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Climate Change and Spatial Planning Concerns in Nigeria: Remedial Measures for More Effective Response

E. C. Onyenechere

Department of Geography and Environmental Management,
Evan Enwerem University, Owerri, Nigeria
E-mail: emmazob@yahoo.com

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ABSTRACT Global warming and the consequent change in climate have posed and are posing threat to existence of life. Many nations including Nigeria lack the necessary coping capability required for coping with the impact of climate change. It has become necessary to integrate climate change concerns into spatial planning. This paper contributes to the dialogue on the linkage between changes in climate and the planning of man's space. It examines the following specific issues; the incidence of change in climate in Nigeria, the vulnerability of Nigeria as a nation to climate change, and the consequences of climate change on spatial planning in Nigeria. The discussion provided the following insights: first, that the incidence of climate change in Nigeria is a reality; second, that Nigeria is vulnerable because it is less endowed with resources and technology to combat the problem and its economy is based largely on natural resources – dependent sectors that are climate sensitive, and lastly it called for considerable planning before spaces are allotted to different uses as a result of the consequences of climate change in Nigeria. Thus, it is easy to envisage a process by which rural or urban planning and management ensures planned adaptation with developments and investments in and around each rural or urban area reducing risks for inhabitants, enterprises and infrastructure to climate change related impacts. Suitable measures are recommended in the study.

INTRODUCTION

Over the years, there has been global as well as regional changing of both climate and weather. This change is made visible especially when focusing on important climatic factors as temperature, rainfall, humidity etc., which have shown significant variability. The Inter Governmental Panel on Climate Change (IPCC) (1990) reports that the global average temperature has increased by at least 0.6°C in the past few decades. Some scientists have also argued that the global average temperature has increased by 0.3°C – 0.7°C over the last century and have also estimated an increase of about 1.4°C – 5.8°C by the end of the 21st century.

Other climatic variables other than temperature have also shown significant variations. Some researchers have done much work in this regard with the aim of verifying if there is any variation in precipitation (rainfall) in Nigeria. They observed that climatic changes affect precipitation and opined that as weather and climate continue to fluctuate, rainfall will also continue to fluctuate and this variability has been recorded globally and regionally within the tropics, the sub-Saharan Africa and parts of Nigeria. These changes in precipitation over sub-Saharan West Africa have been studied by Ward et al. (1999), Nicholson (1981) and Duru (2008).All this variability in climatic variables over a period is what can be coined together and referred to as climate change. This change affects in many ways how space is to be planned. For instance, housing/settlement, agriculture, fishing etc. all have one or two impacts from climate variability; hence climate variability has to be taken into consideration in the planning of space.

Change in climate has resulted in changes in most human and natural activities. Climate change and its effect lead to a shift in the boundaries of major ecological zones as well as the wildlife they support. In many parts of Nigeria, tropical forest and rangelands are already under threats from population pressure and land use systems. This can affect the planning of the space in the region. Also, as a consequence of climate change, some areas will start receiving heavier and steadier rainfall and such areas will inevitably begin to experience increased rainfall-induced erosion. Conversely, in the arid northern part of Nigeria, higher temperatures will contribute to dry conditions which underlie accelerated wind erosion. These are very serious situations given that soil erosion is already of catastrophic proportions in Nigeria, whether it is viewed as gully or sheet erosion. Dust storms in some parts of the Sahel savannah have increased particularly between the 1950s and 1980s (Elasha et al.2006).

Sea level is also accelerating, resulting from

climate change. This necessarily involves inland extension of marine water. This will affect adversely cropland, surface and underground water resources, transportation, residential and industrial layouts, land – based recreational activities and numerous other land use activities. Global warming is expected to lead to increased frequency of drought in much of Northern Nigeria. In addition to temperature increase and heightened human activities, higher frequency of drought will lead to desertification. The encroachment of the desert causes the Sahel and Sudan savanna belt to move southward leading to reduction in the total area occupied by guinea savanna. This will in turn put the whole country at risk, since the guinea savanna is a key food – producing region and a large proportion of livestock consumed in the country comes from this belt and the far north. This paper contributes to the dialogue on the linkage between changes in climate and the planning of man's space. The specific issues examined are:

(i) Is there an actual change in climate in Nigeria?
(ii) What is the vulnerability of Nigeria as a nation to climate change?
(iii) What are the consequences of climate change on spatial planning in Nigeria?

CONCEPTUAL/ THEORETICAL BACKGROUND

In order to provide a framework for the analysis, the concept of climate change is discussed in this section. Intergovernmental Panel on Climate Change (IPCC) (2007b) states that "Climate change is a change in the state of the climate that can be identified by changes in the mean and or the variability of its properties and that persists for an extended period typically decades or longer". Nigeria's First National Communication on climate change under United Nations Framework Convention on Climate Change (UNFCCC) (2003) defines climate change as a change of climate which is attributed directly or indirectly to human activities that alter the composition of the global atmosphere and which are in addition to natural climate variability, observed over comparable time period. Okali (2004) defines climate change by first of all defining climate as the "average weather" together with the variability from the average; it is the synthesis of the weather in a given place over a period of at least 30 years. He listed the main elements of weather to include temperature, rainfall, dew, humidity, wind, sunshine, mist, haze and cloud. It is the collective pattern of expressions of these elements overtime that is described as the climate of the place. Climate change is thus a change in these collective patterns of expression, not just in one element of weather. It is the permanent departure of climatic patterns from mean values of observed climate indices (Obioh 2002). For the purpose of this study, of all the afore-mentioned definitions the definition by IPCC is the most acceptable.

Climate change has been one of the most engaging environmental subjects of debate in recent times. Indeed, the environmental problems associated with the potential impact of expected climate change may prove to be among the major environmental problems facing many countries. In Nigeria, it has been realized that serious environmental problems are likely to arise in association with the anticipated global warming resulting from emissions of greenhouse gases into the atmosphere. These problems in one way or the other affect location and planning of features and economic activities in Nigeria.

Theories put forward to explain the nature and causes of climate change can be grouped into three broad categories: the terrestrial; astronomical and the extraterrestrial. These three theories on their own try to explain the causes of global and local climate change. However, a change of climate implies change in the general circulation of the atmosphere on which climate depends even though that climate involves not only the atmosphere, but also the hydrosphere, the biosphere, the lithosphere and the cryosphere (Ayoade 2004).

But in principle, three external climate variability sources are observed. They are the sun (solar forcing); the change in the earth's orbit caused by celestial – mechanical disturbances (orbital forcing) and disturbances from the intercellular space as cosmic dust and meteorites (Federal Ministry of Environment 2003). It is known that the primary driver of the climate system is the sun, which is the ultimate driving force for the motion of the atmosphere and ocean, the fluxes of heat and water for biological activity. Variability in solar

flare, estimated to have increased by 40% in recent times could have been thought to be the primary factor of the present global temperature trend. This is a change in temperature as a result of natural process.

Today, the warming is considerably enhanced and accelerated by the excessive emission of greenhouse gases. Before the industrial revolution, the quantity of greenhouse gases in the atmosphere is relatively constant and the impact of man on climate was mostly of local nature. The only ways that the early man affected the climate was by cutting of forest and draining of wetlands to gain land for farming. In recent times, changes in land use through deforestation and draining of wetlands have become so extensive that the climate of the entire region of the globe has been affected and this process has been accelerated greatly as a result of industrialization. The intensification of agriculture throughout the world has also led to the increase in the emission of climatically relevant gases, such as nitrous oxide (N_2O), and methane (CH_4). Aerosol emissions and their precursor gases through human activities have been increasing, mainly due to industrial process but also from land and air traffic after release into, and formation in the atmosphere. These aerosol particles affect the radiation. All these are as a result of human influence on climate and it has become discernible. Thus from the above illustrations climate change causes can be split into; human (anthropogenic) factors and natural factors, a fact corroborated by Odjugo (2010).

INCIDENCE OF CLIMATE CHANGE IN NIGERIA: MYTH OR REALITY?

Having defined climate change to mean a permanent departure of climatic pattern from mean values of observed climatic indices, Obioh (2001) includes departure in climatic indices to mean change in climate. Indicators for assessing the evidence of climate change in a region are increasing temperature, increasing evapo-transpiration, decreasing rainfall amount in the continental interiors, increasing rainfall in the coastal areas, increasing disruption in climatic patterns and increasing frequencies and intensities of extreme weather (Ahmad and Ahmed 2000; IPCC 2001a; NEST 2003; Hengeveld et al. 2005). The executive summary of chapter five of the Intergovernmental Panel of Climate Change (IPCC) in 1990 shows the following variations in elements. For temperature the lower atmosphere and earth warms, the stratosphere cools, and near the Earth's surface, the global average warming lies between $+1.5^0$C and $+4.5^0$C with a best guess of 2.5^0C. For precipitation; the global average increases, the larger the warming the larger the increase, increases at high latitudes throughout the year, and increases globally by 3 to 15% (as does evaporation). For soil moisture; increases in high latitude in winter, and decreases over northern mid – latitude continents in summer. For snow and sea-ice; the area of sea-ice and seasonal snow-cover diminish, and the above results are from models.

According to IPCC (1995, 2000) the main evidence of climate change from scientific studies and observations so far are: the Earth's surface temperature is rising faster now than it has done for 1,000 years, the general mean temperature of 15^0C has risen by $0.3\text{-}0.6^0$C since 1900 (0.7^0C over much of Africa during the 20th Century); the 1990s are warmest decades on record and 1998 the hottest year; the five warmest years in Africa over the past century have been between 1988 and 1995. IPCC's (1992a, 1992b) general predictions are that over the next 100 years, the global average temperature will rise between 1.4^0C and 5.8^0C; the change in temperature in the 100,000 years between the glacial and interglacial periods (between the ice ages and warm periods) in the geological times is only $4\text{-}6^0$C and current increase in less than 1,000 years are already approaching this level of change; ice caps and glaciers in the cold region are melting; global snow cover has decreased by 10% since 1960; and melting ice caps and thermal swelling of the oceans have led to sea level rise; global mean sea level has risen by 10-25cm over the last 100 years, sea level is projected to rise by 0.9>-0.8cm in the next 100 years.

In Nigeria, available meteorological data on surface air temperature for Kano, Calabar and Lagos show evidence of increasing surface air temperatures since 1920 (Federal Ministry of Environment 2003). Analyses show surface air temperature of about 0.25^0C for Calabar and Kano and $0.25\text{-}0.5^0$C for Lagos. Also, there are indications that those other climate variables especially rainfall have declined both in

magnitude and temporal distribution. Analysis of monthly rainfall data from 1911 to 1980 reveals a changing pattern in annual precipitation. The results obtained suggest that, among other things, there appears to be a definite decline in the 1941 – 1980 eras (Federal Ministry of Environment 2003).

Available individual and collective researches at regional levels show that Nigeria like most parts of the world is experiencing the basic features of climate change. Some localities are experiencing extreme weather conditions as a result of increasing temperature and an associated changing climate (Olaniran 2002; Ayoade 2003; Odjugo 2005). Ayoade (2003) recorded a slight drop in air temperatures within the late 1940s and early 1950s in Nigeria. According to Mabo (2006) and Ikhile (2007), a sharp increase in temperature between 1971 and 2005 could be linked to the effect of climate change and its associated global warming. Temperature anomalies confirm the facts that global warming is unequivocal (IPCC 2007b). According to Odjugo (2010), increasing temperature is already present in Nigeria. Odjugo and Ikhuoria (2003) and Adefolalu (2007) report that increasing temperature and decreasing rainfall in the semi-arid region of Sokoto, Katsina, Kano, Nguru, and Maiduguri may have resulted in the increasing evapotranspiration, drought and desertification in Nigeria. Others show evidence of other indicators (Fasona and Omojola 2005; Chindo and Nyelong 2005; Ikhile 2007; Nwafor 2007; Umoh 2007).

Fasona and Omojola (2005), Obioha (2008) and Odjugo (2005, 2009) have observed decreasing rainfall in Nigeria especially in the northern part. The decreasing rainfall, increasing temperature and evapotranspiration have resulted in either reduction of water levels or total drying up of some rivers and lakes in Northern Nigeria, while Lake Chad in Nigeria is reported to be shrinking in size at an alarming rate since the 1970s (Chindo and Nyelong 2005;Odjugo 2007). Nkomo et al. (2006), Molega (2006) and Nnodu et al. (2007) confirm the existence of unusual or extreme weather related events such as erratic rainfall pattern, floods and sea level rise in Nigeria. The increasing rainfall in the coastal cities may have partly been responsible for the increasing floods devastating the coastal cities of Warri, Lagos, Port Harcourt and Calabar as observed by Ogundebi (2004), Ikhile (2007), Nwafor (2007), Umoh (2007) and Odjugo (2010). Jevrejeva et al. (2006) and Rahmstorf et al. (2007) suggest that sea levels will rise much higher and faster than previously thought. NEST (2003), Nyelong (2004) and Nwafor (2006) report that in the coastal region of Nigeria, there is a sea level rise of 0.2m and incursion of salt water into the coastal plain for about 2016-3400 sq. km. IPCC (2007b) affirms that Nigeria's entire coastline has been affected by this observed rise.

The micro-level research by Duru (2008) on implication of variability in Rainfall over Imo State reveals that there is a significant variability in rainfall pattern between 1975 and 2007. Also, rainfall data analysis undertaken by Adejuwon (2002) indicates rainfall decline in several locations in Nigeria thereby authenticating the findings of previous researchers. Several past research studies on climate trends (Aisiokuele 2000; Gbuyiro 1998; Oladipo 1995; Anyadike 1993; Olaniran and Summer 1989; Clerk 2002; Nkeiruka and Apagu 2005) have also shown significant variation in temperature and other climatic elements. Odjugo (2010), however, found most of them inadequate for the drawing of climate change conclusions because they either covered a short period or a small area. Singer and Avery (2007) affirm that it takes at least a century of weather data to evaluate climate trend in order to capture long term changes and draw meaningful conclusions. Collectively these illustrations and the various previous research works are indications that there is a significant change in climatic variables indicating change in climate in Nigeria.

Climate models suggest that climate will generally become more variable (Brooks 2004; Hulme et al. 2001). On projections for Nigeria based on 1percent annual increase in CO_2 concentration and at the instance of IPCC, two series of scenarios have been developed IS92 and SRES i.e. Special Report on Emission Scenarios. The scenarios on which the available data were based simply assume a rate of increase in the concentration of CO_2 in the atmosphere. One of the scenarios assumes a rate of 1.0 percent per annum increase in the concentration of CO_2 in the atmosphere. An increase of 1.0 percent per annum will result in a concentration level of over 855 parts per million

(ppm) by the year 2100. It represents a worst case scenario with the potential for a most rapid change in climate. In this regard, it falls into the same class of scenarios as IS92a and SRES A2 (Table 1). Table I reveals the most change that could occur in the climate of Nigeria.

Table I: Scenarios and CO_2 concentration

Scenarios	*CO_2 concentration by 2100*
IS92a	690ppm
IS92b	680ppm
IS92c	475ppm
IS92d	490ppm
IS92e	960ppm
IS92f	620ppm
SRES A1	675ppm
SRES A2	830ppm
SRES B1	550ppm
SRES B2	600ppm
Increase of 1.0%/annum in CO_2 Conc.	855ppm
Increase of 0.5%/annum in CO_2 Conc.	560ppm

Source: Nigeria's First National Communication under the United Nations Framework Convention on Climate Change (UNFCCC), 2003

VULNERABILITY OF NIGERIA TO CLIMATE CHANGE

One irony in climate change as a global problem is that developing countries who contribute the least to cause the problems are the most vulnerable to its impact. They are the most vulnerable because they are least endowed with resources and technology to combat the problem and their economies are based largely on natural resources – dependent sectors that are climate sensitive. Nigeria happens to be one of those countries. Mendelsohn et al. (2000) and Mendelsohn et al. (2006) argue that the primary reason that poor countries are so vulnerable is their location. Countries with low latitudes start with very high temperatures. They estimate a potential loss of GDP of 11% by 2060 based on a 2^0C rise for Nigeria.

There are various reasons why Nigeria is vulnerable to climate change apart from being a developing country. For instance; it is established that every country is affected by climate change, but the degree with which it is impacted to produce damage differs, depending on geographical circumstances, the capacity with which to withstand the impact and the nature of the economy. According to Okali (2004), Nigeria's vulnerability to climate change comes both from being located in the tropics, and from various socioeconomic, demographic, and policy trends limiting its capacity to adapt to change. Therefore, Nigeria's high vulnerability to climate change stems first, from its geographical location – in the tropics and with a long coastline. Secondly, Nigeria is a developing country with little capacity to adapt to climate change due to low levels of awareness, human and financial resources and institutional and technological capabilities. Nigeria as a developing country is particularly vulnerable because a large share of her economy is dependent on climate – sensitive natural resources (IPCC 2001b). Thus, Boko et al. (2007) consider Nigeria as one of the countries expected to be worst affected. Consequently, in Nigeria, women, young, children and the elderly will be most vulnerable to climate change (DFID 2009).

Nigeria has a coastline that is more than 800km long. From calculations, a 0.2 meter rise in sea level will inundate 3,400km^2 of our coast-land; a 1 meter rise will cover 18,000km^2. Niger Delta has a coastland of under 6,000km^2 and the country's total mangrove area is about 8,000km^2 (Onofeghara 1990). Nigeria's economy is dependent on economic activities that take place in our coastal region and we have important cities, infrastructure and installations in the region. According to a prediction in the Guardian, September 17th, 2001, p.80, "Nigeria will lose close to Nine Billion dollars as a result of the Sea Level Rise (SLR), while at least 80 percent of the inhabitants of the Niger Delta will be displaced due to low level of the oil rich region". While DFID (2009) predicts a loss in GDP between 6% and 30% by 2050, worth an estimated US $100 to 460 billion dollars based on possible sea level rise from 1990 levels to 0.3m by 2020 and 1m by 2050, and rise in temperature of up to 3.2^{0}C by 2050 under a high climate change scenario.

Nigeria has more than two-thirds of its area prone to desertification. The resulting decline in productivity from increased desertification will further raise our vulnerability to climate change and worsen the problem of ecological refuge. Water is an important source of energy to the country. Climate change results in reduction in soil moisture in the sub humid as well as the arid regions of Africa. In Africa, trend in the last decade shows a 17% decrease in rain run-off (IPCC 2001a), to which water

reservoir storage is markedly sensitive. Power supplies from hydro power stations are affected by drought and water shortage. Drought and water shortage already threaten the hydro-power potentials of Kainji, Shiroro and other reservoirs which supply nearly half of our electricity energy.

Climate change threatens livelihood, food security and programmes aimed at elimination of poverty (Onyenechere and Igbozurike 2008). Sub-humid, semi-arid, and arid regions of the country (i.e. areas subject to desertification) will be further hit by decreased production due to climate change. Rainfall which determines agriculture everywhere in the country will be adversely impacted by increased variability in timing and amount of rainfall, whereas coastal regions that rely heavily on fishing may also be hit as climate change upsets ocean current and fisheries. Apart from the indirect effect of climate change on food security through climate – linked disaster and changing seasons, biological production itself can be directly affected by climate change. Grain crop production can be depressed by a rise in temperature from global warming. Water shortage and an increase in pests and disease may also depress crop and livestock production and storage and hence food supply, necessitating import. Food security will be affected also because many Nigerians (the rural majority) depend on non-timber forest products (NTFPS) or wild grown products for food and livelihood. Loss of biodiversity associated with climate change will affect this source. NEST (2003) and Ayuba et al. (2007) indicate that constant loss of forest cover and biodiversity in Nigeria is linked to global warming and climate change. Mshelia (2005) and Adefolalu (2007) claim climate change has impacted on agriculture and health in Nigeria. Nigeria is a country already being plagued by diverse ecological problems which have been directly linked to changing climate (Adebayo 1998; Chindu and Nyelong 2005; Odjugo and Ikhuoria 2003). Mshelia (2005) and Jagtap (2007) are of the opinion that the effects will be more pronounced due to existing low level of coping capabilities in Nigeria and other parts of Africa.

Table 2 shows the result of Nigeria's Vulnerability Analysis with Climate Change and Accelerated Sea Level Rise (ASLR) of 1.0m. It equally shows the projections of other parameters in the vulnerability analysis. Results of the analysis indicate that more than 13 million people are presently at risk and may be relocated due to climatic variations and sea level changes. With the projected climate change and sea level rise of about 0.5m, the number of people that may be relocated assuming there is no development would increase to more than 27 million. With development, the number will be about 53 million people. If sea level should rise by about 1.0m with the projected climate change,

Table 2: Nigeria – vulnerability analysis with climate change and ASLR (0.5/1.0M)

Impact category	*Units*	*Present*	*No measure*		*Protection*	
			No Dev.	*30Yr. Dev.*	*No Dev.*	*30Yr. Dev.*
Socio-econ Values at Loss						
-Cap. val at loss	$m	H	C	C		L
-Subs val at loss	$m	H	C	C		L
-People that may be relocated	/1000		103468/ 206937	196589/ 393180	10347/ 20694	19659/ 39318
Socio-econ Values at Risk						
-Cap. val. at risk	$m	C	C	C	L	L
-Subs val at risk	$m	C	C	C	L	L
-People at risk	/1000	25847	47354/ 72350	78573/ 137503	6177/ 11738	15443/ 29942
Socio-econ Values at Change						
-Land use damage (climate change)		H	C	C	L	L
-Land use damage (salinity)		H	C	C	L	L
-Other financial damages		H	C	C	L	L
Ecological values at loss						
Ecological area loss	Km^2	C	C	C	L	L
Spread area loss	Km^2	C	C	C	L	L
Cultural /historical loss						
Cultural/historical sites		C	C	C	L	

Source: Nigeria's First National Communication under the United Nations Framework Convention on Climate Change (UNFCCC), 2003

the number of people that may be relocated assuming there is no development would be more than 48 million. With development and with the projected climate change, the number of people that may be relocated would be more than 92 million. According to Nigeria's First National Communication under UNFCCC (2003), the potential population has been taken into consideration in computing the figures. Recently, DFID (2009) predicted that all the main sectors of Nigeria's economy will be impacted by climate change particularly agriculture. Water, transportation and power are also extremely susceptible and will result in knock on effects to other parts of the economy, especially wholesale and retail. Aspects of the economy that may gain are production and sales of renewable energy, flood protection, medicine, building cooling equipment etc.

CLIMATE CHANGE AND SPATIAL PLANNING IN NIGERIA

Nigeria does not yet have a national climate change policy. Nigeria equally lacks a centralized institution that can champion and coordinate climate change and spatial planning activities. Climate change requires mitigation and adaptation, hence spatial planning which contributes to both mitigation and adaptation. Spatial planning reacts to only those impacts characterized by gradual changes such as shift of climate zones, sea level rise and vegetation changes. It, however, cannot react to sudden events such as extreme weather events or amplification of natural hazards. Spatial planning has a vital role to play in the move to a low carbon energy future and in adapting to climate change. According to Fleischhauer (2005), climate change impacts that have a spatial relevance are those with a specific regional context and / or those that can be reduced by spatial planning.

Climate change has several consequences for spatial planning in Nigeria. As a result, it calls for considerable planning before spaces are allotted to different uses as a result of the consequences of climate change in Nigeria. Since most of the economic activities in Nigeria are climate dependent activities, a change in climate will determine both in the short and long run how these activities are planned in the space. The consequences of climate change on spatial planning are seen in these economic activities discussed below.

In the southern parts of Nigeria, agricultural (particularly farming) activities normally start from March; this is because by this period of the year rainfall, an active driving factor of agriculture should have arrived. But today there is abnormality in the commencement of agricultural activity because as at the second or third week of April in 2010, there is inadequate rainfall to plan and start agricultural practices in consonance with the arrival of rains. Some studies conducted state that the dwindling nature and shift in climate belt in agricultural production are as a result of climate change. The study by Olarewaju (2003) noticed that the climatic situation in Kwara State is no longer supporting the growth of melon and therefore suggested the shift of melon cultivation to southern guinea ecological zone of Nigeria where it may thrive better. Similarly, Adefalolu (2004) associated the decline in production of groundnut (to 30% of the pre-1960 production) with climate change, while Iheanacho (2001) associated millet production losses with drought (derived from short-term climatic changes). The implication of Olarewaju's result is that the farm land of Kwara State which previously supported the growth of melon is now not good for the growth of melon as a result of climatic variation/change in climate. By inference, the growing of melon in that area may today no longer be encouraged; hence the spatial area or the place for such activities should be allotted to more viable economic production activities other than melon production. In the case of millet affected by drought in the Arid zone of Nigeria, expansion of cultivated areas as well as the use of drought- resistant seeds and improved moist conservation practices will be required.

Efficient crop production in the tropics is linked with the onset of rain and length of rainy season because, onset cessation and duration of the rainy season form important components of moisture resource status for determining the production potential of various crops (Olarenwaju 2003). According to Fortunata (2003), the uncertainties which characterize the start and the lengths of the growing seasons are giving a lot of concern to farmers in Uganda. Similarly Nnaji (2001), Odofin et al. (2003) and Adejuwon (2004) linked up reduced agricultural

productivity and low income associated with Nigerian farmers with fluctuation in available moisture pattern. Fasona and Omojola (2005) observed a shift in Nigeria's climatic belt. According to them, the root and tuber productive ecology of the Guinea savannah is giving way to Sudan savannah grassland. Whereas in the northern and middle parts of Nigeria, the cereal productive Sudan savannah ecology is transiting to pure Sahel and the influence of the Sahara is increasing southwards. The predominant Fulani herdsman of the lower Sahel and Sudan ecologies is now moving South- to the Guinea savannah and Forest belt of the South- to find greener pasture for his herds. They linked change climate with human insecurity and communal clashes in parts of Nigeria.

Aside of agriculture, human settlements in Nigeria will be affected by climate change in a variety of ways. Rural and urban population will be affected especially those living near the coast as a result of rise in sea level. This phenomenon has already been reported in Nigeria in the recent past. This was when bar beach in Lagos was flooded and sea water intruded on the nearby roads. Some settlements are known to have already relocated father inland from their original sites in response to sea incursion over some decades. Extreme climate conditions such as high wind, heavy rainfall, heat and cold could result in wide – ranging scenarios such as tropical storms, floods, landslides, drought and sea level rise (SLR). In planning for mitigation, efforts should be geared towards minimizing the negative impact of climate change especially in planning for human settlements.

With respect to industries, categories of industries identified as being vulnerable to climate change are two types. They are: industries whose activities are dependent on climate – industries in this category include construction; transportation and transmission, offshore oil and gas production, thermal power generation etc. and sectors in which economic activity is dependent on climate sensitive resources: Here we have agro-industry, biomass, and renewable energy production.

The potential impact of climate change may be direct or indirect to industries in the following ways;

- Geographical location – industries located in coastal zone will suffer negative impact of sea level rise, coastal inundation and flooding. This includes tourism and recreational industries as well as oil and gas exploration and extraction. Industries in the Northern dry belt will be exposed to effect of warmer climate. This belt is equally prone to devastating thunderstorms, flood and wind storms that can destroy infrastructure.
- Nature of raw materials used by the industries - when raw materials experience any moderate or severe changes in production due to climate change, industries that rely on this input becomes vulnerable.
- Government policies pertaining to climate change – policies like the imposition of carbon taxes for example will increase the cost of production input.
- Other industries such as construction, housing, transport, energy generation and distribution are all affected by the incidence of extreme weather-related conditions.

Spatial planning world over became necessary when the impacts of climate change became significant and risky for large populations. From Davondi et al.'s (2009) study, it is glaring that putting climate change mitigation and adaptation into practice is an imperative for all spatial planning practitioners. They opine that climate change is changing the context of spatial planning and shaping its priorities. They also claim that it has strengthened its environmental dimension and has become a new rationale for coordinating actions and integrating different policy priorities. While Wilson and Piper (2010) explored ways to help new and existing urban developments to reduce energy use and to adapt to climate change through strengthening the relationships between urban and rural areas to avoid water shortage, floods or loss of biodiversity. Since climate change affects land use, an important challenge for conservation is to manage landscapes. Thus, it is easy to envisage a process by which urban planning and management ensures planned adaptation with developments and investments in and around each urban area reducing risks for inhabitants, enterprises and infrastructure to climate change related impacts.

Young (2002) identified three categories of spatial planning related problems in dealing

with climate change impacts. They are incongruence or incompatibility between ecosystems and institutional arrangements, vertical and horizontal interaction of institutions with other similar arrangements, and inappropriateness of small-scale solutions for large-scale problems and vice-versa. Spatial planners have to balance a range of different stakeholders needs such as meeting housing targets, preserving landscape character etc. They need to consider how climate change might affect their development options over the next 100 years or more. They should adopt constraint mapping to determine potentially appropriate places to accommodate the expansion of an existing area, and think about which decision making criteria they should define tipping points for.

CONCLUSION

With an estimate population of about 140 million people spread over a total area of 923,800 square kilometers, Nigeria is one of the most populous nations and one of the largest countries in Africa. This high population makes Nigeria a high potential contributor to global warming and consequently, climate change. Her productive activities are mainly agricultural and industrial which contribute substantial amount of greenhouse gases into the atmosphere thereby accelerating climate change. Even current estimates indicate that emissions from combined livestock population of over 44 million led to the emissions of over 1115 Gg of methane (CH_4). Also, rice production led to the emissions of 1090 Gg CH_4, while savanna burning generated 109 Gg CH_4, 3.4 Gg N_20, 2890 Gg CO and 120Gg Nox. The field burning of 61.2Mt of agricultural crop wastes also led to the emissions of 34Gg of CH_4, 0.7Gg N_2O, 720Gg CO and 26Gg of Nox (Federal Ministry of Environment 2003).

These GHGs generated from several industrial processes in one way or the other finds its way into the atmosphere thereby increasing the threat of climate change in Nigeria. As long as these situations abound, so many activities in space are at one risk or the other. Present and future activities need to be planned and executed in space such that the future is not jeopardized.

The issue of adapting the ways we live to climate change which includes planning for our urban and rural environment is being placed centre stage by recent flood events around the world and particularly in Nigeria. Our built environment professionals need to consider very carefully what they build and where they build it. Thus, spatial planning is necessary if we wish to adapt to unavoidable climate change. Spatial planning at a local level helps in promoting robust adaptation. Though the issue of climate change is becoming recognized by spatial planners with respect to flood risk, but its wider implications for biodiversity (such as the likely cessation of melon production in Kwara State) and water resources are necessary for integration into plans. However, there seems to be a lack of engagement of the planning profession with climate change networks.

RECOMMENDATIONS

Generally, the following remedial measures are currently being recommended: Nigeria should focus more on economic activities that are tertiary in nature which generate little greenhouse gases; development should be limited in areas likely to be flooded; the citing of new facilities and the location of infrastructure should not be very close to the sea so as for them to be free from sea level rise; already threatened infrastructure/facilities be relocated soonest; Nigeria should develop a technology that can capture at least 80% of carbon emitted by industries which are discharged into the atmosphere; the spaces in rural areas and urban centers should be earmarked or apportioned for rigorous and extensive tree planting; there should be a heightened public awareness on the danger associated with climate change; resettlements should be encouraged in certain areas of the country; Nigeria should develop a cleaner source of energy instead of it's over dependence on fossil fuel energy that generate greenhouse gases. While already existing energy production facilities should be physically protected with barriers; agencies responsible for the environment should enforce laws and regulations, particularly with respect to urban planning and development and adherence to industrial standards as well as erection of structures or utilities in ecologically sensitive areas; town and cities should be well planned and free of industrial and municipal wastes; there should be a decentralization of commercial activities

in the Central Business District (CBD) as this causes heavy traffic congestion and high level of gas emissions/exhaust emissions; industries should be relocated to more favourable sites. While appropriate location for new industries be mapped out; drains should be constructed in and around coastal areas of Nigeria; there should be emplacement of storm surge barriers around airports; sites for airports, motor parks and other facilities should be appropriately chosen; and there should be a modification of rural and urban land use, a development of alternative habitat areas and the protection of threatened ecosystems.

Specifically, many different stakeholders in the development planning process should be leading researches e.g. National, State and Local governments are likely to look at changes in flood risk; public water corporations, relevant government agencies, as well as government regulators, should be looking at the impacts of climate change on water resources; and government agencies along with non-governmental organizations should be researching impacts of climate change on ecology, land management and the environment. Climate change and impact researches will need to specify changes in temperatures and precipitation and specify the changes in spatial and temporal respect. This is because spatial planning authorities need a basis for decisions taking into account climate changes, changes of the spatial structure and the possible reaction /involvement of the public to these changes.

Provision of information about the spatial impact of natural hazards connected to climate change is pertinent. There is equally the need to develop procedures to integrate high level quantitative climate risk assessment into the spatial planning process as well as identification of options and the articulation of decision pathways to the appraisal process. Greiving (2004) advocates for adjustment policies which intensify efforts to lower the potential for loss from future climate change impacts through the installation of risk reduction process on local and regional level. Nigeria can infact follow the example of the UK's plan-led system. This involves preparing plans that set out what can be built and where. The plan-led system was updated by an Act of Parliament (the Planning and Compulsory Purchase Act) in December 2004. This PPS replaced Planning Policy Guidance Note 1, General Policies and Principles, published in February 1997.

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