

Review

Drought, desertification and the Nigerian environment: A review

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Drought and desertification are twin global environmental problems. Nigeria is faced with rapid desert encroachment affecting fifteen northernmost states from moderate to severe rate. Out of the 909,890 km² of the country's land area, about 580,841 km² accounting for 63.83% of total land is impinge on by desertification. Climatic variability and anthropogenic activities such as deforestation, extensive cultivation, overgrazing, cultivation of marginal land, bush burning, fuel wood extraction, faulty irrigation system and urbanization are major causes of desertification. Drought and desertification impact directly or indirectly on all aspects of human life and the environment including the ecological, health, geo-chemical, hydrological and socio-economic facets. Despite several efforts by the government to end desertification, the problem still persist due to the gap between the formation of policy and strategies of combating drought and desertification. Drought and desertification can be remedied through integrated approaches such as awareness programmes, protection of marginal lands, tree planting, sustainable agricultural practices and use of alternative energy source.

Key words: Drought, desertification, Northern Nigeria, dryland, environment.

INTRODUCTION

The intimacy between drought and desertification phenomena in the environment has been a long known phenomenon. They were described by Oladipo (1993) as a twin environmental hazard. Drought and desertification are global environmental problems affecting developed and developing countries in many regions of the world, where the required causal synergistic climatic variations and anthropogenic inputs thrive. They are accompanied by the reduction in the natural potential of the land, the depletion of surface and groundwater have negative repercussions on the living conditions and the economic development of the people are affected by it (Abahussain et al., 2002). Drought and desertification processes

integrate climatic elements with human activities in transforming productive land, into an ecological impoverished area generally refers to as desert. Drought and desertification cause degradation of once a fertile land through long term changes in the soil, climate and biota, which results in desert-like conditions.

Nigeria is one of the countries south of the Sahara faced with a rapid desert encroachment, with notable effects on the northern part of the country. Desertification phenomenon has been reported in the northern Nigeria since 1920s, but the impact has been more glaring since the famine of 1971 to 1973 in this part of the country. Desertification affects fifteen northernmost states of the

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country (Jaiyeoba, 2002) and almost one-fifth of the total Nigeria land area is becoming desertified. These states of the country are agricultural area supply most of the country's agricultural products such as beans, soya beans, tomato, melon, pepper, onion, cow, ram and many more. Though the contribution of climatic variability to drought and desertification phenomena, but these are aggravated by the unsustainable activities of human in the environment. Such activities include deforestation for industrial purpose and fuel wood, urbanization, bush burning, agro-activities on marginal lands and other sustainable agricultural activities. Desert encroachment is moving southwards. The impact is intense because agro-economy of Nigeria is dependent on rainfall and hence affected by fluctuating weather. Nigeria signed the convention of the United Nation to Combat Desertification on 30 October 1994 but the desert encroachment assumed increasing proportion and it a threat to the nation's economy (Okoli and Ifeakor, 2014). Tercula (2015) reported that Nigeria loses about 350,000 ha of land every year to desertification and the impacts are manifested on the environment and general livelihood of Nigerians. Desertification causes loss of biological diversity, contribute to disease burden, alter geo-chemical composition of the soil, contribute to water scarcity, reduced agricultural yield hence, contribute to food insecurity, reduced economic growth among other unfavourable impacts.

As emphasized by Medugu (2009), a lot of policies and programmes have been implemented by Nigerian government to combat desertification, yet the problem is rather aggravating because of the problem that has been treated as a sectoral issue instead of an integrated approach that will bridge the gap between the formation of policy and strategies of combating drought and desertification. Among such policies and programmes are Arid Zone Aforestation Project (AZAP) in 1977, the River Basin Development Authorities (RBDA) in 1987, Federal and State Environmental Protection Agency (FEPA / SEPA) and the Great Green Wall Project among others.

This paper examines the causes and impacts of desertification in the Nigeria environment, with a view to proffer solutions that will bridge the gaps in the existing national efforts to combat the environmental problems of drought and desertification

Drought

Drought is one of the main causes of desertification. The lack of general acceptance of a precise and objective definition of drought has been one of the principal obstacles to the investigation of drought. It is therefore important to be aware that different definitions might lead to different conclusions regarding the drought phenomenon. For instance, if the definition is based on the level of rainfall, it is possible that rainfall statistics summarized

over a calendar year indicate no drought, whereas the moisture supply in the growing season does. With regards to food security, drought could be defined as naturally occurring phenomenon (usually aggravated by human activities) that exist over a particular period in a particular area such that precipitation is significantly below normal recorded levels, causing deterioration of land productive systems and invariably low agricultural outputs.

It is important, however, to stress that because drought affects so many sectors in society, there is a need for different definitions (Wilhite and Glantz, 1985). The particular problem under study, the data availability and the climatic and regional characteristics are among the factors influencing the choice of event definition. The following criteria can be used to define drought; meteorological, agricultural, hydrological, and socio-economic criteria.

Meteorological

It occurs when precipitation level fall below the normal long-term recorded level.

Agricultural

It occurs when soil moisture is insufficient to meet the needs of agricultural crops at a particular time.

Hydrological

It occurs when there is a deficiency of water supply due to reduction or absence of surface and subsurface water.

Socio-economic

This form of drought is associated with human activities. It occurs when various human activities are impaired due to reduced precipitation or water availability.

Generally, the phenomenon can be attributed to inadequate seasonal precipitation, a prolonged dry season or a series of sub-average rainy season (Sheikh and Soomro, 2006). The chief characteristic of a drought is a decrease of water availability in a particular period over a particular area. Drought is a condition of severe reduction in water availability and the deficiency could extend over a significantly long period. United Nation Convention to Combat Desertification (UNCCD) (1994) defined drought as the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resources productive systems. Continued land abuse during drought,

however, increases land degradation. Rainfall deficit and the resulting periods of low flow can have severe effects on water management and utilization issues. This includes river pollution and ecological aspects, reservoir design and management, irrigation, small power plants, drinking water supply etc. Future increase in the demand for water will be most critical in periods of severe and extensive drought.

Desertification

Desertification as a concept was first discussed by European and American scientists prior to Aubreville in 1949, in terms of increased sand movements, desiccation, desert and Sahara encroachment and man-made desert. According to the United Nation Convention to Combat Desertification (UNCCD), desertification is land degradation in arid, semi-arid and humid areas resulting from various factors, including climatic variations and human activities (UNCCD, 1997). The following aspects are important in the definition of desertification.

- (a) Climate and human activities as the causal factors
- (b) Vulnerability of arid and semi-arid lands and
- (c) Land degradation and loss of biodiversity consequences.

On this basis, Campbell (1986), Mortimore (1989) and Oladipo (1993) have similar definitions of desertification: a process that causes land degradation due to some prevailing climatic conditions and human activities such that it resulted into the inability of the environment to sustain the demands being made upon it by socio-economic systems at existing levels of technology and economic development. Desertification entails the formation and expansion of degraded areas of soil and vegetation cover in arid and semi-arid and seasonally dry areas, caused by climatic variations and human activities (Wright and Nebel, 2002). It involves denuding and degrading a once fertile land, initiating a desert producing cycle that feed on itself and causing long term changes in soil, climate and biota of an area (Cunningham and Cunningham, 2005).

Desertification could be seen as a process whereby the productivity of arid or semi-arid land falls by 10% or more (Miller, 1999). Miller (1999) classified desertification as mild, serious and severe based on soil productivity. Mild desertification is a 10 to 25% drop in productivity, serious desertification is a 25 to 50% drop and severe desertification is a drop of more than 50% in productivity. Desertification is an advanced stage of land degradation where soil has lost part of its capability to support human communities and ecosystem. In areas undergoing desertification, people in their quest for food and desired livelihood to support the population, pursue land management and cultivation practices that deplete soils

of their nutrient and organic matter content and promote erosion; overgrazing of rangelands, and cut trees and bushes for fuel wood and other purposes (Acosta-Michlik et al., 2005).

The direct effect of desertification on land degradation is either decrease of land productivity or the complete abandonment of agricultural land, which ultimately lead to the food crisis experienced in many arid and semi-arid regions especially Africa. There is direct relationship between drought, desertification and food security. These environmental menaces lead to decreased soil quality which ultimately reduced agricultural productivity-a key determinant of food security.

Features of a desertification process include

- i. Impoverishment of vegetative cover
- ii. Reduced quantity, available and accessible of soil moisture
- iii. Deterioration of the texture, structure, nutrient status of soil
- iv. Reduced biodiversity and presence of more xeric biota
- v. Increase soil erosion

The Nigerian environment and extent of desertification

Nigeria is located approximately between latitudes 4° and 14° north of the equator and between longitudes 2° 2' and 14° 30' east of the Greenwich Meridian. To the north, it is bordered by the Republics of Niger and Chad, to the east by the Republic of Cameroon, to the south by the Atlantic Ocean and to the West by the Republic of Benin. Nigeria is a large country with an estimated population of over 160 million, with a substantial part of its area extending into the Sudano-sahelian belt, which, together with the neighbouring northern Guinea savannah, constitutes the drylands of the country. National Bureau of Statistics in Nigeria (2010) estimated that the country has an approximate total surface area of 909,890 km². About 40% of this land is believed not to have been utilized for settlement, agriculture and other human purposes. Nigeria enjoys a warm tropical climate with relatively high temperature that is typical of the tropics and two seasons; the dry and wet season. In general, where there is hardly any dry season in the extreme southern tip of the country, the wet season hardly lasts for more than three months in the north eastern part of the country. Similarly, annual rainfall totals range from over 2,500 mm in the south to less than 400 mm in parts of the extreme north (Federal Ministry of Environment of Nigeria, 1994). Northern Nigeria is situated in the semi-arid areas bordering Sahara desert with average annual rainfall or less than 600 mm (Folaji, 2007). This rainfall pattern has contributed to the desertification encroachment in 15 northern-

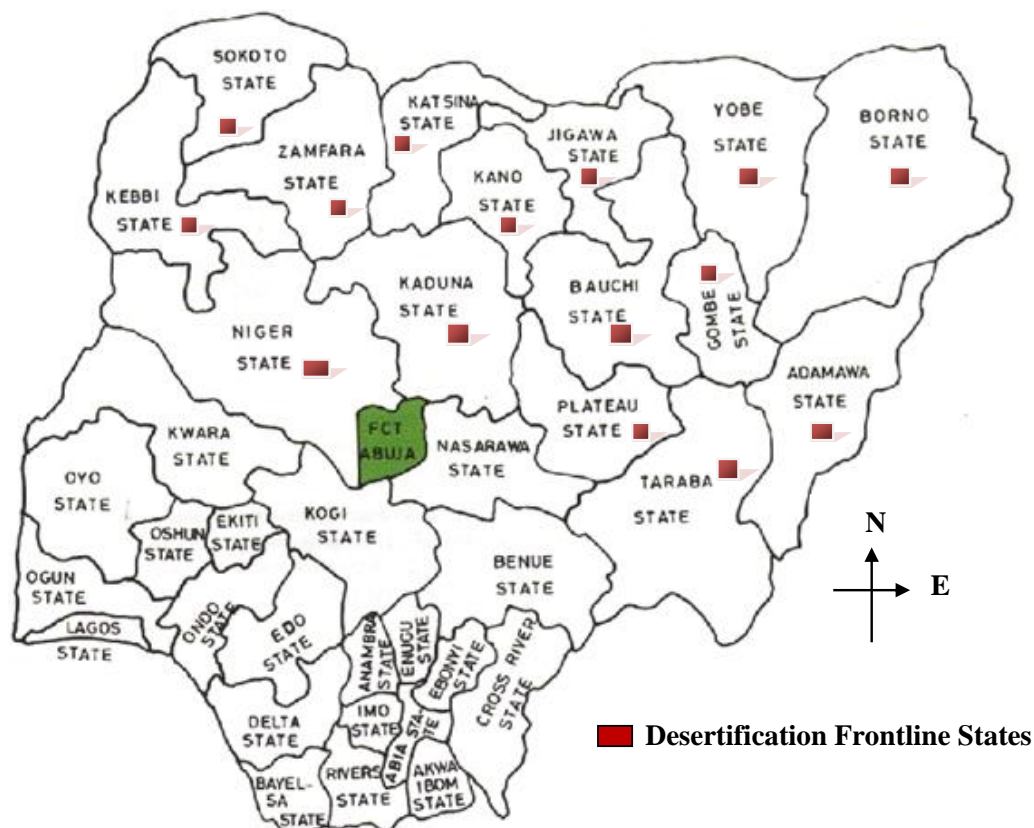


Figure 1. Map of Nigeria showing the desertification frontline states.

most states of Nigeria.

The extent and severity of desertification in northern Nigeria has not been fully established neither the rate of progression has been properly documented. Nevertheless, some reports suggested that progression rate of desertification in northern Nigeria is about 0.6 km per year and Nwafor (2006) reported that recent estimates put the area already lost to desertification at about 351,000 km². According to the desertification map of the world produced by Food and Agriculture Organization (FAO), the World Meteorological Organization (WMO), and U.N.E.S.C.O, about 15% of Nigeria land is prone to desertification (Emodi, 2013).

The visible sign of this phenomenon is the gradual shift in vegetation from grasses, bushes and occasional trees, to grass and bushes; and in the final stage, expansive areas of desert-like sand. It has been estimated that between 50 and 75% of states of Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe and Zamfara in Nigeria are being affected by varying degrees of desertification. As illustrated in Figure 1 and Table 1, there are 15 desertification frontline states in Nigeria out of the total 36 states and the Federal Capital Territory. These states accounts for about 63.83% of the total land area of Nigeria with moderate to severe rate of desertification and about 62 million of Nigerians are

either directly or indirectly affected by desertification problems.

CAUSES OF DROUGHT AND DESERTIFICATION

The causes of drought and desertification are numerous and complex, but like many other issues of environmental degradation, they are basically the resultant interactions of climatic influence and human activities in the environment. The causes include

Climatic variability

Climatic variability is a major driver of many environmental degradation phenomena. Alteration of climatic conditions leads to naturally occurring phenomena of drought and desertification. There has been increasing level of greenhouse gases causing global warming which in turn increase the variability of climate conditions. This alteration in the climatic conditions has manifested as follows;

- i. A decrease in the amount of rainfall in drylands making arid and semi-arid lands more vulnerable to

Table 1. Desertification frontline states of Nigeria.

State	Geographical Region	Land Area		Population (2006)		Rate of Desertification
		(km ²)	% of Nigeria	Number	Density (/km ²)	
Sokoto	North West	27,825	3.06	3,702,676	133	Severe
Zamfara	North West	37,931	4.17	3,278,873	86	Severe
Katsina	North West	23,561	2.59	5,801,584	246	Severe
Jigawa	North West	23,287	2.56	4,361,002	187	Severe
Kano	North West	20,280	2.23	9,401,286	464	Moderate
Kebbi	North West	36,985	4.06	3,256,541	88	Severe
Kaduna	North West	42,481	4.67	6,113,503	144	Moderate
Borno	North East	72,609	7.98	4,171,104	57	Severe
Yobe	North East	46,609	5.12	2,321,339	50	Severe
Bauchi	North East	41,119	4.52	4,653,066	113	Moderate
Gombe	North East	17,100	1.88	2,365,040	138	Moderate
Adamawa	North East	38,700	4.25	3,178,950	82	Moderate
Taraba	North East	56,282	6.19	2,294,800	41	Moderate
Niger	North Central	68,925	7.58	3,954,772	57	Moderate
Plateau	North Central	27,147	2.98	3,206,531	118	Moderate
Total		580,841	63.83	62,061,067	107	

Source: National Bureau of Statistics, 2010; National Population Commission, 2006. * Moderate: 26 to 50% of plant community consists of climax species, or 25 to 75% of original topsoil lost, or soil salinity has reduced crop yields 10 to 50%. * Severe: 10 to 25% of plant community consists of climax species, or erosion has removed all or practically all of the topsoil, or salinity controllable by drainage and leaching has reduced crop yield by more than 50%.

desertification.

- ii. High temperatures, combined with low rainfall which would lead to the drying up of water resources - drought.
- iii. Poor growth of vegetation leading to the formation of a desert-like condition.

A study conducted from 1901 to 2005 showed that Nigeria is not excluded from the impacts of climatic variability and global warming with prominent localized effects in the highly industrialized cities and Northern Nigeria which has resulted into the observed environmental degradations. Increased temperature of average 1.1°C and decrease rainfall of average 81 mm were reported (Onyeausi and Otegbeye, 2012).

Anthropogenic activities

The anthropogenic factors have been the major cause of desertification just like many ecological degradation problems. Human contribute to desertification through poor land use and the ever increasing pressure put upon the limited available resources by the expanding population. Basically, human causes of desertification can be viewed to result from; exploitation of resources from “non-ideal lands”, over exploitation of land resources, unsustainable acts when exploiting, and none replacement of exploited resources or not allowing sufficient time for natural regeneration of exploited resources. The following human activities can cause desertification:

Deforestation

Deforestation is the conversion of forested areas to non-forested land (Olagunju, 2015a). It is the large scale removal of forests resulting to non-forest to meet various human needs. Logging, expansion of agricultural croplands, urbanization, fuel wood collection, mining and resources extraction, fire-hunting and slash and burn practices have been identified as the key drivers of deforestation. Nigeria is considered the world's highest deforested country and has lost about 55.7% of its primary forest. From 1990 to 2010, Nigeria nearly halved its amount of primary forest cover with an annual deforestation rate of 3.67% between 2000 and 2010 (FAO, 2010). The situation appears alarming that the FAO states that the forest in Nigeria will disappear by 2020 if the current rate of forest depletion continues unabated (Onyeausi and Otegbeye, 2012). Deforestation of drylands destroys the trees and vegetation that bind the soil, and because of the prevailing climatic conditions in drylands, the possibility of regeneration of denuded vegetation is low and hence, the land becomes desertified.

Extensive cultivation

Expansion of agricultural land to meet up with the food requirements of the increasing population has led to the degradation of land in Northern Nigeria. New lands are

cleared of trees and other vegetations to establish agricultural croplands in the dryland, many of such lands are unable of recuperation, and hence desertification sets in. In Nigeria, overgrazing and over-cultivation have been reported to be responsible for the conversion of 351,000 hectares of land into desert each year (www.earth-policy.org).

Overgrazing

Overgrazing is most common in the areas whose socio-economic viability depend mostly on extrinsic system of animal husbandry. The dry lands of Nigeria is said to support much of the country's livestock economy, hosting about 90% of the cattle population, about two-thirds of the goats and sheep and almost all donkeys, camels and horses. In the Sudan and the Sahel zones, which carry most of the livestock population, nomadic herdsman graze their livestock throughout the area and are constantly in search of suitable pastures. Additional pressure is also on these natural rangelands by livestock from neighbouring countries, notably Cameroon, Chad and Niger. Overgrazing removes the vegetation cover that protects soil from erosion (UNCCD, 2011) and degrades natural vegetation that leads to desertification and decrease in the quality of rangelands (Sheikh and Soomro, 2006). Between 1950 and 2006, the Nigerian livestock population grew from 6 to 66 million, an eleven fold increase. The forage needs of livestock exceed the carrying capacity of its grasslands (Lester, 2006).

Cultivation of marginal land

Cultivation of marginal areas is one of the causes of desertification. Marginal lands are areas that are unable to support permanent or intensive agriculture which could be easily degraded following cultivation. During the periods of high rainfall, people tend to extend farming activities into the marginal areas. When these periods of high precipitation is succeeded by abrupt dry periods, the exposed land with very little vegetal cover is prone to wind erosion. And desertification may set in which could be irreversible except through carefully planned rehabilitation programme.

Bush burning

Slash and burn practice in agriculture and fire-hunting is a major cause of desertification in northern Nigeria. Owing to the low relative humidity in the area coupled with very dry harmattan wind, there is always a high incidence of bush fires every dry season. When this occurs too frequently, the vegetation may not regenerate; the soil is exposed to erosion and become degraded.

Fuel wood extraction

Due to socio-economic status of the people inhabiting Nigeria dryland, felling of tree for fuel wood will continue increasing if alternative sources of energy in the sudano-sahelian zone are not provided. The demand for fuel wood causes the removal of trees, shrubs, herbaceous plants and grass cover from the fragile land, accelerating the degradation of the soil to desert-like conditions (FAO, 2006). In Nigeria, more than 70% of the nation's population depends on fuel wood. Katsina alone, a northern state, has its over 90% energy from fuel wood (Mohammed et al., 2013). In Kano City, 75,000 tonnes of fuel wood are brought in by lorry and donkey within a radius of 20 km, which leads to denuding of the woodland.

Faulty irrigation management

Irrigation system is a common practice in northern Nigeria. Many farmers lack adequate skills in proper designing and management of irrigation system which has resulted into desert-like condition of many irrigated farmlands as a result of water logging and salinization. This scenario is already a reality on a number of irrigation projects in Nigeria today, such as the Bakolori Irrigation, South Chad Irrigation and the Hadejia – Jamaare Irrigation Projects. For instance, the drying up of Lake Chad that started during the Sahelian drought of 1972 to 1973 is aggravated due to poorly managed irrigation system in the Chad Basin. This has caused the reduction of the lake from 25,000 m² in 1963 to about 3,000 m² in 1986. This prompted the government to stop all irrigation projects in the basin in 1989 because the level of the lake fell 3 m below the critical level.

Urbanization

Nneji (2013) has attributed rapid economic growth and urbanization as causal factors of desertification. The problem is more severe and complicated in developing world. Clearing of lands to accommodate the increasing population and accommodate the necessary infrastructure in northern is commonly done without adequate environmental consideration; this has led to the removal of vegetation cover in the area and as such, making the area desertified. Urbanization in Kano City for instance has been estimated to be increasing rapidly at the rate of between 5 to 10% per annum (Federal Ministry of Environment of Nigeria, 1994). At least, 20,000 ha of land are cleared annually for construction.

IMPACTS OF DESERTIFICATION

The consequences of desertification are far-reaching and

diverse. All aspects of human lives are either directly or indirectly impacted wherever the phenomenon exists. It ranges from food insecurity, water scarcity, and socio-economic hardship to political unrest. Other scholars reported that desertification also causes alteration of ecosystem services locally and globally, loss of biodiversity, habitat loss and species endangerment (FAO, 2000); changes in hydrological and climatic cycle (Shonekan, 2004); reduced agricultural yield (Ramankutty and Foley, 1999) and socio-economic welfare (Singh et al., 2000).

Ecological impacts

An environment is said to be ecologically sustainable when it conserves biological diversity and the life supporting systems for the use of present generation without compromising its use by the future generations. Desertification has resulted to alteration of the ecosystems in the arid and semi-arid zones, which affect the habitat, habitat composition, abundance, distribution and relationships in the communities of living organisms. Ecological impacts include:

Habitat destruction and loss of biodiversity

Diversity is a measure of the amount of variability in the species composition of a community (Don-Pedro, 2009). Bullock and Le Hou  rou (1994) assert that many species are prone to be endangered due to desertification. Nigeria drylands contain a large number of species of plants and animals that are important to humankind as a whole, but which are threatened as a result of desertification process occurring in the area. NAP (2000) revealed that some important animal species such as the sitodunga antelope, cheetah, giraffe, lion and elephants in the northern states of Nigeria have become endangered and indigenous plant species especially those with medicinal values e.g. *Mitrogina spp* (known as Giyaya in the area) are now difficult to locate.

Changes in phenology

Phenology deals with the period or timing of biological events (such as mating, laying of eggs etc) of living organisms in response to climatic and other environmental circumstances. Alteration of the periodic biologic events of animals is one of the first and most easily detectable ecological responses to desertification. There are many ways animal's behaviours are altered in response to desertification. For instance, there could be alteration in their reproduction timing, mating, feeding and migration etc.

Health impacts

Health is the complete state of physical, mental and

social well-being of an individual without necessarily the mere absence of disease (WHO, 2003). Desertification can impact on the public health through increased heat waves, potential to initiate skin cancer and enhancement of favourable environmental conditions for diseased conditions and vectors.

Heat waves

Dense vegetation's provide some level of heat sequestration but which are denuded due to desertification This situation caused an increase in heat waves in northern Nigeria, posing a deal of threats to the health of the people. Human populations have over time acclimatized and adapted to local climates and also able to cope with a range of weather changes. However, within populations, there are individuals whose sensitivity to extreme weather condition is high and are such prone to the risk of health implications of such unfavourable weather conditions. **Extreme heat can cause heat exhaustion, cardiovascular diseases (e.g. heart attacks and strokes)** (Bell et al., 2007). Higher UVR exposure could suppress the immune responses to infection of the human host. In animals, high UVR exposure has been shown to decrease host resistance to viruses such as influenza and cytomegalovirus, parasites such as malaria and other infections such as *Listeria monocytogenes* and *Trichinella spiralis* (Patz, 1996). There has been very little or probably no research in Nigeria and other developing countries on how and how much can desertification impact on thermal stress-related mortality and morbidity in human but some works on animals have been reported. In the Northern Guinea Savannah of Nigeria, Ayo et al. (2010) reported a 20% reduction in feed intake in layers chicken due to thermal stress which resulted into a significantly decreased hen-day production. They also reported 3.7% increase mortality due to stress by heat in the region. Likewise, Oladele et al. (2003) find out significantly low level of packed cell volume and haemoglobin in thermally stressed domestic chicken in northern Nigeria.

Cancer

One of the influences of desertification is deterioration of vegetation cover, such that people especially outdoor workers are exposed to direct influence of the solar radiation. It has been proved that excessive exposure to sunlight can cause skin disease and cancer (Cunningham and Cunningham, 2006). McMichael and Githeko (2001) made an observation in outdoor workers such as agricultural labourers and farmers, that skin cancer developed on areas most frequently exposed (e.g. hands, neck, and face) to sun. There are regional differences in the type of malignancies that are prevalent in Nigeria. The severity of desertification could be a

contributory factor. Skin malignancies have been reported to account for higher percentage of all malignancy cases in the Northern Nigeria compared to the southern Nigeria. For instance, skin malignancies accounted for 6.81% of all malignant cases in Jos (Mandong et al., 2001); a city in the north central with moderate rate of desertification. In Kano (a farther northern city also with moderate rate of desertification), it is 12.7% (Ochicha et al., 2004). While in Maiduguri, in the extreme northern part with severe rate of desertification; it accounts for 20.9% (Nggada et al., 2003). These percentages are high compare to the report of cases in 2007 in Lagos State (Southern Nigeria) as documented by Morbid Anatomy Department of the Lagos University Teaching Hospital (LUTH). Skin cancer, accounted for just 5% of all reported malignancies (Ikawo, 2013).

Vector-borne diseases

Desertification results into increase in ambient temperature, altered precipitation and climatic variability which would alter geographical range and seasonality of transmission of many vector borne diseases. Also, insufficient water supply is typical of desertifying area; this forced the people living in such area to utilize any available water source especially in the developing countries where portable water is lacking. More so, desertification process leads to increased contamination of available sources of water and enhances the transmission of waterborne diseases such as typhoid, infectious hepatitis and cholera (Betterton and Gadzama, 1987). Currently, the World Health Organization (WHO) estimates more than one billion people to be without access to safe drinking water, and that every year approximately 1.7 million die prematurely because they do not have access to safe drinking water and sanitation.

Loss of plants of medicinal importance

Desertification has contributed to the loss of plants of potential medicinal properties. Most woody species serve as source of medicine (Kafaru, 1994; Otegbeye and Otegbeye, 2002) especially to local people. These medicinal plants are neither cultivated nor protected against desertification, so they disappear at a rapid rate with good number of them under threat of extinction especially in the arid and semi-arid lands. Madaci (*A. senegalensis*) an indigenous medicinal plant species use to cure various ailments in Maiduguri and some other place in the northern Nigeria is now endangered due to desertification.

Geo-chemical Impacts

Not only is biological environment is negatively impacted

by desertification; the geological and chemical environments are as well impinged. The geo-chemical effects include:

Global warming

Bruce et al. (1996) defined global warming as an increase in earth's mean global temperature. A part of earth's outgoing infrared radiation is retained by several trace gases in the atmosphere whose concentrations have been increased because of human activities. Vegetation and soil play a great role in sequestering carbon; an important greenhouse gas (Olagunju, 2015b). When desertification occurs, the carbon sequestration ability of vegetation and soil is greatly lost making carbon to be increased in the atmosphere thereby aggravating global warming. An increase of at least an average of 1°C has accompanied the temperature in the northern states of Nigeria bordering the Sahara when comparing the data of 1901 to 2010.

Increased erosion

Soil erosion is the movement and transport of soil by various agents particularly water and wind leading to soil loss. Impoverishment of soil's natural vegetation cover has been a primary cause of soil erosion. When land is deforested, the soil anchorage provided by trees and other plants is lost and the soil is rapidly eroded. Because of the nature of desertification prone area, soil erosion by wind is occurs but erosion by water is more disastrous during the unusual heavy rainfall. Gully erosion, that hitherto was not a major threat in Nigeria has increased, threatening about 18, 400 km² compared to only about 122 km² in 1976 and 1978. A survey conducted in Katsina State revealed that 30% of agricultural land has been severely damaged and lost from further productive use due to erosion which has resulted to crop yield out by 30 to 60%.

Soil salinization

Soil salinity is an important chemical degradation problem facing agriculture (IPCC, 1990). Agricultural sustainability in northern Nigeria is majorly by irrigation system which again predisposes such inland areas to saline soils and reduced crop productivity if not properly managed (Sehgal and Abrol, 1994). Jibrin et al. (2008) assessed the soil sodicity and salinity in Kano River Irrigation Project (KRIP). Analyses of the soil samples from the irrigated land area showed a very high exchangeable sodium percentage (ESP), with a mean value of 14.8 and 17.5% for top soil and subsoil respectively. They reported that ESP increases with depth and that the salinity is low. But compared to reports from non-irrigated area, the salinity is relatively high.

Hydrological impacts

Desertification has also impacted on the hydrology of arid zones. The water resource becomes a limiting factor, making the effects of desertification amplified, such that the ecosystem becomes fragile and at or near its limits of resilience (Batanouny, 1998). Reduction in water supply and over exploitation of groundwater are major hydrological impacts of desertification.

Reduced water supply

Water availability is usually measured in terms of renewable water per capita, population density, as well as total water volumes (Cunningham and Cunningham, 2006). The world Health Organization considers an average of 1,000 m³ (264, 000 gal) per person per year to be a necessary amount of water for modern domestic, industrial, and agricultural uses. Nigeria (especially its northern part) and some other 45 countries, most of them in Africa or the Middle East, cannot meet the minimum essential needs of all their citizens (Cunningham and Cunningham, 2006) and desertification has been implicated as a major contributory factor (Ajayi, 1996). In Yobe state of Nigeria, sand dunes have been reported to be threatening life supporting oasis and burying water point (Toye, 2002). Musa (2008) attributed the drying up of Chad basin in Nigeria to the effect of drought and desertification. Ajayi (1996) provided a striking example of drastic impact of drought and desertification on the Hadejia/Nguru/Kirri-Kissama wetland project for the conservation of water flows. The wetland had a flood plain of about 84,143.8 km². The steady decline in the extent of inundation of the plain due to the phenomena led to the drastic reduction of the flood plain by at least 20%.

Over-exploitation of groundwater

Northern Nigeria depends majorly in most months of the year on groundwater for domestic and agricultural use. Due to desertification, northern Nigeria is faced with increased use of groundwater to meet their growing population. More wells are dug and water is withdrawn faster than natural recharge can replace it. On local scale, this causes a cone of depression in the water table or the depletion of the whole aquifer on a broader scale. Excessive groundwater withdrawals also allow aquifers to collapse, followed by subsidence, or sinking of the ground surface.

Socio-economic Impacts

Desertification is not only unanimously acknowledged to have significant adverse effects on flora and fauna

population, the topographic and edaphic components of the ecosystems or the micro-climate variability, but also, the socio-economic impacts has also be documented (Penny, 2009; Adewuyi and Baduku, 2012). Desertification has severe impacts on food security, livelihood, economic and socio-cultural life of the affected people.

Reduced agricultural productivity and food insecurity

Agriculture is the economic mainstay of the majority of households in Nigeria and is a significant sector of Nigeria's economy. Food security in its most basic form is the access of all people to the food needed for healthy life at all times. Factors that affect soil quality affect agricultural productivity also and indirectly on food supply. Loss of soil structure and cohesion, soil crusting, soil compaction and soil erosion especially in arable lands has been enumerated as consequences of desertification which also reduce agricultural output, hence food insecurity. Toye (2002) reported that at least 50,000 farmers in about 100 villages in Yobe State were at risk of abandoning farming due reduced agricultural output caused by dunes covering a large expanse of their farmlands.

Economic loss and reduced economic growth

Desertification has economic consequences. It weakens populations and institutions rendering them more vulnerable to global economic factors (Koohafkan, 1996). Short fall in earned tax receipts occurs due to low productivity, and has consequences on the capacity of government to reimburse their foreign debt and develop national socio-economic programmes. The persistence of desertification reduces national food production and furthers the need to rely on foreign imported products. Also, government expends so much on ameliorating the effects of desertification, revenues which could have been used for other developmental projects. For example, more than 65 and 55% of Sokoto and Borno States are said to be afflicted (Emodi, 2013). In Gidan Kaura, a village 90 km northwest of Sokoto, sand dunes have been reported to have invaded vast areas of farmland and destroying nearly 300 houses. Villages such as Bulatura, Kaska, Bukarty Toshu, Tubtulova, Yunusari, among others in the extreme northern part of Borno State, have been either completely surrounded by sand dunes or are about to be buried by them. It is estimated that Nigeria loses about \$5.1 billion every year owing to rapid encroachment of drought and desert in most parts of the north (Vanguard News Paper, 2010).

Migration

A major consequence of desertification is migration causing

separation of families as men usually abandon the women and children to seek for employment in the urban centres due to unproductive agricultural practice at the rural areas. For example in Nigeria, people living in drylands usually the herdsmen of the north migrate into towns and villages down south and neighbouring countries that are wetter (NEST, 1991). More so, migration could enhance disease transmission from an epidemic area to another area. Emodi (2013) reported the migration of significant population from Borno State down south due to desertification that has affected their agricultural output.

Resource use conflict

Conflict is perceived divergence of interest, or a belief that the parties' current aspiration cannot be achieved simultaneously (Pruit and Robin, 1983) and conflict arises when there are incompatible or mutually exclusive goals or aims or values espoused by human beings (Deutsch, 1973). While Ross (1983) sees conflict to occur when parties disagree about the distribution of material or symbolic resources and act because of the incompatible of goals or a perceived divergence of interests. In Nigeria, conflicts over land resources are focused on areas of high productivity, especially those that provide seasonally critical resource. These critically limited resources have competitive uses amongst the various rural land users; notably farmers, herders, fishermen and hunters. According to the Institute for Peace and Conflict Resolution, Northern part of the country has witnessed a dense occurrence of conflicts resulting from the effects of desertification especially in the seasons when rainfall is very low and the graze lands are unable to sustain the population of livestock in the zone, and herdsmen (especially the popularly known Fulani herdsmen) geared their livestock to farmland area in the zone or down south in the country, situation which has caused brutal fight between the herdsmen and farmers. A conflict in Barkin ladi Shendam in North Central (Plateau State) in June to July 2002 between indigenous tribes and the nomad fulani, between Ngamo Maitatsine and Boko-Haram over farm lands and grazing areas in Yobe State, Agatu people and Fulani's in Benue State are good examples.

Unemployment

Unemployment occurs when a qualified person is actively searching for employment and is unable to find work. Unemployment is an economic indicator that refers to the number or proportion of people in an economy who are willing and able to work, but are unable to get a job (Cornet, 2002). At least 90% of the inhabitants of drylands live in developing nations, where they also suffer from poor economic and social condition (Whitford, 2002). The effect of desertification is seen on the precariousness of living conditions and the difficulty of access

to resources and opportunities largely due to lack of suitable condition for farming or fishing (main occupations in the rural area). Desertification in rural lands makes the land incapable of supporting population that previously lived there. This results in mass migration out of rural areas and into urban areas, particularly in Africa. These migrations into the cities often cause large numbers of unemployed people, who end up living in slums (Pasternak and Schlissel, 2001; Briassoulis, 2005).

EFFORTS BY THE NIGERIAN GOVERNMENT TO COMBAT DESERTIFICATION

The Nigeria Government has been making efforts aimed to combating environmental problems of drought and desertification. These efforts include national policies, legislative framework, sectoral programmes and partnership with local and international organizations that is saddled with fighting desertification. Nigeria has developed many policies and programmes, received partnership in form of finance, technical assistance, loans and capacity building from partners such as World Bank, IAEA, IFAD, CIDA, UNDP, UNIDO, China Government, Japan international Agency (JICA), Agricultural Development Company Limited, Israel and the UNEP/GEF. The directive of the emirate of the Northern Nigeria by the Anglo-French Commission in 1937 to embark on tree planting to stop desert encroach in the region was probably the foremost desertification combating effort in the country. In 1977, in order to examine the problem of desertification and check desert encroachment in the arid zone of Nigeria, Federal Government set up the Arid Zone Aforestation Project. This project launched tree planting campaigns and forestry projects to check deforestation. Tree seedlings were produced and distributed which led to the establishment of Shelter Belts along the Northern borders of the country. During the administration of Major General Muhammadu Buhari in 1984, Tree Planting Campaigns was used as an instrument to enlighten and motivate people on the negative effects of desertification and the need to combat it (Jibunor, 2014). Federal Environmental Protection Agency (FEPA) was established in 1988 under Decree 58 after the Nigerian government had signed the United Nations Conference on Environment and Development (UNCED), an important step towards addressing desert encroachment in the country. States Environmental Protection Agencies (SEPA) were thereafter established in the 36 states including the Federal Capital with mandate to address environmental problems which include desertification (Medugu, 2009).

Nigeria signed the Desertification Convention on the 31st October, 1994, and ratified same on the 8th July, 1997 thereby qualifying the country as a party to the convention with effect from October, 1997. The creation of the Department of Drought and Desertification Amelioration in 1999 in the Federal Ministry of Environment

was to strengthen the existing institutional arrangement for more effective coordination of activities of Nigeria Government towards the implementation of the CCD. National Action Plan (NAP) of Nigeria which is part of the National Economic and Social Development and Environmental Protection Plan was developed. NAP compiled strategies and submitted it to the Secretariat of the UNCCD Bonn, Germany, which are to help in environmental education and management, public awareness, poverty alleviation and provision of alternative sources of energy among others. These strategic policies include, National Policy on Environment, National Agricultural Policy, National Energy Policy, National Environmental Action Plan (NEAP) and State Environmental Action Plans (SEAPs), National Tropical Forestry Action Plan, National Conservation Strategy, Natural Resources Conservation Action Plan, National Water Resources Master Plan (1995 to 2020), National Biodiversity Strategy and Action Plan, The Green Agenda of the VISION 2010 Report, National AGENDA 21, National Action Programme to Combat Desertification, National Economic Empowerment and Development Strategy (NEEDS) and National Policy on Women.

In 2005, former president, Chief Olusegun Obasanjo initiated a Global Tree Planting Project to halt desert encroachment in 46 local government areas in the country's desertification frontline states. The programme was expected to generate economic activities for the citizens of the states involved and urge them to desist from felling but rather plant trees. Several of such projects was also initiated in some of these states such as the ₦5.2 million project of Gidauniyar Jihar Kastina in Katsina State, Sure-P Programme in Sokoto State for 5 km tree planting in each local government of the state and collaborative programme of Jigawa State and the United State to harness the potential of Gum Arabic to fight desert encroachment and reduce poverty in the state (Haruna and Bukar, 2010). Legislative framework was also enforced to encourage the execution of these projects in Nigeria. Despite these efforts by the Nigeria Government, significant success in remedy desertification in the country is yet to be achieved due to the following factors:

Poverty

The fragile semi-arid land of Northern Nigeria is unyielding to the efforts to reclaim it from desertification, due to the threat pose by the growing poor population in the area. The local people meet their needs from the natural environment by burning the scanty bush area for game, deforest for firewood, and their livestock overgraze the available vegetation. The 2010 poverty survey by the National Population Commission showed that the North-west and Northeast geo-political zones, which are desertification frontline states, had the highest poverty rates in

the country with 77.7 and 76.3%, respectively, relative to the national rate of 69.1%. The poverty condition will continue to impede the government reclamation efforts if holistic approach is not put in place to alleviate poverty in the country.

Communal resource use

Unregulated access to land resources that are communally owned may lead many individuals to maximize their own gain by over exploiting the land resources. Since no one is accountable to such land, its open access caused common rearing of animals and farming, such that the carrying capacity of land is exceeded and desertification results.

Lack of political will, institutional weakness and corruption

This is a major impediment to combat desertification in Nigeria. Institution role in establishment and enforcement of policies and law is significant in environmental management. Laws in Nigeria is more against poor people or people of no political influence, hence, people of influence engaged in unsustainable environmental practices majorly deforestation, without any consequence. Even with the contribution of donor agencies in combating desertification in Nigeria, political office holders sees investing money in fighting desertification as waste of resource and divert it partly or wholly to another sector of the economy. Corruption from the side of the desertification policy implementation partners and institutions also militate against effective policy implementation.

REMEDIES TO DROUGHT AND DESERTIFICATION

Solution to the problem of desertification must target all aspects that relate to the problem. Though some desert conditions are irreversible even if all anthropogenic causes are stopped now, but some are reversible. Some of the remedies to desertification include:

Awareness

Raising awareness of desertification at local, national and global level is key to remedying drought and desertification. It is probably the cheapest means in combating desertification because it serves as a preventive measure. Awareness will provide people with the understanding of the causes and consequences of the phenomena so as to stop all possible causes and encourage actions that would remedy some of the consequences and prevent further degradation of soil.

Protection of marginal lands

Due to the incapability of marginal lands to support permanent or intensive agriculture, there is need for proper evaluation of such lands with government policy and enforcement aimed at protecting them from any activities that is capable of denuding its vegetation cover.

Planting and protection of indigenous tree and shrub species

Increasing the area of conspicuous vegetation into desertifying lands is vital in managing desertification. This could be done through intensive and technologically supportive reclamation, by planting and establishing indigenous trees and vegetation known to the area. Planting of trees coupled with avoided felling should be embraced in arid and semi-arid zones until if possible a forest zone is attained (Mumoki, 2006). Planting of trees should be in:

- i. Soil stability
- ii. Protection of soil from erosion
- iii. Retention of soil moisture and nutrients
- iv. Carbon sequestration

Sustainable agricultural practices

Agroforestry is a form of farming system that plays an extremely important role in the land management of semi-arid and arid zones. Agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland. It combines agricultural and forestry techniques to create more diverse, productive, profitable, healthy, and sustainable land-use system. Grazing systems should be improved from denuding the natural rangelands whose consumption will lead to aridity condition hence establishment of new pastures for grazing by livestock should be ensured. All water to be used for irrigation should be examined to be devoid of level of salt that could result in salt accumulation, as well as ensuring a good drainage system (Sultana, 2008).

Use of alternative source of energy

Feeling of the few trees and shrubs in desert-prone areas for fuel wood can be reduced through the development of sustainable alternative energy sources such as biofuel. This will not only conserve forest resources but will reduce environmental pollution.

CONCLUSION

Drought and desertification is a twin global environmental problem of arid and semi-arid regions. The phenomena

integrate climatic elements with human activities in transforming productive land, into an impoverished area generally refers to as desert. Nigeria is a country faced with desertification problem with 15 states accounting for about 68.38% of the country's total land area, challenged with varying degrees of desertification. Impacts of drought and desertification are felt in all aspects of the environment and human livelihood. Remedies to these problems involves awareness, protection of marginal lands, planting of indigenous tree and shrub species, sustainable agricultural practices and use of alternative energy source. There is need to bridge the gap between the formation of policy and strategies of combating drought and desertification so that government efforts to combating desertification can be productive.

Conflict of interests

The authors did not declare any conflict of interest.

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