

## THE IMPACT OF CLIMATE CHANGE AND ANTHROPOGENIC FACTORS ON DESERTIFICATION IN THE SEMI-ARID REGION OF NIGERIA

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*(Received 19 February 2002; Revision Accepted 4 June 2003)*

### ABSTRACT

This paper examines the impact of climate change and anthropogenic factors on desertification in the semi-arid region of Nigeria. Climatic data (Temperature and rainfall) for 52 years (1950-2001) from 25 meteorological stations were collected and analysed. Questionnaires were also used to solicit respondents' perception on the causes, effects and solution to desertification in Nigeria. The data were computed and analysed using the square method, maps and bar graphs. The results among others show that while temperature has been on the increase, rainfall has been decreasing. The continued aridity and pressure on the land from farming, grazing and indiscriminate bush burning have led to southward desert encroachment. Currently, approximately 22.6% of the country's landmass is being affected by desertification. The desertification process has resulted in southward migration of sand dunes, water scarcity, reduction in crops' production, ecological degradation and emigration of people and animals. Integrated efforts from the Local Communities, States and Federal Government together with NGOs and International Bodies to combat desertification through massive afforestation, enlightenment campaign, avoidance of indiscriminate bush burning, reduction in deforestation, overgrazing and overcropping among others are recommended.

**KEY WORDS:** Climate Change, Sand dunes, hydrothermal, Desertification and Afforestation.

### INTRODUCTION

Man's massive assault on the atmosphere began with the Industrial Revolution. This started first with coal and then increasing amounts of petroleum and natural gas have been burned to power industries, heat and cool cities and drive vehicles (Roy, 1999). This burning leads to the release of greenhouse gases such as carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO), nitrous oxide (N<sub>2</sub>O), sulphur dioxide (SO<sub>2</sub>), Chlorofluorocarbons (CFCs) and Methane (CH<sub>4</sub>) among others. With the destruction of the sinks of some of these gases through deforestation and water pollution, the level of atmospheric concentration of these gases has risen steadily (Odjugo, 2001). The greenhouse gases destroy the ozone layer thus allowing the infiltration of more short-wave radiation, and also make the atmosphere to be less transparent to the long-wave heat energy which radiated back into space from the earth (Oke, 1995 and Ojo et al. 2001). Slowly but inexorably, the trapped or retained heat raises the average tropospheric temperature, giving rise to global warming. During the first century of the Industrial Revolution, from 1780 to 1880, mean global temperature rose by only 0.3°C. Between 1880 to 1980, temperatures increased by 0.6°C and between 1980-2000 an increase of 0.5°C has been recorded. This period (1980-2000) also recorded the 12 warmest years since temperature records started (Folland et al, 2001, Michell et al 2001 and Odjugo, 2001). Should the current process continue, a maximum temperature rise of 5.8°C by the year 2100 has been predicted (Watson, 2001).

Temperature differences are the engine driving global circulation of winds and ocean currents and help create conditions inducing or inhibiting winter and summer precipitation and daily weather conditions (Katung, 2000 and Ojo et al (2001). The increasing global temperature has led to perturbation of the world weather elements, which is manifested in climate change. Climate change

could be expressed as short or long-term fluctuation of weather extremes. Although, the world climate has been changing since weather records started, the change is most pronounced in the 1980s to date (Environment Canada, 2002). This is manifested in the incidence of extreme one day precipitation, overall precipitation, above-normal temperatures, drought and desertification, among other effects (Fellmann, et al. 1999; Odjugo, 1999 and 2000).

Desertification means the steady advance of the margins of the world's deserts into their adjacent dry lands, converting (through natural climatic fluctuations and anthropic alteration) formally productive or usable pastures and croplands into barren and sterile landscape (Fellmann, et al, 1999 and Dianifaba 2002). Both natural and anthropogenic factors have been identified as causes of desertification in any part of the world (Safriel, 1999, Yawe 2000). It is obvious at this juncture that the world climate is changing and the changes have resulted to some environmental degradation such as drought, soil erosion, loss of vegetal cover and desertification. Kjellen (1999) notes that although the problem of desertification is of global significance, its concrete effects are felt at the national and local levels, while Iselekpitime (2000) opines that detailed knowledge of the local and national effects of drought and desertification are very important for effective planning and adaptation. The substantive objectives of this paper therefore, is to evaluate: the extent of climatic change in the semi-arid regions of Nigeria since the middle of the last century (1950-2001); the impacts of the climatic change and human factors on desertification and finally; the effects of desertification on the people and ecology.

In order to achieve the above stated objectives, the paper is organised into six sections. The first section looks at the theoretical framework and literature review. While section two deals with the study area, sections three discusses the material and methods employed in the study. The result is discussed in section four looking first at, the hydrothermal

condition and its effects on desertification and secondly, the perception of the inhabitants on the causes and effects of desertification. While the planning implication is treated in section five, the summary and conclusion were addressed in section six.

#### Theoretical Framework and Literature Review

The processes involved in desertification could be fully conceptualised using the Population - Environment (P-E) analysis approach. The detail discussion of the P-E concept could be found in (Pickering and Owen, 1997; Bilsborrow and Carr, 2000 and Lutz, et al. 2002). These authors picture directly or indirectly linear linkages between population (Human activities) and the environment (Natural processes) through consideration of various kinds of intermediating processes and how they result in desertification. Rather than viewing population - Environment linkages in terms of a linear causal chain of separate boxes, Njama (2000), and Lutz, et al. (2002), visualised it as a series of concentric circles where the inner circles (Population and human made environment) are fully embedded in the broader circle (Natural environment).

Whatever pattern of linkages involved either linear or concentric, the P-E concept shows that as population increases human needs and activities as well as pressure on the land also increase through agriculture, energy demand and urbanisation (Pickering and Owen, 1997 and O'Neill et al., 2001). If the land especially the fragile ecosystem of the desert border is overused and the carrying capacity is exceeded persistently, land gets progressively degraded and lost the ability to renew itself. At this stage erosion will continuously denude the land until desert features are well established (Dregne, 1977; Bilsborrow and Okoth-Ogendo, 1992; Kemp, 1994 and Jolly, 1994).

The natural processes of desertification are initiated by persistent drought (Pickering and Owen, 1997; Mebitaghan, 1998; Katung, 2000 and Akonga, 2001). The causes of drought are primarily meteorological, since it results from failure of rains expected as a result of changes in atmospheric circulation systems (Oguntoyinbo, 1991 and Ayoade, 2002). It is along this line that Ayoade (2002) defined drought as rainfall deficiency extending over months or years drying up water supplies and affecting crops and plants. The occurrence of drought may be attributed to several factors but can be specifically (for Nigeria) be considered in terms of climatic effects of the Inter Tropical Discontinuity (I. T. D) as described in detail by Kowal and Knabe (1972) and Oguntiyinbo (1991). Other researchers in the Sahelian region of Africa linked the frequent and prolonged drought to climatic effects of El Nino Southern Oscillation (ENSO) which is fully discussed in (Kidson, 1977; Adedoyin, 1989; Oguntiyinbo, 1991 and Barry and Chorley, 1992). Of all the droughts in Nigeria, the most severe were those of 1972-1974 and 1982-1984 (Enabor, 1987 and Akonga, 2001). With the drying up of plants due to harsh climatic condition and drought, the soil is exposed, erosion sets in and desert - like condition is created (Mainguet, 1994 and Mebitaghan, 1998).

It is clear at this point that the causes and processes of desertification are combined forces of man and nature. This view was held by researchers like Rapp (1974), Warren and Maizel (1977, Rozanov (1982), Ahmad and kassas (1987), UNCED (1992), Mainguet (1994), Parry (1996), Pickering and Owen, (1997), while few others blamed it on human actions alone (Dregne, 1978; Mabbutt, 1984;

Mortimore, 1987 and Dregne et al., 1991). The rate of southward advancement of the desert into Nigeria over the years has been researched into. The southward advancement was 4km in the 1980s, 7km between 1990-1995 and 8km from 1996-2000 (Duru, 1984; Nwokedi, 1996 and Yawe, 2000). It is these established rates that are employed in this study to locate the southern limit of areas prone to desertification in Nigeria.

The consequences of desertification have been linked to enhanced soil erosion, sand dune development, salinization, soil impoverishment and loss of biodiversity (Nelson, 1988; UNEP, 1991; Mainguet and Letolle, 1998 and Katyal and Vlek, 2000). On the impact of desertification on agriculture, Omiunu (1985) noted that drought /desertification with its associated aridity has significant negative effects on food production in Nigeria. As rainfall amount and duration decreases in the northern Nigeria, Abubakar (2001) noted a shift from the production of long duration guinea corn to millet, which requires shorter duration of rainfall. He further showed that in Borno, Yobe, Sokoto and Zamfara States the percentage production of Guinea Corn and Millet was 70% and 30% respectively in 1980, but as at the year 2000, it has changed to 40% and 60% respectively. On ecological implications, Balogun (2002) noted that the Sahel Savanna, which was limited to the northeastern part of Borno State in 1980s, has spread to all the seven states bordering the Niger Republic. He added that Sahel Savanna has engulfed most parts of the Sudan Savanna, while the Sudan Savanna has been encroaching into the Guinea Savanna belt. Desertification has also been found to either dry up rivers, lakes or reduce their depth through erosion deposits. For example, Lake Chad, which had a mean depth of 3m in the early 1960s, is less than 2m as at 2000 (Abubakar, 2001). The surface area of the lake which was 23,500km<sup>2</sup> in 1963, has shrunk to between 2,300 and 2500km<sup>2</sup> in 1984 and by 1998-2100, the surface area has reduced to only 8km<sup>2</sup> (Adefolalu 1983 and Olaniran 2002).

More than 100 countries suffer from the consequences of desertification worldwide and it is estimated that the environmental impacts affect between 900 million and 1 billion people (Pickering and Owen, 1997 and Yugunda, 2002). As much as 3,592 million ha or 70% of the total world dryland area is affected by desertification. Of this, about 78 million ha suffer from irreversible degradation and is thus unreclaimable economically (UNEP, 1991 and Katyal and Vlek, 2000). For areas that could be reclaimed, afforestation programmes, irrigation and water management and proper agricultural practices among others were recommended (Warren and Agnew, 1988; Onyewutu, 1991; Katyal et al., 1994; and 1999; Parry, 1996; Smaling et al., 1997; World Bank, 1999 and Katyal and Vlek, 2000).

#### The Area of Study

The semi-arid region of Nigeria under study covers the Savanna belts (Fig. 1). It occupies approximately 720,902 km, which is about 78% of the total land mass of Nigeria (Geo - Informative International Report, 1976). It has Sudan Savanna type of climate (Koppen's Aw climatic classification) with summer rains and winter dry. Annual rainfall ranges between 400mm in the north and 1200mm in the south which is concentrated for a period of 3 to 6 months (April-October) in a year: Mean annual temperatures are high throughout the year ranging from 29°C to 32°C. Humidity is low with a mean annual range of 30 - 60%. Two prevailing air masses are prominent in this region. The warm moist Tropical Maritime (mT) that prevails for 3 to 6 months (April-October) and the hot dry Tropical Continental air mass (cT) which blows from the

Sahara desert and prevails for 6 to 9 months in a year starting from November. While the former brings rainfall, the latter comes with dryness (Osaigbovo, 2000).

The vegetation type is that of tropical Savanna. In the Southern part of the semi-arid zone, Guinea Savanna (Parkland) is found. This gradually merges into Sudan Savanna while the northern border of the country is dominated by Sahel Savanna. Most areas of the Sahel and the Sudan Savanna are being taken over by the encroaching desert. In the northeastern border, Montane Vegetation is found on Adamawa and Mandara Mountains.

In the northern extreme of Nigeria bordering the Niger Republic (From Binji through Katsina to Kukawa), the weakly developed regosols is found. The regosols are generally loose, excessively drained and intensely leached. Apart from the humus rich surface layer, the regosols show little evidence of pedogenesis. But in some areas like the Sokoto plain, Katsina, Kano and Borno (Maiduguri) the desert deposits have been subjected to greater pedogenesis giving rise to the brown and reddish brown soils (Areola 1982). Ferruginous tropical soils and ferrisols predominate in all other parts with the exception of areas around Lake Chad and along the rivers where the riverine and lacustrine type of hydromorphic soils are found.

#### MATERIALS AND METHODS

Climatic data (Temperature, rainfall) were collected for 52 years (1950–2001) from the Nigeria Meteorological Station, Lagos. The data were collected from 25 meteorological stations in the semi-arid region of Nigeria. The map of Duru (1984) showing the desert area of Nigeria was used as a base line. The rate of Southward estimates of desert encroachment by Duru (1984), Nwokedi (1995) and Yawe (2000) were used to compute the current total area occupied by the desert. The total area in kilometres was converted to degrees and minutes with the premise that within the equatorial and sub-equatorial region the distance of 1° Latitude is 111.318 km (Adeleke and Leong, 1978). Thus:

$$\begin{aligned} 1^\circ &= 111.318 \text{ km} \\ 1' &= 1.86 \text{ km} \\ 1'' &= 30.92 \text{ m.} \end{aligned}$$

With this, the southern limit of the desert border was fixed from the Duru (1984) baseline. Duru (1984) and Nwokedi (1995) use various environmental factors in determining the areas being desertified. These include the meteorological drought, surface and underground water, shift in sand dunes and the fragile nature of the ecosystem based on sahelian vegetation change.

For a better understanding of the inhabitants' perception of the causes, effects and solution to the encroaching desert, four states (Borno, Kano, Sokoto and Jigawa) were randomly selected. 500 questionnaires were distributed in each state giving a total of 2000. A total of 1866 well-answered questionnaires were analysed. The data were analysed using the square method, maps.

#### RESULTS AND DISCUSSIONS

##### Hydrothermal Conditions

The mean annual temperature variation in the semi-arid region of Nigeria for the period of 1950–2001 is shown in figure 2. A gradual rise in temperature is noticed. The warmest year was experienced in 1998 (32.5°C), The second warmest was experienced in 2001 and the third was

1973 which coincides with the 1972-1973 drought the most severe drought ever experienced in Nigeria (Enabor, 1987; Oguntiyinbo, 1991 and Akonga, 2001). This result corresponds with the world record, which has 1998 as the world warmest year closely followed by 2001 (Environment Canada, 2002). The temperature anomaly using 1950–1980 normal in Fig. 3 shows that, between 1950–1968, temperatures were below normal, but since 1969 to the present day, it has been above normal. The anomalies in mean annual temperature since the 1980s, is frightening and disturbing. When we consider the 'normal' for 1950–1980, 1960–1990, 1970–2000, there is an increase of 0.75°C over the preceding normal. Should this trend continue at this rate, for the next 100 years from 2000, that is by 2100, the mean annual surface temperature over the semi-arid region of Nigeria would be higher than 2000 values by at least 2.5°C.

Figure 2 shows the mean annual rainfall distribution between 1950–2001 and the departure from normal in Fig. 4, while the decadal variation is shown in Fig. 5. All revealed a declining trend in rainfall, most especially since 1971. Rainfall decreases from 1185mm (1950–59) to 903 mm (1990–99). With the exception of 1952 and 1956, rainfall were above normal between 1950–1970, while it was below normal since 1971 till date except 1978 and 1980 that is slightly above normal. The driest periods were 1972–1973 and 1982–1983. These periods also experienced the worst drought condition in the region, while a persistent drought-like condition is being experienced since the early 1990s. This agrees with the work of Olaniran (2002), who shows that 1971–1980 and 1981–1990 decades had the least percentage of normal rainfall since weather records started in Nigeria.

The foregoing evidences show that the climate of the semi-arid region of Nigeria is undergoing rapid changes. It is getting hotter and drier a clear evidence of global warming. Such drier atmospheric condition has a lot of ecological implications, which include desertification and ecological degradation (Katung, 2000).

The warming climate has been identified as a major cause of desert encroachment into Nigeria. For example, Duru (1984) revealed that the advancing Sahara desert is threatening the Sahel Savanna and he quantified the annual rate of Southward advancement to be 4km. Nwokedi (1996) shows that between 1990–1995, the average rate of desert encroachment was 7 km. Yawe (2000) points out that the desert has been advancing at an annual rate of 10km in the northeastern part of Nigeria, 8km in the northwest and a general mean of 8 km. With these, the spatial spread of the desert prone area was computed (Table 1) and the area in Km was converted to degrees and minutes. The mean distance covered by the Southward advancement of the desert between 1984–2002 was 120 km which is approximately 1° 5'. With this, the Southern limit of the desert prone area was fixed (Fig. 6). Employing the square method, the area being threatened by desertification in Fig. 6 was computed. It shows that 209,249 km<sup>2</sup> which is approximately 29% of the northern Nigeria and 22.6% of the entire nation is gradually being desertified. This is slightly lower than the 28% of the world's landmass that is currently being desertified (Yawe, 2000 and Yugunda, 2002).

This computed result is compared with desertification information derived from the 20 northern States Environmental Protection Agencies (SEPA) in 2000. Out of the 720,902 Km<sup>2</sup> of the 20 states that constitute Northern Nigeria, 260,417 Km<sup>2</sup> representing 36.1% is being desertified. When compared with the entire country with a landmass of 925,000km<sup>2</sup> it is found that approximately 28.2% of the

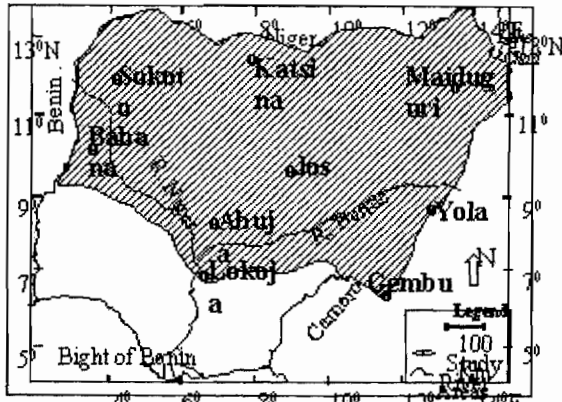


Fig. 1: Semi-Arid Region of Nigeria

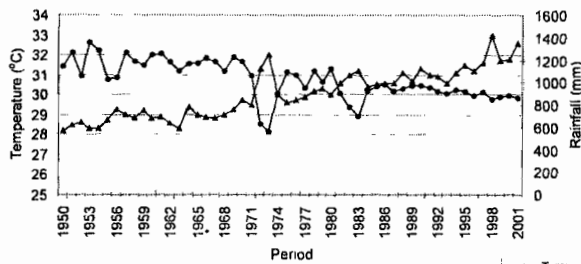


Fig. 2: Mean Annual Temperature and Rainfall Distribution (1950-2001). Source: Nigeria Meteorological Station, Lagos

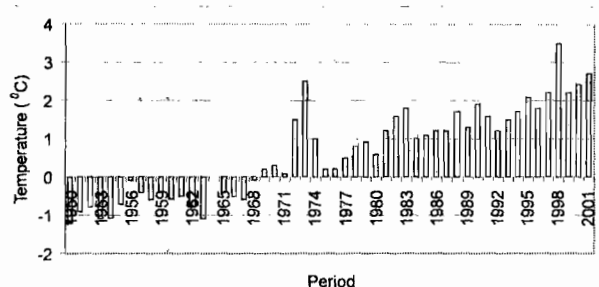


Fig. 3: Mean Temperature Departure in Northern Nigeria From 1950-1980 Normal. Source: Nigeria Meteorological Station, Lagos

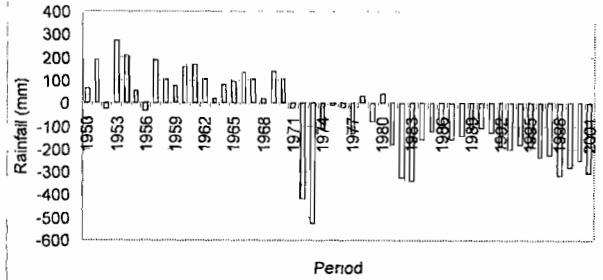


Fig. 4: Mean Rainfall Departure in Northern Nigeria from 1950-1980 Normal. Source: Nigeria Meteorological Station, Lagos

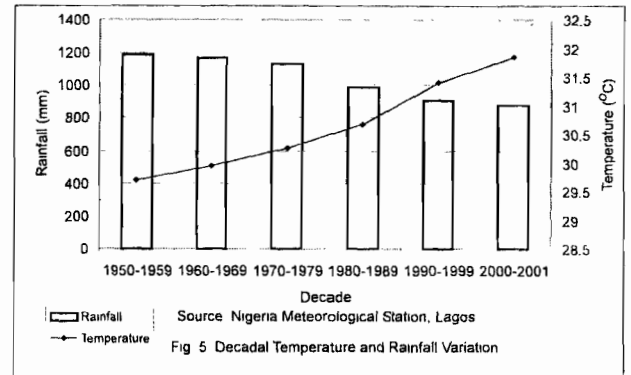


Fig. 5: Decadal Temperature and Rainfall Variation. Source: Nigeria Meteorological Station, Lagos

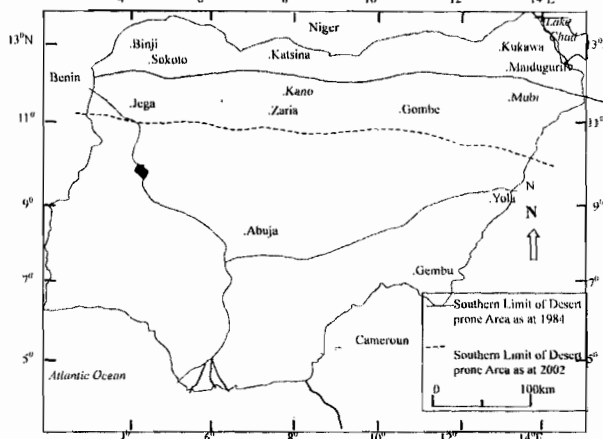


Fig. 6: Desert Prone Area in 1984 and 2002

country is gradually being turned to desert. Based on both computations, between 22.6-28.2% of the country is gradually being encroached by the desert.

**Causes and Effects of Desertification**

As shown in Table 2, the causes of desertification as revealed by the respondents to the questionnaires are both natural and anthropogenic, with the natural factors topping the list. The most severe causes of desertification as shown in the table, are climatic change (increasing intensity of temperature and sunshine and decreasing amount and duration of rainfall) and frequent and successive droughts. These coupled with economic hardship (Unemployment, underemployment, high cost of living and poverty) and rapid population increases lead to deforestation for construction works and intensive agricultural practices due to lack of mechanised farming implements. Personal observation of 10 storey buildings

revealed that an average of 320 sticks were used to support the decking of a three-bed-room flat building, plus the plywood of the decking floor. Investigation further revealed that these sticks and plywood are hardly used twice since they are sold as fuel wood immediately they are removed as support. The implication is that an upward of 300 would-be-trees, are destroyed for every storey building constructed. One could now appreciate the volume of small trees destroyed annually with current vertical growth of our cities. Indiscriminate bush burning is another serious cause of vegetal destruction and desertification (Table2). As a destabilising factor to enhance the killing of bush meat, hunters during the dry season, burn the bush during most of their hunting expeditions. While farmers burn the bush to ease clearing, the herdsmen do the same to facilitate sprouting of the grasses for their animals to graze on. In addition to these factors, overgrazing resulting from limited pasturage, poor irrigation practices and poor governmental attitude toward

**Table 1: Southward spatial spread of Sahara Desert**

Period	Estimated Annual Spread (Km)	No. of Years	Area Covered (Km)
1984-1989	4*	6	24
1990-1995	7**	6	42
1996 - 2002	8***	7	54
Total			120

Source: Fieldwork, 2002

Estimated by: \*Duru (1984)\*\* Nwokedi (1996)\*\*\* Yawe (2000)

**Table 2: Causes of Desertification**

Causes	Percentage
Climatic changes	21
Successive droughts	18
Economic hardship	15
Population increase	12
Intensive agriculture	8
Indiscriminate bush burning	8
Overgrazing	7
Poor irrigation	6
Political Factors	5

Source: Fieldwork, 2002

eradicating environmental degradation enhanced the rapid spread of the desert in Nigeria (Table 2).

The noticed climate change and desert encroachment have disastrous effects on natural resources and disrupt existing economic and social systems. The effects as revealed by the respondents are shown in Table 3. The worst and the most destabilising effects of desertification as revealed by 27% of the respondents is the sand dune formation. States that are worst hit by such migrating sand dunes according to Yawe (2000) include Borno, Yobe, Sokoto, Katsina, Jigawa and Nassarawa. Exactly 20% of the respondents (Table 3) show that such migrating sand dunes have buried large expanse of arable lands, thus reducing viable agricultural lands and crops production. This harsh condition has led to massive emigration and resettlement of people in the areas down south not affected by sand dunes. Such emigration gives birth to social effects. Socially, the emigrants lose their dignity, social value and often times increasing spate of communal clashes among the herdsmen and the farmers as shown by 9% of the respondents (Table 3). Moreover, since the farmlands, get smaller by the year, occasionally incursion of the cattle into the farmlands trigger unprecedented clashes resulting to loss of lives. Yugunda (2002) had a similar result when he reported that between 1998 and 2001, such clashes claimed 13, 9, 22, 14 and 12 lives in Gombe, Borno, Adamawa, Sokoto and Katsina States respectively. Destitution is another social effect (Table 3). As a result of limited arable land to provide employment for the people, poverty, dejection, lost of hope, crimes and social vices abound. Yawe (2000) and Akonga (2001) show that most of the destitute always migrate to the urban areas to beg for food and money thereby compounding the already tensed urbanisation problems.

The steady increasing temperature and decreasing rainfall together with the erratic pattern of rainfall produce a minimal recharge of ground water resources, wells and rivers thereby creating water crisis as indicated by 16% of the respondents (Table 3). So many wells, boreholes and rivers have either totally dried up or hold water that is seasonally useful and so, scarcity of water for domestic, industrial and irrigation thus become a common phenomenon. There is the tendency for a concentration of

**Table 3: Effects of Desertification**

Effects	Percentage
Sand dunes	27
Reduction in arable land/crops production	20
Water crisis	16
Emigration / resettlement	13
Destitution	10
Communal clashes	9
Loss of Vegetation	5

Source: Fieldwork, 2002

**Table 4: Solution to Desertification**

Solution	Percentage
Afforestation	30
Improvement in standard of living	25
Use of alternatives to firewood	16
Sustainable agricultural practices	11
Avoidance of deforestation	7
Use of alternatives to wood for construction	6
Enforcement of existing environmental laws	3
Establishment and funding of environmentally based research bodies	2

Source: Fieldwork, 2002

users around the remaining sources of water. Under such circumstance, there is increased possibility of additional contamination of the water supply and transmission of water borne diseases such as cholera, typhoid fever, Guinea worm infection and river blindness.

Changes in or loss of vegetation and ecosystem destabilisation are other major effects of desertification (Table 3). This effect is not only on the vegetation, but also, on the animals and birds. Since their natural habitat has been grossly altered, some of these animals have migrated while others are exposed to the ever-searching hunters.

#### Planning Implications

One of the planning implications of drought and desertification is shortage of necessary local foodstuffs and inability of the peasant farmers to realise enough income from the sales of their excess farm produce. This results to hunger and poverty - the two major obstacles to development in any nation. These problems according to Kotze and Holloway (1999) and Soares (2001), should be seriously fought against for any meaningful development to take place.

One of the most effective techniques of combating desertification as identified by 30% of the respondents is through the planting of trees a process known as afforestation (Table 4). Trees that are well planted and maintained will increase the moisture content (humidity) of the atmosphere thereby increasing the amount of cloud cover and rainfall while at the same time reducing the temperature. With such improved weather, the natural growth and regrowth of the vegetation will be enhanced. Apart from conservation of the soil and promotion of biodiversity and landscape quality, afforestation also assumes an additional function, as a carbon 'sink' and 'reservoir' for mitigating the detrimental effects of global warming (Safriel, 1999). Over the years, experience has shown that afforestation programmes are wrongly implemented partly because of the type of trees used and the pattern of planting. To be effective, indigenous economic trees should henceforth be planted as to attract the active participation of the rural dwellers who will have additional good reasons to support the afforestation programme. Indigenous tree species such as *Terminalia Catapa* (*Ebelebo*), *Eucalyptus Camaldulensis* and *Azadirachitha indica* (Neem or dogoyaro tree) are recommended because, these specie of



trees based on personal observation and experience are drought and fire resistant and they grow well in the semi-arid region of Nigeria. In addition, the indigenous people attached much importance to these trees because of their claimed medicinal value, grain preservation and pest control. However, the acquisition of massive hectares of land for afforestation programme deprives the farmers of their arable land, and before long, they go back to invade the plantation for farming due to limited arable land available to them. Instead of this method, the trees should be planted in the farmlands scattered so that the farmers should be able to farm on the land. The trees should be entrusted to the care of the farmers and they should be paid for looking after them. The work of the conservationists will be, to supervise the progress and extent of care the farmers are giving to the trees.

Excessive woodcutting for domestic cooking and construction works as noted earlier, constitutes one of the critical factors of deforestation and desertification. As a way forward, alternatives to firewood such as coal, solar cookers, biogas plants, and electricity should be made available at affordable rate. Alternatives to wood such as iron and aluminium in construction industries, furniture and roofing should be vigorously pursued.

There are many existing laws in Nigeria made to protect the natural vegetation from unwarranted destruction. These include the Forestry Ordinance of 1937, 1947, Forestry Amendment edict of 1973 and the Endangered Species Decree of 1985 (Fubara, 1998). Strict enforcement of these national laws will help immensely in conserving the trees thereby combating the desertification process. Sad to say that these laws have failed to hold partly due to lack of preservative and conservative culture of the people and the government, poverty level of the people and the high level of corrupt law enforcement officers.

Another area that requires serious attention is the promotion of sustainable agricultural practices through avoidance of overgrazing, overcropping and indiscriminate bush burning. All of these reduce the plant cover available to protect the soil during the long dry seasons. They also affect biological productivity and inhibit regeneration of woodland. To reduce the problem of overgrazing, overcropping and indiscriminate bush burning, the Federal Environmental Protection Agency (FEPA) and the Ministries of Environment; Agriculture and Natural Resources have a lot to do. They need to embark on massive public awareness campaign in the media, schools, churches, Community Based Organizations (CBOs), Non-Governmental Organizations (NGOs), Multinational Organizations (MNOs) and government parastatals.

There is an urgent need for the country to set up national structures charged with the co-ordination and execution of research programmes and dissemination of information on drought and desertification. This development could be supported by national integrated and multi-disciplinary programmes covering every aspect of desertification control. Governments at all levels should make fund available and such fund should be strictly monitored to be sure that it is used for the purpose of combating the menace of desertification. Because in the past, funds released to address ecological problems were channelled to unrelated projects and purposes leading to non-realisation of the expected results (Chibuzor, 1999).

The massive assault on ecological resources in Nigeria is due mainly to poverty resulting from gross unemployment, and underemployment. How can you

prevent a poor and hungry farmer without fertiliser and other forms of mechanised farming implements from destroying the forest for fertile arable land? How can an ecological conservationist stop a hungry and the unemployed from fetching firewood for sale and cooking? It is almost impossible, and this is the basic reason for reported clashes between environmental conservationists and the local farmers. For all the above aforementioned solutions to yield fruitful results, government should improve on the economy through the reduction of cost of living and unemployment. This in turn, will improve the standard of living, reduce pressure on the land, and support programmes that could halt the encroaching desert. But if specific poverty eradication measures are not taken, rural population will have no alternative than exert ever-greater pressure on the natural resources and this will accelerate the rate of desertification in Nigeria.

### Conclusion

This paper reveals that for the past 52 years (1950-2001) drastic ecological changes have occurred in the semi-arid region of Nigeria. While temperatures have been on the increase, rainfall has been declining. This climatic change and the pressure on the land from farming, overgrazing, deforestation and indiscriminate bush burning have led to desert encroachment and its associated ecological degradation, such as, loss of vegetal cover, crops failure and water scarcity with their economic and health implications. Other impacts include soil erosion and the southward migration of sand dunes, which is currently displacing so many inhabitants in northern Nigeria. This paper also reveals that approximately 209,249km<sup>2</sup> representing 29% of the total landmass of northern Nigeria and 22% of the entire nation is being gradually affected by desert encroachment.

Tackling the various processes that the term desertification subsumes is a major challenge, given that the processes are not only humans' but also natural. That notwithstanding, solution to combat desertification should lie on controlling first, the causes. Thus, cause-treatment approach is the best way to counter the degradation processes and to ensure sustainability in the fragile arid and semi-arid ecosystem of Nigeria. To halt the desert encroachment therefore, overgrazing, overcropping and deforestation should be reduced while indiscriminate bush burning should be avoided. Other solutions include, massive afforestation programme through the use of fast growing but drought resistance trees, aggressive educational campaign on the causes and impacts of desertification, improvement of the people's standard of living and the provision of alternatives to fuelwood such as electricity, kerosene, gas and cooking coal at affordable prices.

Finally, the paper noted that the problems of desertification are of global significance but its concrete effects are felt at the national and local levels. Combating desertification therefore requires an integrated or collective effort of local, state, national and international bodies, in providing both the technical and financial means of halting the advancing desert and its dire consequences.

### ACKNOWLEDGEMENT

I wish to acknowledge the following persons who helped in data collection Suleiman Ahmed, Dubu Maigida, Amarin Aishatu, Gambo Danjuma, Aimufia Odalo and Nuhu Sunu.

APPENDIX (Questionnaire)

This questionnaire is purely for academic reason and it is intended to solicit your opinion on the causes and impact of desertification on man and the environment in northern Nigeria. Please, be rest assured that, the information given will be treated with strict confidentiality.

State----- Local Government Area----- Age-----  
 Occupation----- Highest Education Attained-----

1. Is there any evidence of desert encroachment in your area of residence?  
 Yes ( ) No ( )
2. List at least 5 causes of desert encroachment in northern Nigeria  
 (a) -----  
 (b) -----  
 (c) -----  
 (d) -----  
 (E) -----  
 (F) -----
3. Of all the causes listed in question (2) above, rank them in order of importance, starting with the most important cause.  
 -----
4. Briefly comment on one of the causes of Desertification.  
 -----
5. List at least 5 effects of desert encroachment in northern Nigeria  
 a -----  
 b -----  
 c -----  
 d -----  
 e -----  
 f -----
6. Of all the effects listed in question (5) above, rank them in order of severity, starting with the most severe effect.  
 -----
7. Briefly comment on one of the effects of Desertification.  
 -----
8. List at least 5 solutions either already in place or could be taken to avoid the desert encroachment.  
 a -----  
 b -----  
 c -----  
 d -----  
 e -----  
 f -----
9. Who is responsible for the remedial measures already in place (If any)? You may which to tick more than one.  
 Individuals ( ), Community ( ), Local Government ( ), State Government ( ),  
 Federal Government ( ), International Organisations ( ) and Non Governmental  
 Organisations (NGOs) ( ).

Thanks,

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