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THE IMPACT OF CLIMATE CHANGE ON WATER RESOURCES: GLOBAL AND NIGERIAN ANALYSIS

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ABSTRACT
This paper investigates the impact of climate change on global and regional water resources. Primary climatic data (Rainfall and Temperature) for Nigeria were collected from the Nigeria Meteorological Station, Lagos between 1960 and 2002. Changes in Lake Chad waters were collected from the National Centre for Remote Sensing (NCRS), Jos. World temperature and water resources data were collected from different sources. The data were analysed using percentages and time series among others. The result shows that the atmospheric concentration of most greenhouse gases (GHGs) is increasing and this has resulted to changing global climate with increasing temperature. The rise in global average temperatures since 1860 now exceeds 0.6^{O}C. The effect of the GHGs concentration on global warming as at 2100 is estimated by three scenarios to be 1.5^{O}C (Low), 2.5^{O}C (Middle) and 4.5^{O}C (High). In Nigeria, while rainfall has decreased by 92 mm, temperature increased by 0.8^{O}C since 1960. This has led to increasing evapotranspiration and water stress resulting in the drying up of rivers and lakes. For example, Lake Chad has reduced in size from 22902 km^2 in 1963 to 16884 km^2 in 1972 and 304 km^2 in 2000. While climate change will make some countries to experience increase in water resources, majority will face serious water stress. Based on projection, by the 2080s, most countries in the Middle East, around Mediterranean, part of Europe, North and South Africa will face acute water stress while Southern and Eastern Asia, U.S.A. and Alaska. will experience reduction in water stress. By the 2020, 2050, 2080s the total population that will face increasing water stress due to climate change will be 2.3, 3.2 and 3.7 billion respectively. Some recommendations were made to reverse this ugly situation.

Key Words: Climate change, Greenhouse gases, Lake Chad, water stress and water resources.

INTRODUCTION
Climate change is a long-term shift, alternation or change in the type of climate prevailing over specific location, a region or the entire planet (Ayoade, 2004). Climate change could also be seen as a change in the variability of climate even if average weather conditions remain unchanged (Hengeveld et al., 2002). Variability is an inherent attribute of climate and climate (global or local) has never been static. What is crucial is the degree of variability that the change is subjected to as well as the duration and impact of such variability on man and the ecosystem.

A critical look into the palaeoclimatology of the world indicates clearly that the global climate has never been static, rather, it has gone through various changes (warming and cooling) in the geologic past. This has brought about many controversies concerning the current global warming. While some see it as a pointer of an impeding

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danger when reflecting on the implications of similar condition between 5000 BC and 3000 BC (Odjugo, 2000c; Ayoade, 2003; NEST, 2003 and Pobeni, 2004), others view it as a normal climatic variation and nothing to make noise about or draw conclusion from (Clerk, 2002 and Mshelia, 2004). From whichever angle it is viewed, available evidence from measurements and global climatic models such as General Circulation Models (GCMs), Atmosphere-Ocean General Circulation Models (AOGCMs) and Hadley Centre Climate Models (HadCM) among others show that the world is experiencing warming for the past few decades (Akitikpi, 1999; Environment Canada, 1999; Odjugo, 2000b; Hengeveldk, et al., 2002; Buba, 2004; Nyelong, 2004 and Hengeveld, Whitewood and Fergusson, 2005). The on-going global warming has been observed by many research works to affect and will continue to impact not only on extreme weather conditions like flood, drought, desertification among others (Smith, 1994; Lambert, 1995; Environment Canada, 1999; Odjugo, 2000b and Odjugo and Ikhuoria, 2003), but on human health (Weihe, 1979; Sloof, 1996; Martens et al., 1999; Odjugo, 2000a;), agriculture (Reilly, 1996; Karim et al., 1998; Parry et al., 1999; Sorte, 1999 and Odjugo, 2001) and hydrothermal conditions (Akitikpi, 1999; Arnell, 1999; van Deursen, 2000: Buba, 2004; Nyelong, 2004 and Porbeni, 2004).

The concept of hydrological cycle is crucial in the discussion of water resources. The hydrological cycle consists of three components namely; the inflows, outflows and storage.. If the inflows (recharge) to the aquifer are less, than the amount of stored water for possible usage will be reduced leading to scarcity. Ordinarily, the earth's water supply remains constant but man is capable of altering the cycle of that fixed supply through population increase, urbanisation, rising living standards, agriculture, industrial and economic growth. With these activities, man has placed greater pressure on the natural environment resulting to imbalance in the hydrological equation, which has started telling much not only on the climate but also water resources available at local, regional and global levels. Further alteration of the hydrological system can result in extremely negative consequences for rivers and their watersheds, lake levels and aquifers which will be detrimental not only to water resources currently available but to future generations (EPA, 1998).

Although the availability of adequate and quality water is crucial to human health, and that water is second to air with regards to its importance to human life, little attention is being paid to how it will be impacted upon by climate change especially at local levels in the developing countries (Buba, 2004 and Nyelong, 2004). Moreover, Mshelia (2005) noted that climate change will impact on the hydrological cycle at a variety of spatial and temporal scales. The temporal scales may vary from very short intervals to annual scales while the spatial effect may be local, regional or global. It is on these premises that this paper investigated the impact of climate change on global and Nigeria water resources. This is important because, (Mshelia, 2005) noted that the impact of climate change on water resources will be felt by both developed and developing countries, but more by the developing countries who cannot afford the cost needed for coping strategies. Nigeria is one of such developing countries that may be hardly hit, not only because about two-third of her landmass lies in the semi-arid region, but also is already under threat and stress of desertification and frequent drought (Odjugo and Ikhuoria, 2003, Chindo and Nyelong, 2004; Nyelong, 2004 and Odjugo, 2005).

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MATERIALS AND METHODS

Secondary climatic data (Rainfall and temperature) of Nigeria were collected from the Nigerian Meteorological Station, Lagos between 1960 and 2002 in 28 synoptic stations. This period is selected because drastic changes in Nigeria climate after the little ice age started in 1960s, which was attributed to rapid population growth, urbanisation and deforestation (Dibie, 2001). Data on the area coverage changes and depth of Lake Chad waters between 1963 and 2000 were collected from the National Centre for Remote Sensing (NCRS) Jos, and the work of (Chindo and Nyelong, 2004). This is the period when satellite imagery and actual measurements data of the lake water is available (Chindo and Nyelong, 2004). These data allow for the analysis of regional (Nigeria) hydrothermal trend. World temperatures, precipitation, greenhouse gas emissions and water resources data since record started in these elements were collected from different sources like Intergovernmental Panel on Climate Change (IPCC), Environment Canada, Carbon Dioxide Information Analysis Centre (CDIAC) online and Nigerian Environment Study/Action Team (NEST). With these data, the global climate and water resources trend is analysed. The data were analysed using percentages and time series analysis.

RESULTS AND DISCUSSION

Causes of climate change

Both natural events and processes (Biogeochemical) and anthropogenic influences (Human) cause changes in climate. The major natural factors that enhance climate change include volcanic eruptions and changes in the intensity of sunlight reaching the earth. Changes in the intensity of sunlight reaching the earth can cause cycles of warming and cooling, like the four large glacial-interglacial swings during the past 400,000 years (Hengeveld et al., 2002). The essential anthropogenic factors responsible for climate change are changes in greenhouse gas concentration occasioned by deforestation, industrial and domestic wastes, water pollution and alteration in land use for agricultural practices. These causes of climate change are modelled in Fig. 1. The greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) among others. Of these GHGs released into the atmosphere, about 60% are absorbed by either the ocean, land biota or decomposed by chemical reaction, while the remaining 40% is concentrated in the atmosphere, which traps the short wave radiation resulting in atmospheric warming (Odjugo, 2000a).

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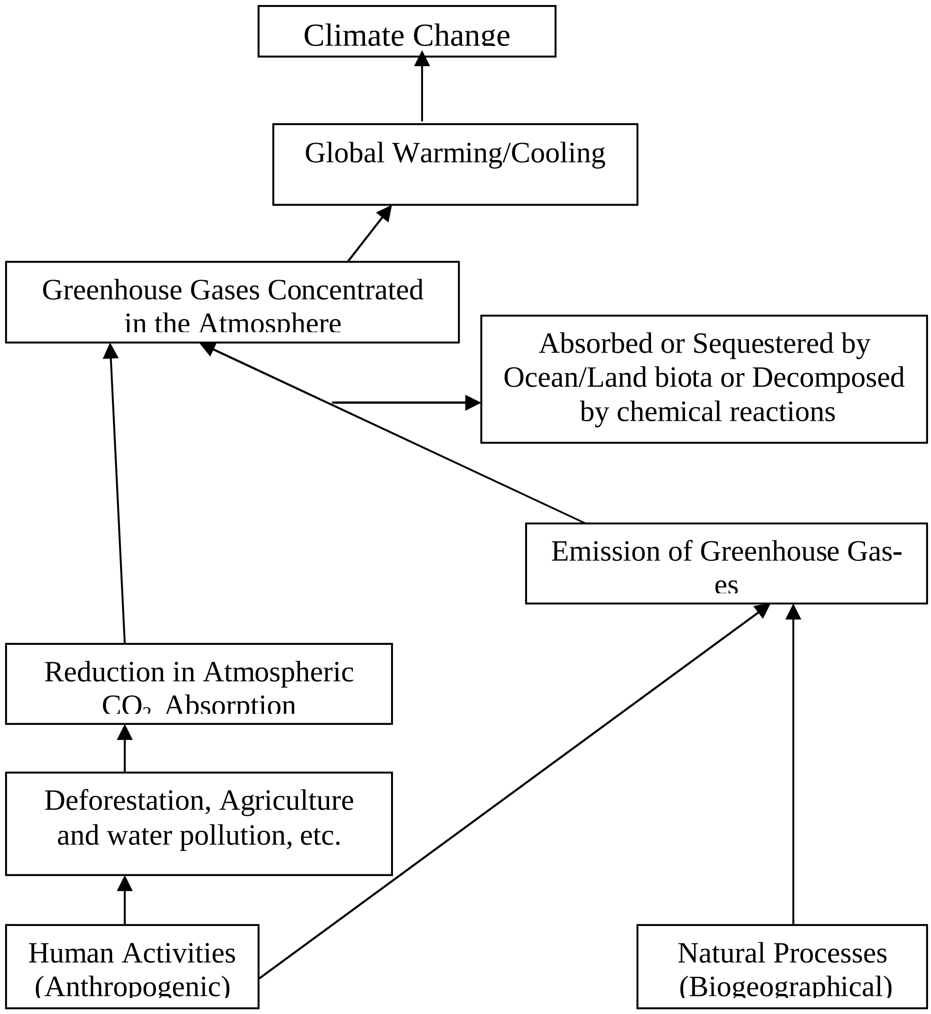

Fig.1: Causes of Climate Change

The evidence from proxy ice cores data indicates that the atmospheric concentration of CO_2 has remained relatively constant at 260 to 280 ppmv (Parts per million by volume) throughout the past 1000 years of the current interglacial until some decades ago. This shows that the global carbon budget has been in remarkable balance. The current concentration is now about 375 ppmv, more than 3% higher than the pre-industrial concentration. By 2100, it is estimated that this value may either double (750 ppmv) or triple (975 ppmv)(Fig. 2).

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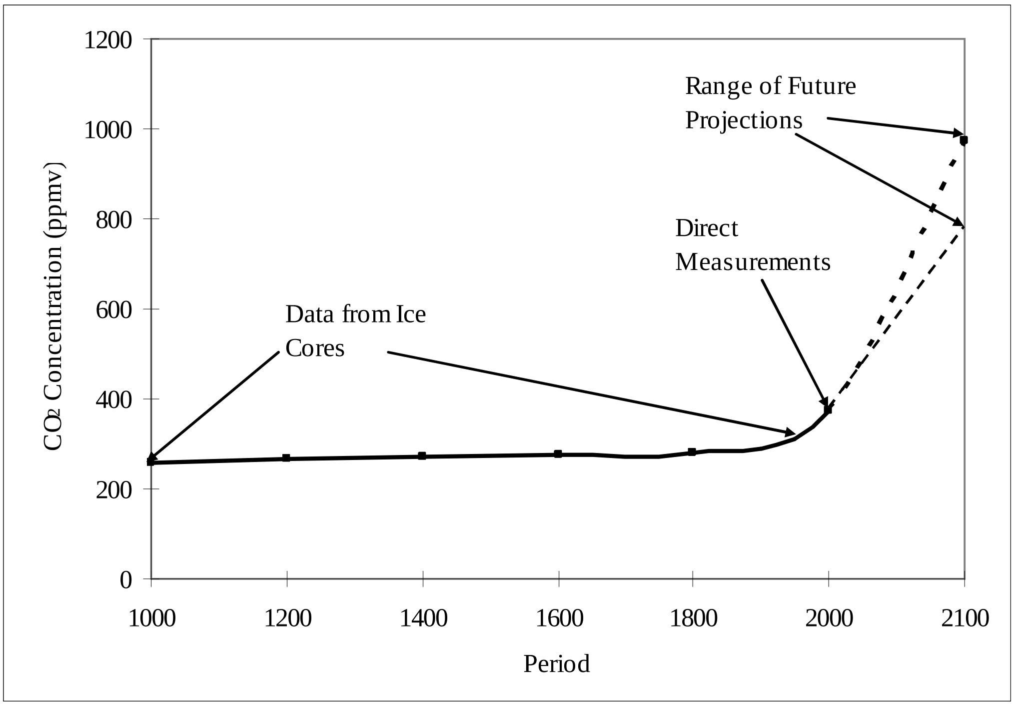

Fig. 2: CO_2 Concentration for the Past Millennium

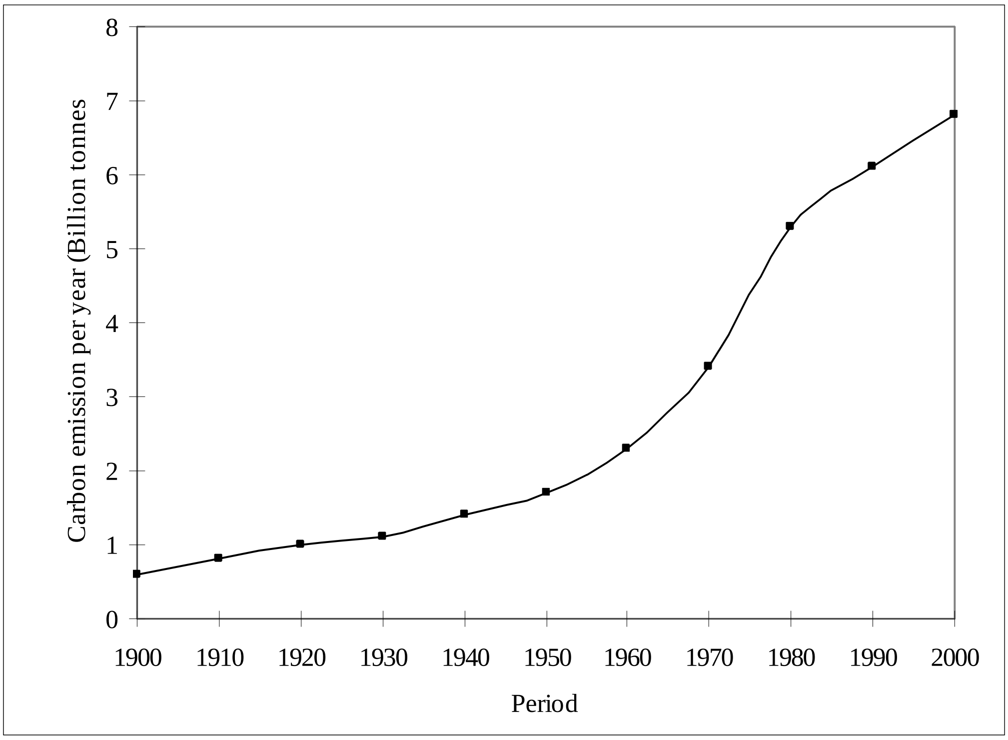

Fig. 3: Carbon Content of Annual Carbon Dioxide Emission from Fossil Fuel Combustion

A natural emission of CO_2 (43 x 109) is 1.6 times (38%) higher than the anthropogenic sources (26.6 x 10^9) tonnes per year (Smith, 1994 and Porbeni, 2004). Al-

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though the natural emissions are higher, balance is maintained by nature since the excess is sequestered as carbon sinks in oceans and forests. Human activities for the past few decades have significantly affected or upset this natural balance. While deforestation and water pollution are reducing the amount of carbon sequestered, burning of fossil fuels (coal, oil and natural gas), bush burning, industrial and automobile smokes and cement production among others add to atmospheric concentration of carbons. During the 1990s, these sources on average added an estimated 6.4 billion metric tonnes of carbon or 23 billion tonnes of carbon dioxide to the atmosphere each year (Fig. 3). This is more than 10 times the estimated rate of emissions a century ago. This anthropogenic emission of CO_2 from fossil fuel burning is very unevenly distributed throughout the world with the industrialised nations contributing more (Odjugo, 2000c; Porbeni, 2004 and Hengeveld et al., 2004). However, while the contribution of the industrialised nations has been on the decrease, that of the developing nations is rapidly increasing (Table 1).

Table 1: Regional Distribution of CO_2 emission from fossil fuel combustion, 1950 and 2000

Region	1950 (%)	2000 (%)
North America	47	26
Eastern Europe & Former USSR	16	12
Other industrialised countries	30	21
China	1	13
Other developing countries	7	28

Source: CDIAC Online.

Wetland's decay of organic matter is a primary source of methane (CH_4) hence, its popular name "swamp gas". Other sources include digestive processes of certain insects and rudiments such as termites, sheep and cattle. The ice core data shows that the highest value obtainable before the pre-industrial concentrations was 700 ppbv (parts per billion by volume). The current concentration is about 1750 ppbv, which is about 150% higher than the pre-industrial concentration. This has been projected to be as high as 3700 ppbv, a 110% higher than the current value by 2100 (Fig. 4).

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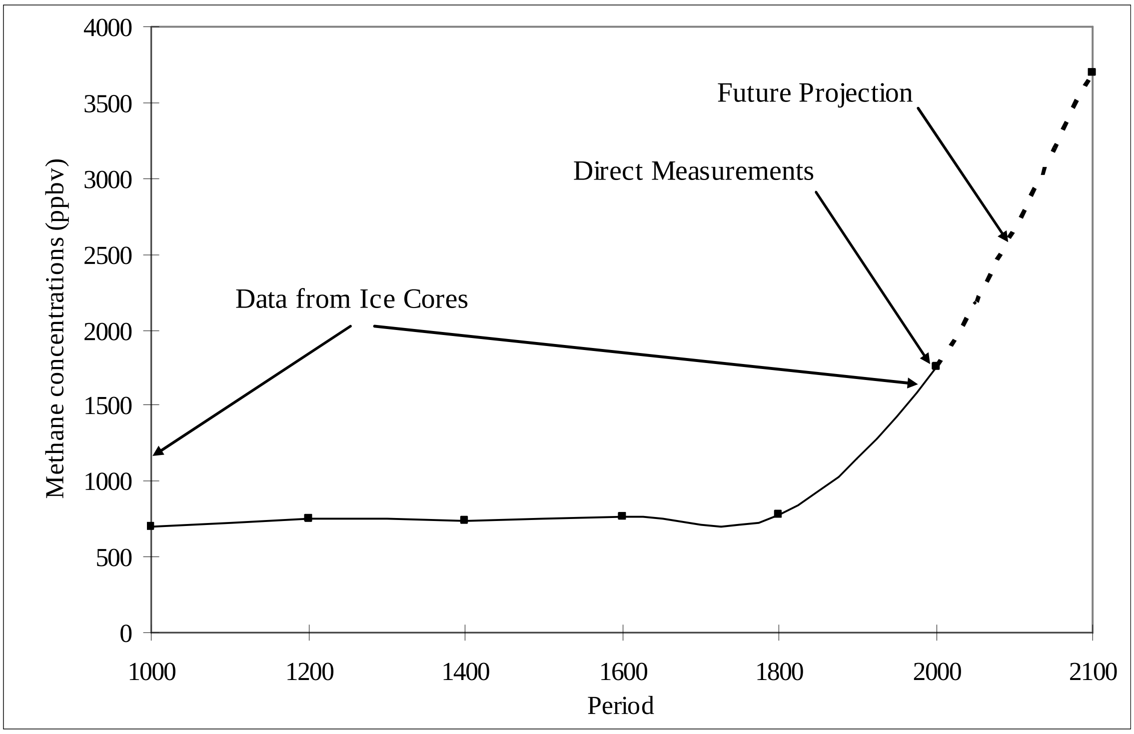

Fig. 4: Trends in Methane Concentration Over the Past Millennium and Future Projections

The emission of CH_4 by human activities is currently 1750 ppbv while the natural factors contributed only 665 ppbv. This shows that while the natural CH_4 emission is 38% that of human activities is 62%. Of this 62%, fossil fuels burning added 17%, animals (17%), rice (10%), landfill (8%) and other human activities 11% (CDIAC, online). The current 1750 ppbv value is about 150% higher than the 700 ppbv of the pre-industrial concentration. However, it is projected that CH_4 emissions will likely hit 3700 ppbv (110% higher than today) (Hengeveld et al., 2005).

Nitrous oxide (N_2O) present atmospheric concentration is 319 ppbv, which is about 17% above the pre-industrial values. They are emitted largely from agricultural soils, animal wastes, industrial production of nylon and nitric acids and biomass burning among others.

CO_2 currently contributes approximately 49% of the greenhouse gases, CH_4 (18%), CFCs (14%), N_2O (6%) others (Halon, tropospheric 0_3, etc) is 13%. Although CO_2 has the highest contribution to greenhouse gases, its potency is far lower. For instance, a gram of CH_4 is about 23 times higher than the effects of the same volume of CO_2. A gram of sulphur hexafluoride (SF_6) released into the atmosphere is about 22,000 times that of CO_2 with respect to tropospheric depletion. The lifetime of CO_2 in the atmosphere varies but obviously less than five years (Smith, 1994). While the lifetime of CH_4 in the atmosphere is 12.2 years, N_2O (120 years), CFCs (50-1700 years) and that of SF_6 is 3200 years. Therefore, while a molecule of CO_2 could cause damage to stratospheric O_3 just for few years, other greenhouse gases could cause ozone layer damage for between decades to thousands of years. Although, the potency of carbon dioxide released into the atmosphere through human activities may be significantly lower than many other greenhouse gases, the much greater volume of emission still

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make it the most important influence in humans enhancement of the natural green-house effect.

Temperature and precipitation

Since 1860, about 145 years ago when scientific recording of temperatures actually started, studies have shown that global climate has experienced noticeable variations (IPCC, 1996; Hengeveld et al., 2002 and Ayoade, 2004). The world temperatures were below average until the late 1930s, when alternating cooling and warming started till the early 1980s, when a renewed and pronounced warning continued through the 2000s (Fig.5).

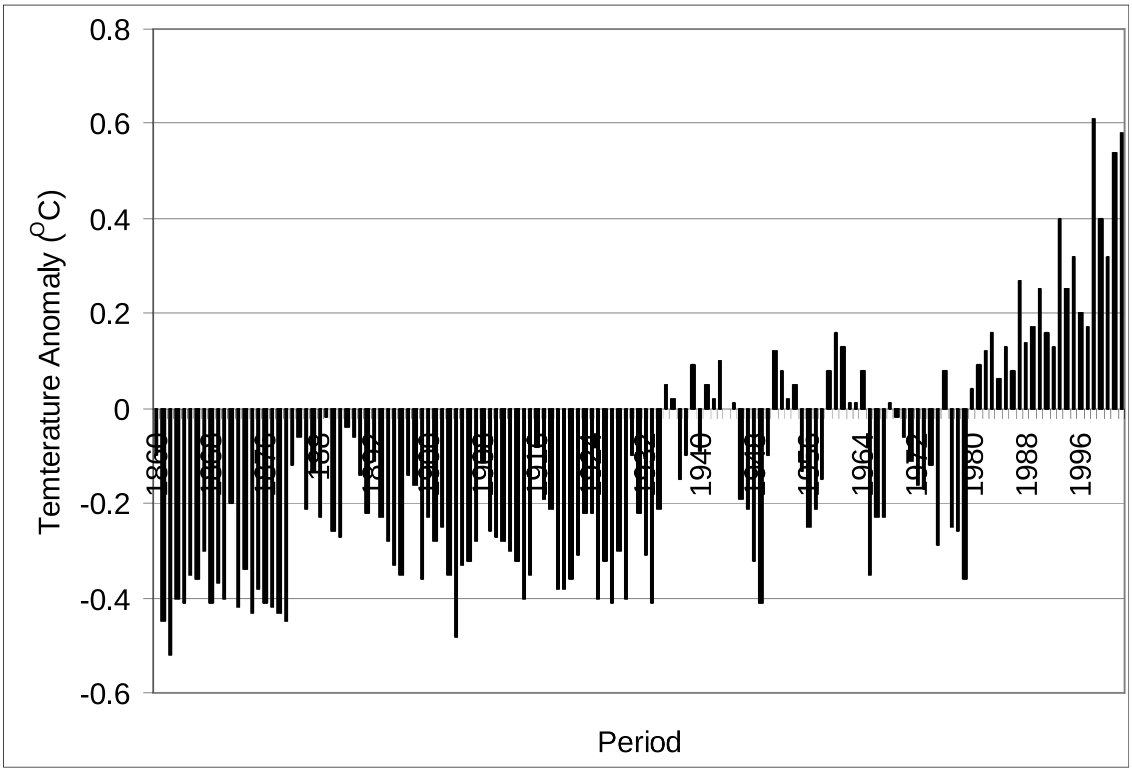

Fig.5: Observed World Temperature Changes Between 1860-2002
Sources: (IPCC,1996; Nyelong, 2004)

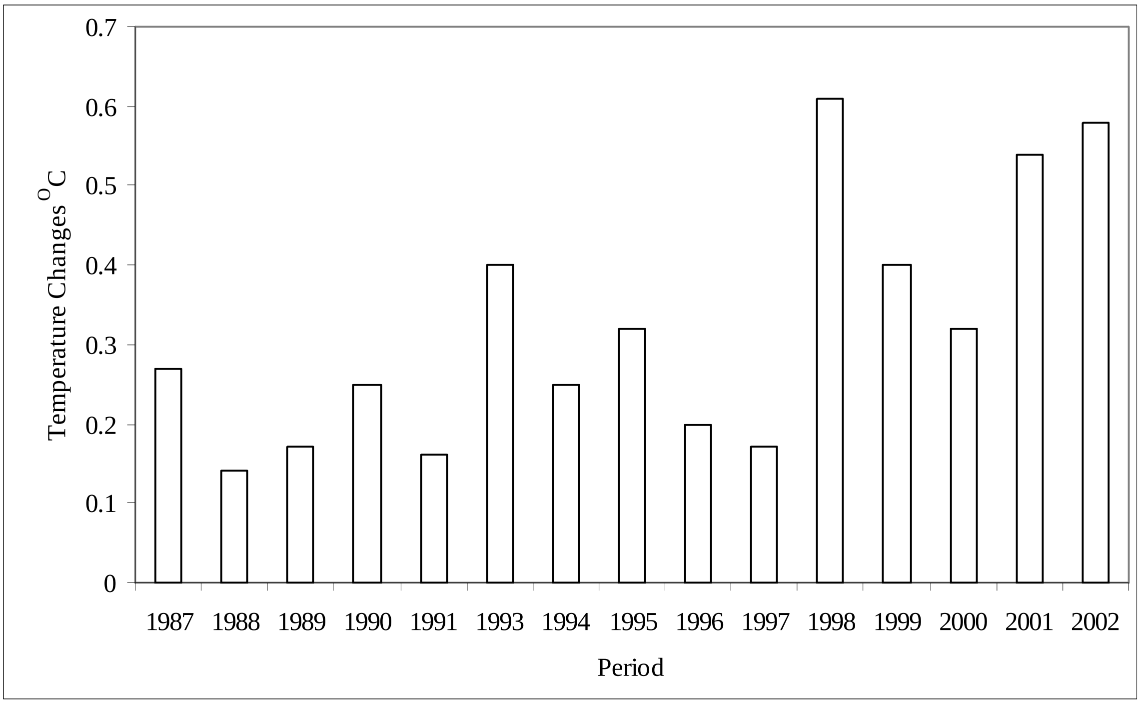

Fig.6: The World Warmest 15 Years since 1860

As shown in figure 6, temperatures in the 1990s were among the warmest on record with 1998 being the warmest individual year, followed by 2002 and 2001, while the 15 warmest global surface temperatures were found within 1987 to date with the 1990s the warmest decade (Fig. 6). Global temperatures at the earth's surface have increased by 0.4-0.8^{0}C, with an average of 0.6^{0}C since record started in 1860 and it is projected to increase between 1.5^{O}C (Low), 2.5^{O}C (Middle) and 4.5^{O}C (High) by 2100. (IPCC, 1996). In Nigeria, temperature has been on the increase especially in the 1990s and the 2000s (Fig. 7a and 7b). This warming condition was attributed to growing population, urbanisation, and deforestation, decreasing rainfall and increasing desertification (Dibie, 2001; NEST, 2003; Odjugo and Ikhuoria, 2003 and Odjugo, 2005). Since 1960, just a period of 44 years, temperature increase of 0.7^{0}C is experienced in Nigeria, which is higher than the global increase of 0.6^{0}C since 1860.

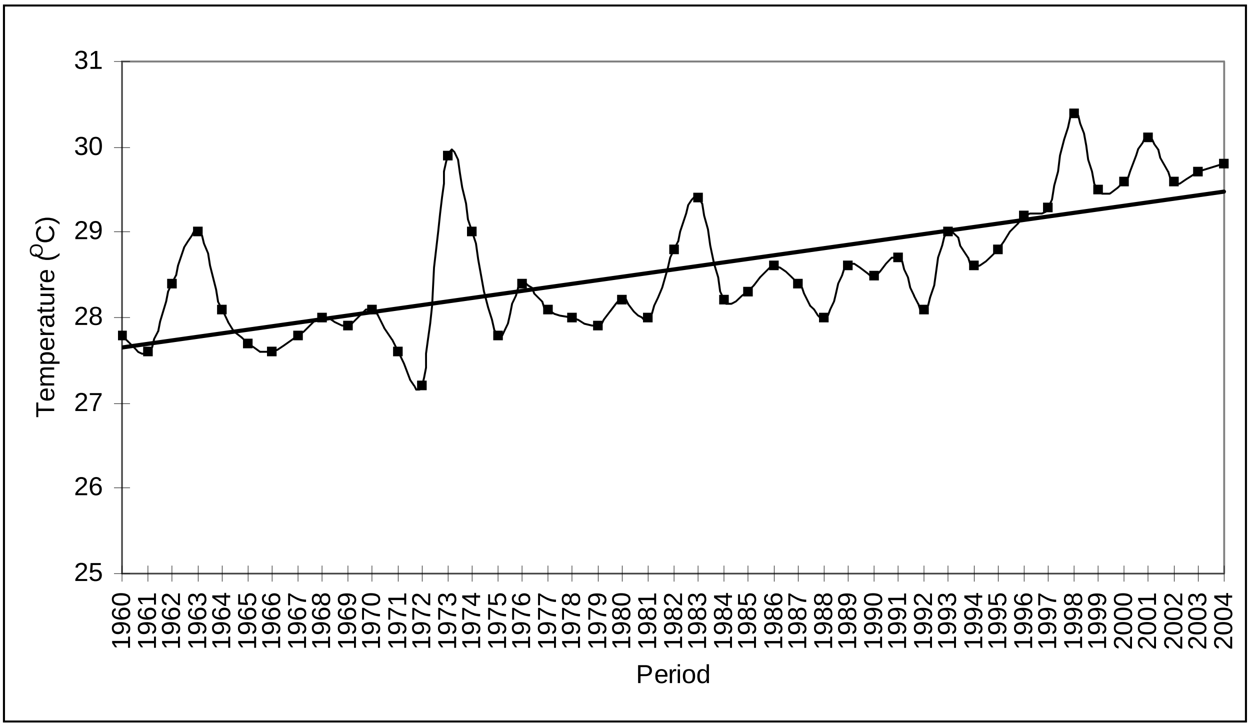

Fig. 7a: Temperature Variation in Nigeria (1960-2004)

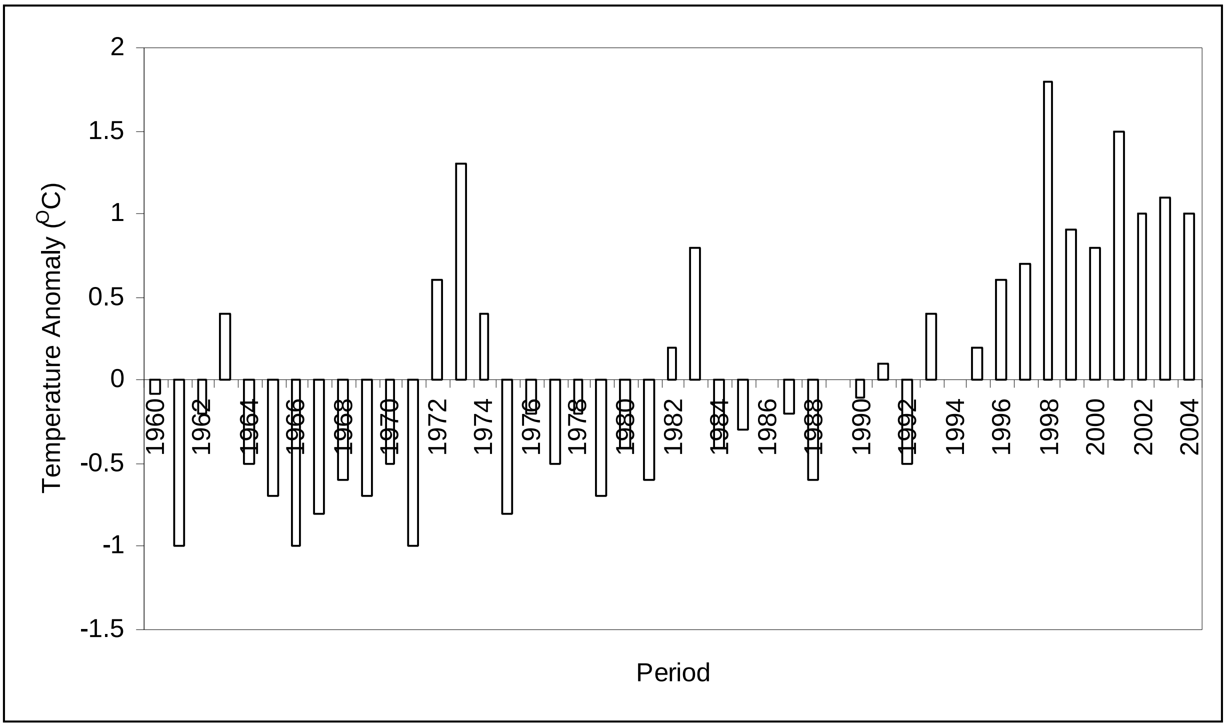

Fig. 7b: Temperature Anomaly in Nigeria

This increasing global temperature has started having drastic negative impacts and will continue to affect hydrological bodies. Available evidence reveals that, the polar ice has started thawing. For instance, the North Pole sea-ice has thinned by 40%,

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while global snow cover has shrunk by 10% and mountain glaciers have also retreated by 15% since the 1960s (Porbeni, 2004). The thawing ice and higher coastal precipitation that is associated with global warning has led to sea level rise and it is estimated to increased by 1m by 2100 (IPCC, 1996). IPCC (1996) noted that the sea level rise will lead to coastal inundation and erosion. Currently, this problem is already causing serious concerns in the coastal region of Nigeria. Since 1990, most previously well-drained areas in coastal cities like Lagos, Warri, Calabar and Port Harcourt now experience either seasonal or permanent flooding (Dibie, 2001 and Odjugo, 2005). The current sea level rise and coastal flooding have resulted in salt water intrusion into fresh water resources thereby creating scarcity of fresh water in the inundated area (NEST, 2003). A metre rise will not only inundate but also spread salt water to about 18400 km^2 of Nigeria coastal areas (NEST, 2003).

Globally, over land surfaces, precipitation average has increased from the year 1900 to 1957 and since then, it has been on the decrease (IPCC, 1996 and Nyelong, 2004). The projected regional precipitation as 2020 shows that while some regions will experience increasing precipitation others will face decreasing precipitation. The Sahellian region will experience a precipitation decrease of 6 – 10%, while Southern Europe and Southern Asia will record a decrease of 5 – 10%. On the other hand, Central and North America, Southern Asia, and West Africa below 10^0N will experience an increasing precipitation of 2 – 20%, 5 – 15% and 1 – 15% respectively. (Smith, 1994 and Nyelong, 2004).

In Nigeria, Dibie (2001) noted that before 1970, a higher proportion of the rainfall totals were above the 1300 mm (1940-1970) normal. Apart from the 1973 drought, the condition that existed before 1970 still continued until 1980 when drastic decline in rainfall was experienced (Fig. 8a). Between 1960 and 1980 only 3 years (14%) had rainfall below the 1960-2004 mean of 1280 mm while the remaining 18 years (86%) had rainfall above the mean. On the other hand, between 1980 and 2004 or for a period 23 years, only 3 years (13%) were either normal or above normal while the remaining 21 years (87%) were clearly below the 1960 – 2004 mean (Fig. 8b). Between 1960 and 2004 rainfall in Nigeria decreased by 92 mm. This implies that within just four decades in Nigeria, there was a rainfall drop of 92 mm (7%).

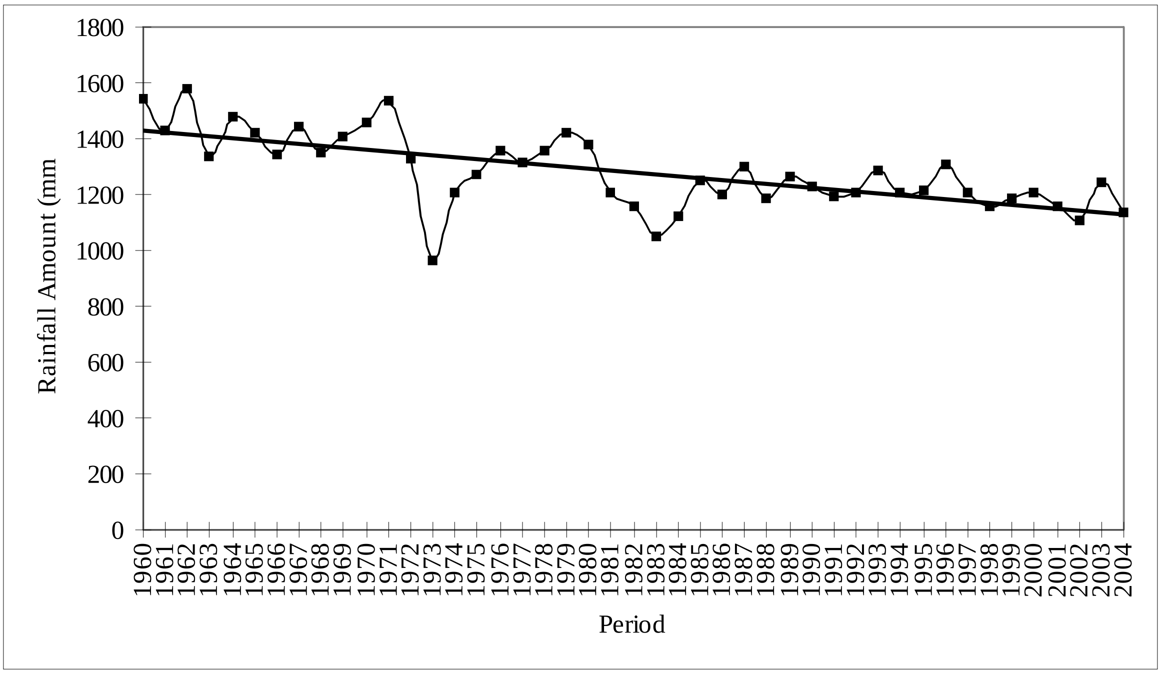

Fig. 8a: Rainfall Variations in Nigeria (1960-2004)

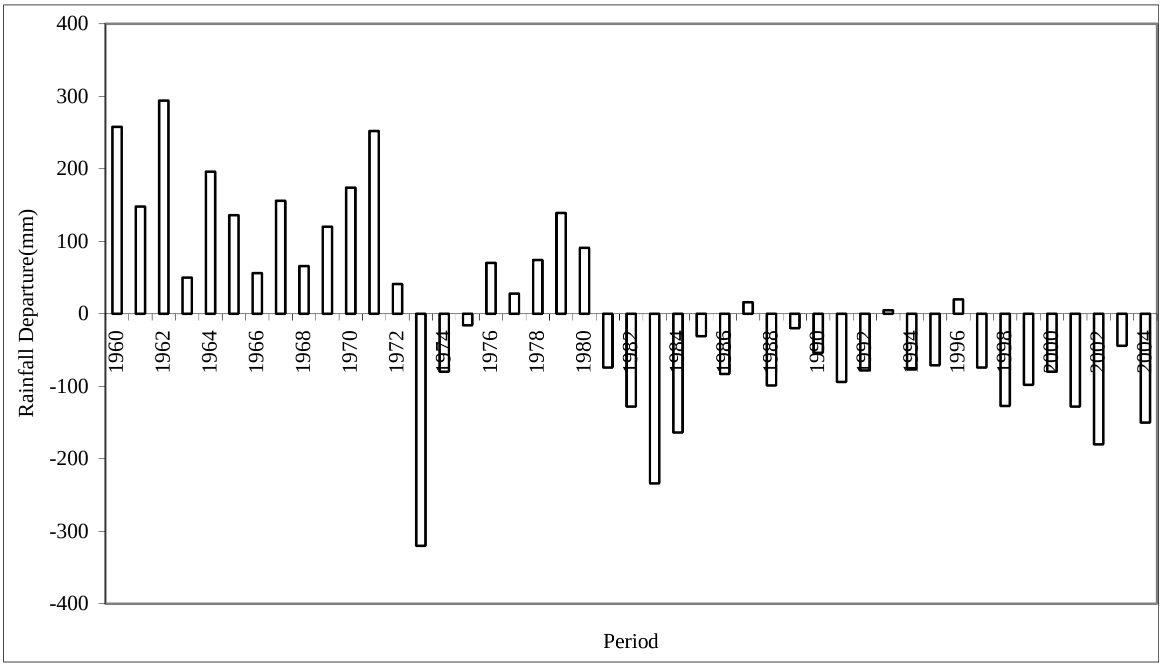

Fig. 8b: Rainfall Departures in Nigeria from the 1960-2004 Mean.

Although, there is a general decrease in rainfall in Nigeria, the climatic data between 1960 – 2004 shows that Nigeria south of 7^0N down to the coast is experiencing slightly increasing rainfall of 1-3% within the study period. Areas mostly affected were coastal stations between Ondo , Benin City and Calabar. This is a clear depiction of an evidence of global warming, because many studies have shown that climate change with its associated global warming will bring about more rainfall in most coastal regions and aridity to most continental interiors (IPCC 1996; Bosilovich et al., 2005 and Mshelia, 2005). Apart from the general rainfall decline, another character-

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istic feature worthy of note is a major shift in rainfall. The 500 mm Isohyet prior to 1970 was not found in Nigeria (Fig. 9a). By 2004, this Isohyet has drifted southward by 150 km in the Lake Chad region and westward by 950 km, almost taken over the entire northern fringe of the country (Fig. 9b). The 1000 mm Isohyet shifted southward by between 60-120 km. Also worthy of note is the 1200 mm Isohyet that engulfed the Jos plateau prior to 1970. This has shifted entirely off the Plateau zone down south, a distance of about 300 km at the river Niger-Benue conference.

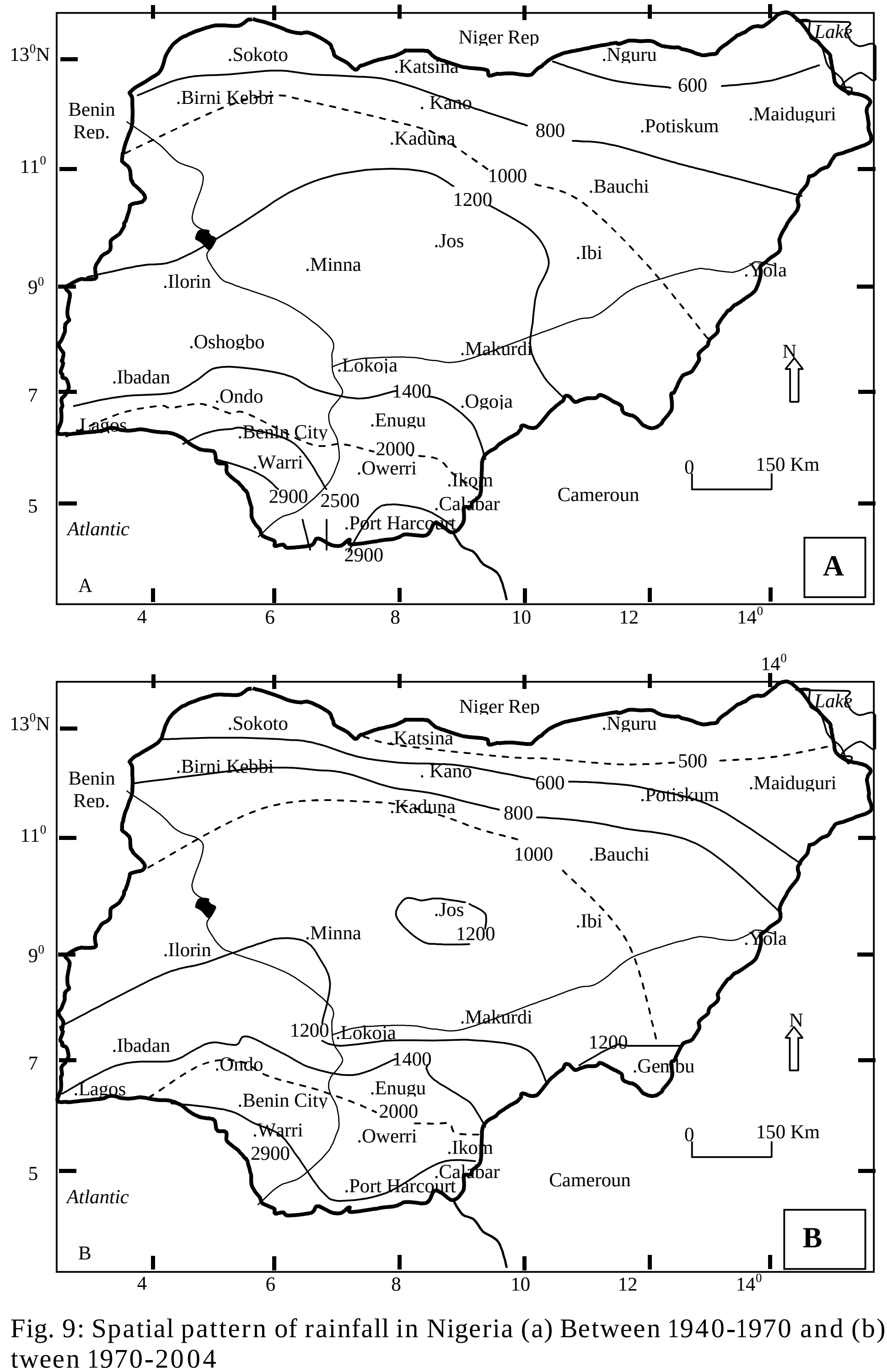

Fig. 9: Spatial pattern of rainfall in Nigeria (a) Between 1940-1970 and (b) Between 1970-2004

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Global water resources

Any country using <10% of her renewable water resources is classified as having no water stress. While 10 – 20% is classified low stress, 20 – 40% and >40% are regarded as medium and high stress respectively (Arnell, 1999). With this scenario, it is observed that population living in countries using between 20-40% of their water resources, as at 1990 was 1.750 billion out of 5.218 billion world population in that year. This amounted to 33.5% of the world population. In the same year, 406 million people (7.6%) were living in countries using more than 40% of their water resources (Table 2). By 2050, it was estimated that countries with population living with medium stress (20 – 40%) will almost double increasing from 33.5-62.7%, while those with high stress will increase over four times, from 7.8% to 33.8%. While it is a measure of relief that countries with medium stress will drop from 62.7% (2050) to 58.8% (2085), it becomes a matter of concern that high stressed countries will increase from 33.8% (2050) to 49.1% (2085).

Although, it has been generally asserted above that climate change will increase water stress, regional variation in vulnerability is expected. While climate change will make water stress worse in some countries, others will experience reduced stress. Table 3 shows the difference between the total population in countries where climate change increases stress and where it decreases stress. The general trend is that while the countries where climate change exacerbates water resources stress increases from 2.705 billion (2025) to 3.728 (2085) an upward of 27.4%, countries with decreased water stress increased from 2.369 (2025) to 2.866 (2085) billion, a drop of 17.3%. It implies that water stress will outweigh water decrease by 10.1%. A critical look at the net difference between the total population in countries where climate change increases and decreases stress in Table 3 shows an increasing value from 335 million in 2025 to 863 million people in 2085. This indicates that the imbalance between increased and decreased stress will be more than double in a period of just 60 years interval.

Table 2: The present and future water resource stresses

Period	World population (Millions)	Population in countries using >20% of their water resources (Million)	Population in countries using >40% of their water resources (Million)
1990	5218	1750 (33.5%)	406 (7.6%)
2025	8055	5028 (62.4%)	2370 (29.4%)
2050	9525	5974 (62.7%)	3217 (33.8%)
2085	10994	6464 (58.8%)	5316 (49.1%)

Source: Arnell , (1999)

(%) Author's Computation.

Table 3: Population in countries with increase and decrease water stress

2025	Population (Millions)
Increase	2705
Decrease	2369
Net	335
2050	
Increase	3260
Decrease	2736
Net	524
2085	
Increase	3728
Decrease	2866
Net	862

Source: Arnell, (1999)

By 2025, stressed countries with increase in stress will include Mexico, Guatemala, and Cuba (North America), Ukraine, UK, France, Italy etc (Europe), from Syria through Iran, Saudi-Arabia, India and Bangladesh (Asia), all North African countries, some West Africa countries (like Niger, Nigeria and Mali, etc) and South Africa (Africa). This agrees with the work of Tao et al., (2003), which showed that as from 2021, water demand will increase worldwide due to climate change. Water shortage they added will be worsened in Western Asia, the Arabian Peninsula, Northern and Southern Africa, North-eastern Australia, South-western North America and Central South America. On the other hand, stressed countries with decreased stress will be Alaska and U.S.A. (North America), Peru (South America), China, Thailand, Cambodia, Philippines and other Southeast Asian countries among others. By 2050, UK may move out of the stressed class, while Greece, Zimbabwe and Madagascar moved to stressed class. Apart from these countries, the geographic distribution of the direction of change in stress is the same as in 2025. By 2085, the same scenario in 2050 exists with few countries like Honduras, Nicaragua and Mauritania, moved to stressed class and Madagascar from stressed country to increase stressed class. (Arnell, 1999 and Nyelong, 2004).

A cautionary note here is that this water stress scenario, is an estimate based on Hadley Centre HadCM2 model and no one could be hundred percent certain of its accuracy. This is partly because projections of population growth have wide ranges, and partly because estimates of future water use per capita are uncertain. Despite these shortfalls, the scenario provides a clue to future water situation based on climate change.

Regional water resources: Case Study of Lake Chad

As shown in Table 4, Lake Chad occupied a total land area of 60,000 km^2 about a million years ago (Chindo and Nyelong, 2004). By 1963 when satellite imagery was available, the Lake was occupying 22,902 km^2. Within 9 years, that is in 1972 the Lake area coverage shrank to 16,884 km^2. This amounted to shrinkage of 26.3% and mean annual reduction of 668.7 km^2. By 1987, the total area has dropped to 1746 km^2, a decline of 89.7%. This is a clear indication that within 15 years interval, the Lake shrank with 15,135 km^2 giving an annual shrinkage of 1009.2 km^2. By 2000, the Lake has reduced to a mere 304 km^2, a reduction of (1442 km^2) 82.6% within 13

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years, with an annual shrinkage of 110.9 km². Moreover, the Lake's depth has dropped from 5.8 m in 1963 to a mere 2.2 m in 2000.

Table 4: Shrinkage rate of Lake Chad

Years	Area (Km²)	Reduction in Area (Km²) *	Average Annual Reduction (Km²) *	Mean Depth (m)
1 million years ago	60,000	6,018 (26.3%)	668.7	5.8
1963	27,902	15,135 (89.7%)	1,009.2	3.4
1972	16,884	1442 (82.6%)	110.9	2.8
1987	1746			2.2
2000	304			

Sources: NCRS, Jos and Chindo and Nyelong, (2004)

Generally put, the Lake Chad has reduced in size from 22,902 km² in 1963 to just 304 km² in 2000. This shows that what is left in 2000 is just 1.3% of 1963 while 98.7% of the 1963 size has dried up. One could now imagine or appreciate what is left of the Lake today. The most drastic reduction occurred between 1972 and 1987. This period coincided with the severe and prolonged drought of the 1970s and the 1980s, in the Shallian region of Africa. The 1987 to 2000 saw the second dramatic reduction. Although drought in this period is not as severe as those of the 1970s and early 1980s, they are more frequent. This period of frequent drought coincided with the time of highest temperatures observed globally, in the Sahellian region and also in Nigeria. Rainfall in the Northern region of Nigeria where the Lake is found has been on the decline since the 1980s, while the encroaching Sahara desert has impacted much on the size and depth of the lake through sediment deposits and enhanced evapotranspiration (Odjugo and Ikhuoria, 2003). These natural factors (drought, increasing temperature, decreasing rainfall and desert encroachment) accountable for the shrinking lake are indicators of climate change. The increasing temperature since the early 1970s (regional warming) and decreasing rainfall observed in Nigeria especially in the north-eastern part where Lake Chad is found actually resulted in evapotranspiration exceeding water recharge in the Chad basin.

Apart from these natural forces of climate charge on the Lake Chad, unsustainable human utilisation of the Lake water resources as a result of population pressure in the region in form of irrigation, animal husbandry, domestic and industrial uses are added human factors that reduces the Lake area coverage (Evans and Mohieldeen, 2002 and Odjugo and Ikhuoria 2003).

The resulting impact of the dwindling water resources in Nigeria has also led to observed changes in water levels in the Kainji dam, and other smaller dams. Potentials for establishing new dams are reducing due to low water mark in most rivers especially in the Northern Nigeria (NEST 2003 and Nyelong, 2004).

CONCLUSION

The paper observed globally and in Nigeria, an increasing temperature and decreasing rainfall amount over the years especially since the 1970s. This observed changing climatic condition has started affecting the water resources in most parts of the world whereby 2.3, 3.2 and 3.7 billion people world-wide will likely experience increasing water stress by 2025, 2050 and 2085 respectively. Lake Chad has shrunk from 22902 km² in 1963 to a mere 304 km² in 2000, while the depth has dropped from 5.8 m to

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2.2 m within the same period. While we advocate global reduction of greenhouse gases through sustainable technological development to reduce the effects of climate change, we also advise strongly global reduction of sea and ocean pollution, deforestation and increased afforestation programme to enhance carbon sink. Finally, the changing climatic condition and dwindling water resources are pointers to impeding water danger and its consequences on other sectors like agriculture, industry and tourism. It is hereby strongly suggested that countries currently stressed or that will experience water stress in the future like Nigeria, should start developing coping strategies, which will take care of the water scarcity, accompanying climate change. The coping strategies should include the protection and effective management of the watersheds, the ground and surface water resources. The current plan of inter basin water transfer from the Congo Basin, a distance of about 1600 km is a welcome idea and may be a possible solution to avoid the total disappearance of the Lake Chad.

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