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CLIMATE CHANGE, DESERTIFICATION, AND DUST GENERATION IN NIGERIA: A REVIEW

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ABSTRACT

People, nations, and/or countries are becoming increasingly concerned with events occurring within and outside their environments. Of great interest to them is the subject of climate change. This is undoubtedly so because of the magnitude of destruction done by recent climatic events. Massive flooding resulting from hurricanes with usually great speed and magnitude has been reported. Heavy storms lasting longer and the melting of ice caps and frozen seas due to increasing temperatures are also causing flooding. Desertification and its concomitant effects of famine and shrinking of water bodies resulting from drought are becoming very common. Of great concern to Nigeria now is the issue of desertification. It ordinarily turns arable fields to dust bowls. This article, therefore, examines the extent of desertification in Nigeria vis-à-vis climate change and its implication in dust generation.

INTRODUCTION

The average pattern of weather, called climate, most often remains the same for centuries if it is left to itself. This is unlike weather which changes all the time. Although climate is relatively constant in comparison with weather, climate may not be strictly the same from one decade to another or from century to century.

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Changes in climate have occurred in the past, and are still occurring. Lamb (1966) attributes such changes to the controlling influences of climate which are never quite the same. These influences include a variation in the sun's output, changes in the concentrations of atmospheric gases, mountain building, volcanic activity, and changes in surface or atmospheric albedo.

The present climate change, by way of global warming, is being mostly attributed to changes in the concentrations of atmospheric gases. For more than 2 centuries now man has through his activities of burning fossil fuels, conversion of natural grassland to farm-land, and deforestation, been increasing the concentration of carbon dioxide and other greenhouse gases such as methane, chlorofluoro-carbons, nitrous oxide, and ozone in the earth's atmosphere. From the early 1700s there has been an increase from about 280 to 360 parts of carbon dioxide per million in 1990 (Barry & Chorley, 1992). This is an increase of about 29%. Most computer climate models suggest that the globe will warm up by 1.5 to 4.5°C if the gas reaches the predicted level of 600 parts per million by the year 2050 (Linacre, 1992). The rapidity of the present warming is unprecedented with enormous implications for mankind (Linacre, 1992; Obasi, 1992). Barry and Chorley (1992) report that changes in the past were considerable as global temperatures were around 5°C lower during the Ice Age (2.5 million to 10,000 years ago) than they are now. Thereafter, according to them, was warming until the altithermal period around 7,000 years ago when the earth was about 2°C warmer than now. Then there was a cooling, and later the medieval warm Epoch around AD 1000. This was followed by the little Ice Age which brought down temperature by a degree especially during the winters until about AD 1650. Since then, there has been a general warming, interrupted by the cooling between 1940 and 1965.

The effects of a greenhouse-induced global rise in temperature, whether direct or indirect, would vary with location. Meyer (1996) predicts the high latitudes will experience a greater warming than the tropics (low latitudes). This will reflect, among other things, in the variation of rainfall patterns. Even small increases in air temperatures could alter precipitation levels and thus making some areas wetter and others drier. The location of Nigeria within the tropics makes it experience relatively high temperatures all year round. Even though it has been predicted that the tropic will experience a lesser warming (Meyer, 1996), any warming at all will imply an addition to the already existing high temperatures of the area. This equally means the enhancement of rainfall in some areas and drying in others. Such has enormous implications for land cover, water bodies, and the earth surface in general. An increased rainfall implies more luxuriant growth for vegetation, increased sizes of water bodies, and more soil moisture. On the other hand, a reduced rainfall in combination with rising temperatures will mean withering of vegetation, drying up of water bodies, and the drying up and baking of soil. This article aims at examining the extent of desertification in Nigeria, alongside climate change and its implication in dust generation.

MATERIALS AND METHOD

Major data of interest employed in this study are as follows: (i) rainfall amounts for the extreme north and south of Nigeria; (ii) maximum and minimum temperatures for seven stations, namely: Ikeja, Benin City, Port Harcourt, Kano, Sokoto, Maiduguri, and Jos; (iii) mean annual evaporation for four stations, namely: Kano, Maiduguri, Yola, and Port Harcourt; and (iv) dust deposition amounts for southern and northern Nigeria. These data were colleted at different periods.

RESULTS/DISCUSSION

Rainfall, Temperature, and Evaporation in Nigeria

The Tropical Maritime Airmass (mT) and the Tropical Continental Airmass (cT) are the dominant airmasses that influence the rainfall pattern of Nigeria. The extent of the influence of each one of them is determined by the position of the Inter-Tropical Discontinuity (ITD). The ITD moves forth and back over the country thereby determining which of the airmasses takes pre-eminence in exhibiting its characteristics over it. The mT originates from the Atlantic Ocean and moves into Nigeria through the south-west-direction (see Figure 1). This moisture-laden wind brings rain to Nigeria with more of it received at the coast and wanes hinterlands. The cT comes into the country from the Sahara Desert following a north-east direction. It is dry and dusty. Its appearance in Nigeria signals the beginning of the dry season. Its greatest influence is in the north and dwindles southwards. Based on this natural arrangement, the southern part of the country is far wetter than the north. While the coastal areas receive over 4,000 mm of rainfall spread over 8 to 10 months, the extreme north (south of the Sahara) receives less than 250 mm spread over 3 to 4 months (Oguntoyinbo, 1983). This makes the extreme north to be more susceptible to desertification than the coastal areas of the country.

Temperature over Nigeria also follow the north-south pattern. Here the mean maximum temperatures increase from the southern coastland toward the north, while mean minimum temperatures decrease from the south toward the north except where there are altitudinal effects.

The highest monthly mean temperature of 32.2°C is received by the coastal area as compared to the 40.6°C of the extreme north (Oguntoyinbo, 1983). Table 1 shows the monthly mean of daily temperatures at selected stations in Nigeria.

The stations were selected in such a manner to give an insight into the implication of the contrasting temperatures between the extreme northern part of the country and the extreme south in desertification.

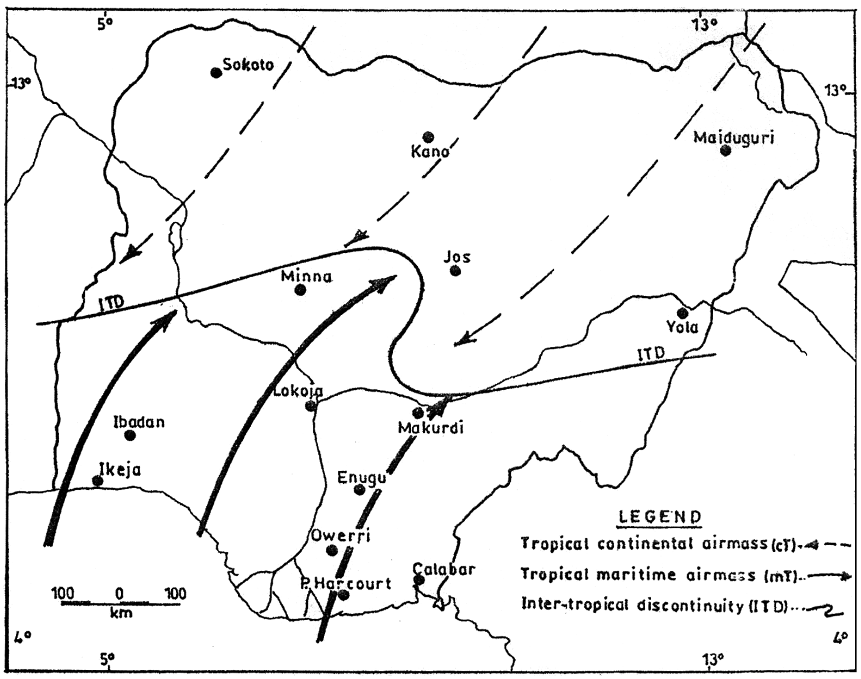

Figure 1. Nigeria: Tropical maritime/continental airmasses and inter-tropical discontinuity—mT, cT, and ITD respectively.

Evaporation and evapo-transpiration over Nigeria equally follows the north-south pattern. Measured mean annual value of evaporation as recorded with three different types of measuring pans namely, the American class A pan, the raised pan, and the sunken pan, indicate the north as having the highest and the south the lowest (see Table 2).

The high evaporation values for the north relative to those of the south can find justification in the drier condition and high maximum temperature of the area. This means much drought and, by extension, desertification in Nigeria.

Climate Change, Drought, and Desertification in Nigeria

Drought may act as a manifestation of climate change (Littmann, 1991; Middleton, 1985; Moulin, Lambert, Dulac, & Dayan, 1997). This may equally be said to be true for desertification because of the close relationship existing

Table 1. Monthly Mean of Daily Temperatures of Selected Stations in Nigeria

S/N	Station	Location	Maximum (°C)	Minimum (°C)
1	Ikeja (Lagos)	Extreme south	30.7	21.8
2	Benin City	Extreme south	30.6	21.9
3	Port Harcourt	Extreme south	30.6	22.9
4	Kano	Extreme north	33.1	19.2
5	Sokoto	Extreme north	35.3	20.9
6	Maiduguri	Extreme north	34.4	19.3
7	Jos	Extreme but with altitudinal effects	27.8	16.6

Source: Adapted from Oguntoyinbo (1983).

Table 2. Pan Evaporation at Selected Stations in Nigeria

			Mean annual evaporation (mm)		
S/N	Stations	Coordinates	Class A pan	Raised pan	Sunken pan
1	Kano	12° 03′ N, 8° 32′ E	3,511	3,056	2,538
2	Maiduguri	11° 51′ N, 13° 05′ E	4,047	3,312	2,862
3	Yola	09° 14′ N, 12° 28′ E	2,971	2,525	2,278
4	Port Harcourt	04° 51′ N, 07° 01′ E	1,630	1,520	1,352

Source: Adapted from Ayoade (1976).

between it and drought. Drought and desertification, though not identical, have so much in common. Drought, it is generally agreed to mean a climatic condition where there is an insufficient supply of moisture from precipitation or stored in the soil which results in the poor performance of crops and animals, the disruption of economic activities and general ecological changes. Desertification though controversial is taken to mean an environmental condition where the land's biological productivity is reducing as a result of man's misuse of land and its cover, and the changing climate. Christopherson (1992) identifies the principal cause of desertification as poor agricultural practice (overgrazing and inappropriate agricultural activities), improper soil-moisture management, erosion and salinization, deforestation, and the ongoing climate change. The environmental manifestations of both terms look alike, though those of drought are short-lived relative to those of desertification. Both are intertwined by climate.

Drought, which usually begins with the reduction or lack of precipitation, may kick-start desertification. It is most likely so if the drought occurs in an arid or a semi-arid area. Incidentally, the study area, Nigeria, seems to have drought as an inevitable part of the climate of the arid and semi-arid region. Prolonged droughts in these areas have often resulted in the difficult or impossible recovery of the plant communities, and by extension human and animal lives. Such stressed up ecology makes a pathway for desertification to set in. On this relationship, Nigerian Environmental Study/Action Team (NEST, 1991), sees drought as simply administering shock to the ecosystem and plays the role of a catalyst for producing accelerated desertification. Equally, the potential exists for desertification to become self-accelerating, with droughts promoting the process (Nicholson, 2000).

Extent of Desertification in Nigeria

Drought and desertification are prevalent in the arid and semi-arid areas of Nigeria. These areas are found north of latitude 12°N covering about 15% (about 140,000 km^2) of the country's landmass (NEST, 1991). Now areas below 12°N and about 11°N are fast joining areas affected by desertification as a result of the southward expansion of the desert biome (Christopherson, 1992). The Sahel Savanna is the worst hit by desertification; followed by the Sudan; and to very little extent the Guinea Savanna. The Savanna areas form the transitional zone between the humid areas to the south and the true desert (the Sahara), to the north. The states of Nigeria affected by desertification are Sokoto, Kebbi, Zamfara, Katsina, Kano, Jigawa, Jose, and Bornu (see Figure 2). Christopherson (1992) suggests that many millions of additional hectares of land are added each year to the about 800 million hectares of desertified lands since 1930 as estimated by the United Nations.

Several authors have documented episodes of droughts in Nigeria (High, Oguntoyinbo, & Richards, 1973; Oguntoyinbo, 1983). The severity of some of these droughts, especially in the early 1970s and 1980s, helped in extending the limits of desertification. These droughts have not only taken their tolls on vegetation and the lives of man and animals, but also on the Lake Chad. The surface area of it has decreased from 25,000 km^2 in 1963 to 1,350 km^2 (Coe & Foley, 2001). Its very location in the extreme north-eastern Nigeria makes it very prone to the effects of droughts and desertification.

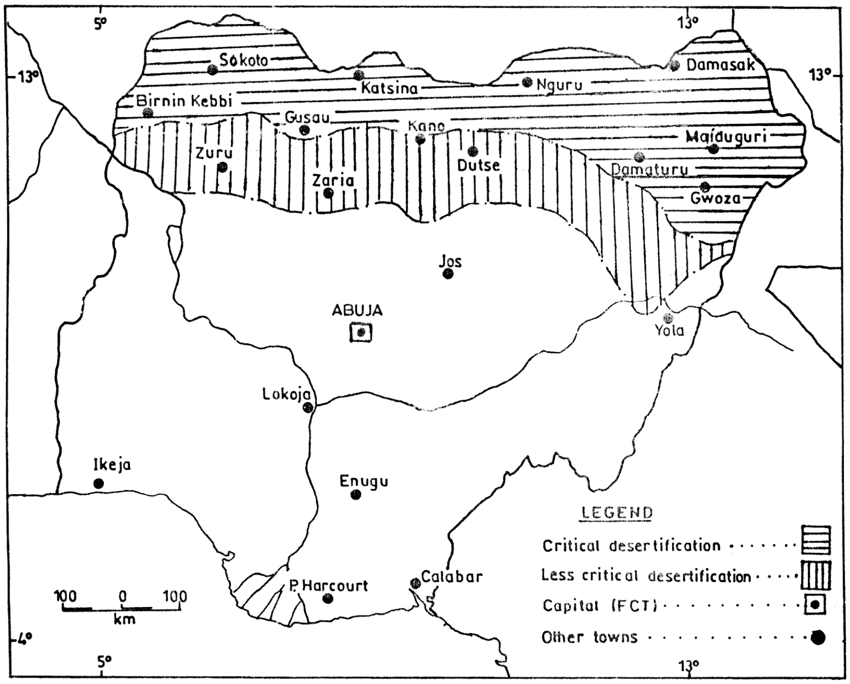

Figure 2. Nigeria: area of desertification.

Desertification and Dust Generation in Nigeria

The more soil is exposed to drier conditions, the more friable it becomes. In Nigeria (and in particular the northern part), the average temperature is already considered high implying high evaporation rate which makes the soil dry. When soil becomes dry and friable there is the tendency to generate more dust, especially in the presence of wind and the absence of land cover. Northern Nigeria is made even drier and dustier by the Tropical Continental Airmass that is dry and dusty during the dry season usually referred to as Harmattan. Schütz, Jaenicke, and Pietrek (1981), D'Almeida (1987), and Swap, Ulanski, Cobbett, and Garstang (1996) have identified the Sahara Desert as the world's largest source of aeolian soil dust. All these make northern Nigeria experience more dust production and distribution than the southern part as can be seen in Table 3.

The particles of the dust so generated are of various sizes. Three sizes of dust particles have been classified by Goudie and Middleton (2001), namely: mean, modal, and media. The 8.9-7.43 μm detected by McTainsh and Walker (1982), for Kano, Northern Nigeria is classified under median.

Table 3. Dust Deposition Amounts in Nigeria

S/N	Source	Location	Annual deposition (gm^{-2})
1	Measures and Brown (1996)	Gulf of Guinea (Southern Nigeria)	3.4-11.5
2	McTainsh and Walker (1982)	Northern Nigeria	137-181

Source: Adapted from Goudie and Middleton (2001).

Climate change as manifested by drought and desertification has been implicated in the substantial increase in dust generation (Goudie & Middleton, 1992; Littmann, 1991; Middleton, 1985; Moulin et al., 1997; N'Tchayi Mbourou, Berrand, & Nicholson, 1997). Based on data from Nigeria, Senegal, Sudan, and Mauritania, Middleton (1985) and Goudie and Middleton (1992) noted increases in dust output frequency concurrent with drought periods since the mid-1960s. N'Tchayi Mbourou et al. (1997) on their own part have observed increased in both frequency and annual duration of dust conditions, particularly stations in the Sahel since the late 1950s. One implication of this is the turning of once known arable lands to dust bowls.

Climatic Significance of Dust in Nigeria

Dust has several implications for climate. As the earth's surface is made bare by drought, desertification, and overgrazing, the surface albedo is raised and the dust injected into the air alters the regional heat balance by reflecting away more solar radiation (Meyer, 1996). Such processes promote atmospheric stability and suppress rainfall as a result of net cooling, withering of vegetation based on reduced rainfall, and the swirling upward of more dust thus increasing the initial impact. Dust in the atmosphere does not only create cooling, it equally may cause warming. Dust modifies solar radiation transmitted through to the earth's surface and terrestrial radiation emitted to space, and the balance between them determines whether cooling or warming is created which in turn depends to an extent on such variables as the size distribution of dust particles and the chemical composition (Goudie & Middleton, 2001). Another possible impact of dust is its influence on marine primary productivity (Jickells, Dorling, Denser, Church, Arimoto, & Prospero, 1998). Dust may also cause ocean cooling (Schollaert & Merrill, 1998) when it is blown into the ocean and some of its particles settled on the surface of the ocean. These particles reflect back to space some part of the solar radiation reaching it, thus reducing the amount of energy absorbed by the ocean.

CONCLUSIONS

As more and more arable lands in Nigeria, especially in the Sahel and Sudan regions, are made barren and degraded by desertification, by the same token dust is being made more abundant. Prolonged drought periods have been reported to be pathways to increased desertification, and by implication increased dust generation. Incidentally, the frequency of prolonged and severe drought periods is increasing. The implication of this dust generation for food supply should be of concern to Nigeria and Nigerians. When rainfall in suppressed by it, it means making an already dry condition drier thus resulting in poor performance and/or death of crops and animals. On the other hand, the creation of warming by dust ordinarily should increase rainfall if it were a humid area, but in the case of an arid or semi-arid region with its high evaporation rate, and whose average temperature is already considered to be high, it is different. Such will mean higher temperatures and evaporation rate with enormous implication for agriculture. Plants will wither and animals will have little or no pasture to graze on and will be in discomfort. If dust increases enough to the extent that it results in the cooling of the Atlantic Ocean at the southern part of Nigeria, rainfall will be reduced in the coastal regions since the warmth of the warm Guinea current may be reduced. This will result in change in the ecosystem of the coastal region of the country.

To overcome these problems created by dust, Nigeria which is still grappling with the feeding of its ever-increasing human population, needs to increase water supply for agriculture. Such can be done by building more and bigger dams for irrigation, especially in the arid and semi-arid regions. This will help guarantee food security, and by extension, the needed economic stability in the country.

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