sunk in locations with abundant subterranean water storage which is subject to sustained yearly recharge and replenishment by precipitation and surface run-off. The underground water reservoirs must not be disposed to saline intrusion and other polluting hydrological elements like crude oil, molten magma, acids and dangerous gases. Proper seismic, geologic and remotely sensed assessments of the subterranean water positions should be carried out in this regard to counter this challenge. In addition, the surface of the geomorphic basins where the boreholes are sunk should be covered with fresh grasses and evenly spaced trees. The grasses would counter intense surface evaporation while the trees would serve as reliable shields against the prevailing gusty winds which might destroy some of the surface facilities installed on the geomorphic basins.

The establishment of boreholes has been encouraging in the areas of sedimentary rock formations in Nigeria. As established during the field studies, artesian water occurs in the Sokoto-Rima Basin of the North-West while in some locations in the Palaeocene-Eocene sedimentary rocks of the coastal areas of the South-West, similar artesian water is found in adequate quantity for human exploitation. On the whole, the quantity of water available in the rivers as well as in the subterranean sedimentary rock complex depends directly and indirectly on the climate preferably precipitation. Therefore, a fundamental change in the precipitation regime would affect the overall quantity and quality of water in the streams, rivers and the subterranean sedimentary rock complex in Nigeria.

Adequate provision of water for plants, animals, domestic uses and for industrial consumption is most essential in Nigeria. However, many villages, towns and cities in the country do not have adequate access to safe, secure and reliable sources of water. Factors such as climatic fluctuations, evaporation of surface waters, absence of water studies, pollution, inadequate exploitation and supply of water, poor funding of dam and borehole projects, inadequate technology, unsatisfactory management of river basins, impact of rural conflicts, and non-integration of experts' services in water planning activities, among others, have been identified as responsible for this situation. (Okhakhu, 2014) Adequate funding, proper planning, and impeccable management of water resources inter-alia would help resolve these observed water challenges in the country.

The recognized methods of exploiting and collecting atmospheric, surface and subterranean water resources in Nigeria consist of the use of different containers and tanks to store rain and river waters and the digging of local wells and establishment of boreholes which pump out water continually from the beneath layers

 

using both the public and private power systems. Besides the incidents of environmental pollution and disease contamination of these water supply sources, there also exists the problem of unreliability of the supplies owing directly to fluctuations in weather and climatic conditions in the country. This challenging background stimulates the urgent need to embark on effective planning and development of Nigeria's available water resources based on authentic hydro-geomorphic and meteorological data. The overall idea is to develop adequate water resource capacity which is accessible, sustainable and secure for domestic and industrial consumption in the country.

**Weather, Climate and Agriculture**

All aspects of the agricultural production chain in Nigeria which involve land preparation, the selection and sowing of viable crops, crop growth and management, harvesting, storage, transport, and marketing of outputs are closely dependent on the prevailing weather and climatic conditions (Acheampong, 1988; Ayoade, 2004). Rainfall, solar radiation, temperature, and wind are the most essential weather and climatic elements which exert such extensive influence on agriculture in the country (Okhakhu, 2013). The role rainfall plays in the country's agriculture includes the regular supply of fresh moisture to the crops, and to the soils for crops' growth, the recharge and replenishment of streams and rivers which waters are used for daily irrigation, and for the sustained recharge of ground water resources which are continually extracted by boreholes and wells for human, animal and plant consumption. The rainfall amount, its variability and seasonality authentically explain the differences in farming types and patterns, and livestock management practices in the different ecological zones in Nigeria (Udo, 1978; Okhakhu, 2016).

Whereas the variations in rainfall amount do not provide adequate bases for crop distribution patterns in Nigeria, these variations directly offer satisfactory explanations for the division of the country into three broad cropping zones. As observed in reconnaissance studies, perennial tree and root crops are adequately produced in the much wetter rain-fed South, South-West and South-East; mixed root and grain crops are cultivated in the Middle Belt where rainfall is moderate in received amount on the surface; and grain crops are grown in the Northern ecological zone which is extensively deficient in significant rainfall amount. In the South-Eastern Coast and the Niger-Delta Region where the wet period is over 240 days per annum, perennial tree crops of immense economic values such as rubber, cocoa, oil palm, kolanuts, oranges, cashew, pears, guava, coconuts, cherries and plantains are grown in plantations. Root crops which include yams, cassava, cocoyams and sweet potatoes are also largely produced in this ecological zone. In the Middle Belt where the wet season extends from 100 to 200 days, sorghum is extensively grown by the farmers. In the extreme Sahel North, the wet period lasts between 80 and 100 days. Consequently, millet, a cereal of huge economic value which requires less rainfall and moisture, is largely produced by the Hausa-Fulani and Shuwa Arabs. Animal rearing, particularly cattle, sheep, goats, donkeys and camels, thrives in the vast ecological zone owing to absence of tse-tse flies which cause sleepy ailments in animals and presence of many domestic wells which are supported by government-sponsored irrigation schemes.

Rainfall is a very significant factor in agricultural production in Nigeria. This notwithstanding, it also exerts some limitations on the sector particularly during the peaks of the rainy season. In the South and South-Eastern parts of the country where the yearly received rainfall amount exceeds 3,000mm, incidents of soil degradation and water logging are observed. Akwa-Ibom, Bayelsa, Cross-River, Delta, Edo, Enugu, Imo and Rivers States have had to contend with the devastative consequences of rain-induced soil erosion of cultivated seeds and seedlings, fertile soils, submergence of farm bans and related storage facilities, and the complete wash-off of immediate farm settlements by raging floods. Excessive rainfall has also affected the total yields of crops in these parts of the country. In the arid Sahel North of Nigeria, adequate irrigation schemes for crop and animal production have been hampered owing to deficiency in rainfall amount, extensive insecurity caused by the Boko Haram Sect and poor government intervention. Excessive evaporation of domestic wells and waters in the rivers during the dry season has also accounted for the slow pace of agricultural production in the arid ecological zone against the past successful agricultural production recorded.

Solar radiation is of vital importance in agriculture since it is the natural energy which powers adequately the agricultural system like any other ecosystem. This natural energy determines the thermal characteristics of the environment, namely the air, soil temperatures, sunshine, and the photoperiod. Photosynthesis which is the basic process of food manufacture in nature and associated photoperiodism, the flowering response to daylight, are both controlled by solar radiation. The maximum amount of plant tissue which can be photosynthesized within a crop depends on the availability of suitable radiation assuming unlimited carbon dioxide, water and soil nutrients. In photosynthesis, the visible rays are the most effective elements although ultraviolet rays can also influence germination, energy and the quality of seeds. Radiation intensity is another essential factor in crop growth and development. The optimum light values for normal crop growth and development are generally

 

around 8-20 kilolux (Adefolalu, 1989; Ayoade, 2008). When there is deficiency of radiation in the agricultural environment, the root system of the crop would be formed abnormally, its foliage would become yellowish, and there would be a tendency for the stalk to grow at the expense of the foliage. This abnormal crop development in the farms leads to poor agricultural harvest at the end of the production year. The recognition of the effective role of solar radiation in the cultivation and management of crops on the environment can suitably reverse this agricultural abnormally not only in Nigeria but throughout the world's ecological zones. Solar radiation with its intensity also plays this essential role in the growth and development of all vegetal resources found on the earth's surface.

Soil moisture referred to as soil water also plays a significant role in the growth and production of all types of crops. It provides the medium by which essential chemicals and nutrients are carried through the plant. It serves as the main constituent of the physiological plant tissue. It is also a vital reagent in photosynthesis. Moisture which serves as the main source of water supply to crops is immensely controlled by rainfall. Rainfall, solar radiation, temperature and wind largely determine the rates of evaporation and evapotranspiration in the farm environment (Jackson, 1977). No doubt that the absence of adequate soil moisture leads to gradual withering of crops and plants. Also, the excessive presence of soil moisture results to water-logging of the soils which prevents sufficient aeration of the cultivated crops. In addition, water-logged soils could produce toxic chemicals which are capable of destroying crops in the farmlands. Where drought conditions prevail in the farm environment, and adequate rainfall or irrigation is hampered by the prevailing dry winds or human inadequacies, the crops would die and other related vegetal resources might wither extensively. Therefore, effective planning of climatic essentials during the rainy and dry seasons by agro-climatologists is necessary to ensure adequate and sustainable food and cash crops production in Nigeria. These suitable measures have been carried out in the temperate and arid areas of the world particularly in the US, Britain, Germany, China, Libya, Saudi Arabia, Israel, and Australia. Adequate funding of agricultural activities by the government, provision of suitable technology, daily researches by agricultural scientists and agro-climatologists in humid tropical agriculture, improved transport environment and marketing conditions, and the provision of adequate security in agricultural zones by government agents could make the positive difference in this regard in Nigeria.

Air and soil temperatures affect the growth processes of crops and other vegetal resources in the natural environment. As Ayoade (2004) observes, all crops have minimal, optimum and maximal temperature limits for each of their stages of growth. In Nigeria, cocoa production requires high temperatures between $28^0$C and $33^0$C while other crops such as coffee, bananas and sugarcane are greatly sensitive to chilling and frost conditions. Air and soil temperatures below $6^0$C and above $50^0$C are not suitable for the cultivation of tropical crops. A humid temperature below $6^0$C could retard the essential processes of plant aeration, transpiration and nourishment while a high temperature above $50^0$C would expose the crops to unprecedented transpiration, dryness, leaf fall and destruction of internal protoplasm. This assessment suggests that most tropical crops in Nigeria cannot be grown successfully unless the most suitable air and soil temperatures prevail at the appropriate periods. In planning major agricultural operations in Nigeria now and in the future, solar radiation, balanced rainfall, suitable temperatures, favourable winds, adequate soil moisture, and effective relative humidity should be considered, incorporated and utilized by experts and the farmers in order to attain optimum food and cash crops production.

**Weather, Climate and Transportation**

Another important way of using the land as a veritable resource is through the development of efficient and reliable transportation systems which include road, railway, air, and water transport. The safety, efficiency and the smooth operation of all the types of transport in Nigeria are directly influenced by the weather and climatic conditions. The occurrence of extreme weather forces such as air turbulence, torrential rainfall, thunderstorms, sandstorms, and poor atmospheric visibility induced by cumulus clouds and harmattan haze have led to frequent procrastinations, postponement and cancellation of some scheduled flights in Nigeria. These weather forces have also increased the rates of vehicular accidents, train derailments, plane crashes and ship wrecks in the country. Plane crashes and vehicular accidents have intensified in the developing countries recently owing to mechanical challenges and extreme weather forces. In Nigeria, countless incidents of road accidents, sea and few air mishaps have been observed (Okhakhu, 2010). Conversely, favourable weather conditions facilitate the smooth take-off and safe landing of different airplanes, reduce fuel utilization, and promote pleasant air-borne political and socio-economic interactions among domestic and foreign nationals. These benefits are possible only when essential climatic conditions are taken into consideration during the planning of strategic air transport activities in the country. This favourable situation would also prevail on the roads, railways and at the seas when climatic controls are efficiently integrated in the planning of structures, design of facilities and holistic modernization of the transport industry by experts. Urban climatologists, mechanical and structural engineers and artisans are needed first in this regard.

 

Transportation involves the movement of people, goods, information and services among different places on the earth's surface. In Nigeria, transportation takes the five-cardinal dimensions seasonally: North, East, South, West and Central. As observed, the entire transport system in the country is largely weather sensitive. Poor visibility, inundated surfaces, gusty winds, sandstorms, thunderstorms and torrential rains have greatly accelerated transportation hazards in Nigeria. Heavy and prolonged rainfall has persistently created pot-holes on and eroded some portions of the roads and railways in the South-West, Swampy Delta South, and in the South-Eastern parts of the country. Recent reconnaissance surveys clearly confirm the degradation of the Lagos-Benin Highway, Akure-Ibadan Road, Owerri-Umuahia Road, Benin-Auchi Road, Warri-Port Harcourt Highway, and the Okene-Auchi Road by erosive floods.

The railway industry in Nigeria is also greatly affected by the local weather. The dry season, particularly in the northern part of the country, is characterized by high temperatures, extremely harsh and gusty winds, dangerous sandstorms and wild bush fires. The gusty winds blow parcels of sand which cover up the train tracks while the dry weather increases the risk of fires which consume the sleepers. Moderate temperatures and excessive atmospheric humidity in the south-east of Nigeria cause rusting of the trains and corrosion of the train tracks. In the Delta south, heavy rainfall leads to slippage of sub-grade materials used in the construction of the train tracks while fast flowing floods wash off many sections of the train tracks in Lagos, Ibadan, Enugu and Port Harcourt. The disruption of communication signals caused by sporadic lightning and thunderstorms has delayed adequate service delivery in the railway industry in Nigeria. These limitations would have been adequately prevented if authentic climatic principles were considered, harnessed, incorporated, and utilized in the industry through engagement of experts' services.

Air transportation, like the railway industry, is greatly affected by the weather in Nigeria. A number of flight delays, postponements, diversions and outright cancellations have occurred at the country's airports as a result of dark low clouds, strong winds, dangerous thunderstorms and violent atmospheric turbulence during the rainy season, leading to considerable financial losses and passengers' dissatisfaction with the sector's operations. Poor atmospheric visibility precipitated by polluted dew and harmattan haze has been observed in the mornings, afternoons and evenings during the dry season in the continental locations and the far north of Nigeria. This weather hazard is not conducive for the cruising phase, smooth take-off and safe landing of airplanes, helicopters and associated smaller aircrafts. More so, the fast movement of aircrafts in the atmosphere is hampered by these dangerous weather occurrences. Recent technological improvements in the air transport industry in Nigeria have not resolved all these weather limitations. Inadequate funding of weather observations and documentation in standard meteorological stations and distorted security in some parts of the country have worsened the situation in the industry.

The inland water transport is not spared of these weather and climatic limitations because its smooth operation depends largely on the waters in the rivers which are recharged by rainfall during the rainy season and reduced by excessive evaporation during the dry season. Adequate navigation of the rivers by large vessels is possible during the peaks of the rainy season when the water volume is high because of increased rainfall induced by the tropical maritime winds which originate from the Bight of Benin in the South of Nigeria. There is a reversal of this meteorological process during the hot-dry season when extreme temperatures are experienced owing to increased solar radiation and absence of rainfall and cloud cover particularly in the Central and far North of the country. During this season, the waters in Rivers Niger and Benue are greatly reduced as a result of infiltration and excessive evaporation. The large water vessels at this period cannot navigate from Benue to Cameroun for international socio-economic transactions. The movement of large vessels is possible only from Benue to Yola while in the River Niger, the large vessels can proceed from Minna to Lokoja specifically. Other important Rivers in Nigeria like the Kaduna, Sokoto, Katsina Ala, Cross River, Ethiope, Ogun, Osun and Yobe-Gana also experience this significant water fluctuation. This seasonal hydrological fluctuation in the rivers makes the inland water transport a non-widespread beneficial socio-economic engagement in Nigeria.

**Research Findings**

Based on the scientific assessment of climatic implications of environmental development with specific focus on water resources, agriculture, and transportation in Nigeria, the following findings are made.

First, the study clearly observes that Nigeria's position in West Africa makes it a unique country which is naturally endowed with abundant hydro-geomorphic, vegetal, animal, mineral, climatic, and fertile soil resources. These vast resources require effective planning and management using essential climatic principles to produce optimum outputs for domestic and foreign consumption.

Second, the study identifies three major sources of water in Nigeria which are precipitation, surface and subterranean water bodies. Of these hydrological resources, precipitation which is a widely distributed element of climate consistently plays the most appreciable role in the natural and human environments in the country.

 

On the surface level, the study establishes that Nigeria is a well drained country with a close network of rivulets, brooks, bays, lagoons, streams and rivers. Currently, the study indicates that there is absence of accurate scientific assessment of the magnitude of these surface water resources which are unevenly distributed and subject to considerable seasonal and climatic variations.
It observes that most of the streams and rivers in the Central and Northern parts of Nigeria often carry less water on their courses. This makes these water bodies easily depleted during the long dry season owing to excessive evaporation and sustained surface infiltration. This adversely limits normal navigation of the rivers by different water vessels.

It underscores that in planning to attain sustainable infrastructural development particularly in the areas of water provision and electricity generation in Nigeria, the alternating lengths of rainy and dry seasons should be considered and utilized by the development specialists. This would help prolong the safety and durability of these facilities put in place on the Nigerian environment.

Authentic hydrological data based on the nature of geology and relief characteristics of Nigeria reveal that the country is deficient in ground water resources. It currently has 9,500 billion litres of ground water which represent some 0.20% of the world's total. This study reveals that over half of Nigeria is underlain by crystalline rocks of the basement complex which are neither porous nor permeable to adequate atmospheric precipitation necessary for subterranean water storage.

It shows that many villages including towns and cities in Nigeria do not have adequate access to safe, secure and reliable sources of water for human and industrial consumption. Climatic fluctuations, evaporation of surface waters, absence of scientific hydrological studies, pollution, inadequate exploitation and supply of water, poor funding of dam and borehole projects, inadequate technology, unsatisfactory management of river basins, rural-urban conflicts, and non-integration of specialists' services in water planning, designing of facilities and operations are accountable for this situation in Nigeria.

The study observes that all aspects of the agricultural production chain in Nigeria are closely dependent on the prevailing weather and climatic conditions. Specifically, the rainfall amount, its variability and seasonality explain the differences in farming types and patterns and livestock management practices in the three different ecological zones identified in Nigeria.

More so, it indicates that adequate technology alone does not minimize the effect of weather on crop production but rather a period of favourable weather directly interacts with suitable technology to produce higher crop yield. The most essential weather elements which are suitable for optimum crop production are solar radiation, precipitation, temperature, wind, relative humidity and soil moisture.

Finally, the study observes that frequent extreme weather and climatic forces such as atmospheric turbulence, torrential precipitation, thunderstorms, sandstorms, lightning, floods and poor visibility have caused procrastinations, postponements and cancellations of scheduled flights, vehicular accidents, train derailments, airplane crashes and wreckages of water vessels in Nigeria.

**Recommendations**
This study identified precipitation, surface and subterranean water resources in Nigeria. It also observed that accurate scientific assessment of the magnitude of surface water resources had not been carried out by specialists within the country. First, detailed scientific assessments of the three major sources of water resources in Nigeria should be carried out by trained hydrologists, hydrological engineers and fluvial geomorphologists. The results of such assessments should be used to plan and execute essential water projects for specifically viable water endowed areas in the country. Adequate funds, the required technology and other vital logistics should be provided in time by the Federal Government of Nigeria. The United Nations and related international bodies should assist the Nigerian government in this regard owing to its dwindling domestic currency value occasioned by the decline in the global crude oil price. Atmospheric precipitation needs to be collected in constructed surface and underground tanks by the people while its run-off should be channeled carefully into the surfaces of identified river basins which could be constructed as modern boreholes for water derivation and provision to the immediate rural-urban settlements. To this end, very special attention should be paid to the weather controls and climatic variations in Nigeria. In the northern locations of the country, different water supply schemes and irrigation projects should be created closer to the dry season resistant rivers such as Rivers Sokoto, Hadeija, Yobe, Kaduna, Niger and the Benue. Adequate weather-resistant and rust-coated pipes should be used to connect the water schemes to the villages, towns and cities. Effective management through adequate funding and

 

maintenance of the water projects is necessary. In addition, water minimizing methods should be demonstrated by the water management to the understanding of the consuming settlements. The essence is to reduce water wastage particularly during the dry season which is characterized by extreme heat with excessive evaporation.

The continuous disruption of the ecological equilibrium of the river banks through reckless exploitation of alluvial sands and other essential river debris must be prevented and prohibited through legal enactments and efficient control particularly in the northern parts of Nigeria. All illegal acts of deforestation devoid of balanced forest regeneration programs on the river basins must be controlled and prevented completely by the Nigerian Forestry Authorities. Continuous monitoring of the people's activities in the rivers, regular assessments of the river sites by experts and prohibition of extensive water withdrawal in the rivers during the dry season are suitable measures to avert these hydrological challenges of excessive evaporation and surface infiltration in Nigeria. The planting of grasses and medium-sized trees close to the river sites and on the surfaces of river basins is a suitable solution in the right direction.

The challenges of climatic variations and fluctuations, although natural by occurrence, were identified in the study. These problems could be alleviated through the construction of domestic wells, dams, boreholes and the development of different artificial geomorphic units which could release enough moisture into the warm atmosphere to facilitate the processes of rain formation in the Central and Northern parts of Nigeria. The areas of regular water surplus should assist the areas of consistent water deficiency during the dry season. This measure is realistic where conflicting rural-urban interests are reconciled for the benefits of the people.

The limitations of agricultural production in the humid tropical Nigeria require the provision of adequate agricultural technology, supply of essential inputs, adequate funding by the government, effective extension services, scientific innovations, availability of fertile soils, suitable storage facilities, timely processing of harvests, functional network of transport, and profit-yielding marketing system to be resolved. These measures should interact favourably with solar radiation, optimum rainfall, suitable temperatures, mild atmospheric humidity, soil moisture and air, atmospheric winds and proficient supervision authentically supported by sustainable security in the three identified ecological zones in Nigeria to succeed holistically.

The relevant measures which would help ameliorate and confront the challenges of extreme weather and climatic forces on the Nigerian transport industry are reliable and authentic weather prognostications predicated on holistic meteorological observations and processed weather data derived from the synoptic weather stations. Weather prognostications are reliable weather forecasts carried out by meteorologists or climatologists based on the past and current atmospheric conditions which enable the immediate future weather characteristics to be ascertained (Wickham, 1970; Ayoade, 2008). The essence of the predictions is to issue reliable weather warnings to the public through the different media which would serve as protective guidelines against the destruction of lives, plants, properties and facilities by violent weather occurrences such as hurricanes, tornadoes, sandstorms, lightning and thunderstorms. When the weather predictions are assessed as mild, suitable and authentically favourable, different human activities particularly in the transport industry could proceed as planned. When the weather prognostications are assessed as urgently dangerous and dicey by the weather specialists, adequate restraints in realistic techniques and orders are urgently advised. In Nigeria, the observed weather threats to smooth transportation are poor visibility, atmospheric turbulence, sandstorms, lightning, thunderstorms and extreme heat from the atmosphere. These weather hazards must be clearly observed and avoided by the drivers of vehicles, captains of sea vessels, pilots of airplanes and operators of trains in Nigeria during the both seasons.

## Conclusion

This study has examined the climatic implications of environmental development with specific focus on water resources, agriculture, and the transport sector in Nigeria. It observed that Nigeria is immensely endowed with abundant water resources, fertile soils for agricultural production and suitable environment for the construction of a functional transportation system. However, these three significant sectors, as the study observed, are largely influenced by the prevailing weather and climatic elements to some extent that the anticipated socio-economic benefits of direct development are reduced considerably. Based on this situation, the study suggests, among other important measures, that the characterizing details and essentials of rainy and the dry seasons should be carefully observed, harnessed, incorporated and utilized in environmental planning aimed at adequate water provision, sustained food and cash crops production, and the facilitation of efficient transport system in Nigeria.

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