International Journal of African and Asian Studies - An Open Access International Journal
Vol.1 2013

Review of Climate Change and Its Effect on Nigeria Ecosystem

Olaniyi O.A[1]., Ojekunle Z.O[2]. and Amujo B.T[3]
1,3 Joseph Ayo Babalola University, Ikeji, Arakeji, Osun State
2 Federal University of Agriculture, Abeokuta. Ogun State
Email: tundeniyiakinola@yahoo.com

Abstract
This paper examines the issue of climate change and its impact on the environment. The effects of man's activities as well as those of natural phenomena on global warming, climate change and the environment are presented and discussed. The options that are available as response to global warming: mitigation, adaptation and possible human suffering as consequences of what cannot be avoided by mitigation and adaptation are presented. An overview of the Nigerian environment, preparedness for the impact of global warming and related problems are also presented. The status of environmental data and the need for environmental baseline survey and the creation of a comprehensive database for the country driven by geographical information system are presented and discussed. The paper then underscores the need for governments at all levels to adequately fund geo information production and cultivate the culture of its usage for adequate and proactive response to global warming, sustainable environmental management and national development.
Keywords: climate change,mitigation, adaptation,global warming,environmental management.

INTRODUCTION

Climate change refers to an increase in average global temperatures. Natural events and human activities are believed to be contributing to an increase in average global temperatures. This is caused primarily by increases in greenhouse gases such as Carbon Dioxide (CO_2). Nigeria is experiencing adverse climate conditions with negative impacts on the welfare of millions of people. Persistent droughts and flooding, off season rains and dry spells have sent growing seasons out of orbit, on a country dependent on a rain fed agriculture. Alarm bells are ringing with lakes drying up and a reduction in river flow in the arid and semi arid region. The result is fewer water supplies for use in agriculture, hydro power generation and other users. The main suspect for all this havoc is Climate Change. Scientific studies show snows are disappearing rapidly. Climate Change has been confirmed following release of the 4th IPCC Assessment report. Africa will be worst hit by the effects of Climate Change which Nigeria is part of it.

1. THE EFFECTS OF CLIMATE CHANGE IN NIGERIA

The agricultural sector contributes some percentage of the Nigerian Gross National Product and majority of the rural populace are employed in this sector. The dominant role of agriculture makes it obvious that even minor climate deteriorations can cause devastating socioeconomic consequences. Policies to curb the climate change by reducing the consumption of fossil fuels like oil, gas or carbon, have significant economical impacts on the producers or rather the suppliers of these fuels. Nigeria is the eighth largest oil supplier in the world and the ninth largest deposits of gas. The Nigerian national economy would be massively affected by a sustainable reduction of fossil energy consumption. Nigeria is practically a monoculture: about 80% of the government income, 90-95% of the export earnings and more than 90% of the foreign exchange revenues evolve from the oil sector. However, during the last years the government of Nigeria tried to diversify. Special attention is nowadays paid to gas which emerges in the joint-production of oil. So far the gas has mainly been flared (75%), simply due to the lack of technical facilities to make use of it.
A study commissioned by the World Bank in 2007 Nigeria accounts for roughly one-sixth of the world-wide gas flaring which in turn, spews some 400 million tons of carbon dioxide into the atmosphere. However, the World Bank survey has listed Nigeria and 15 other oil producers, as countries that have progressively reduced gas flaring. Following the Kyoto-Protocol is a double-edged sword for Nigeria: The probably positive long term effects on the climate change are opposed to the negative short term effects for the economic development. Observing the Kyoto-Protocol would reduce the income of the OPEC – States, amongst them Nigeria, about 25% until 2010. This would be a catastrophe for the Nigerian development plan.
The countries politics and public discussions are barely addressing the mentioned problems. The last two years were so much dominated by the internal questions of power that political issues as regards content or even specific problems like the climate change would not have attracted real attention outside the circle of environment experts or NGOs. In terms of short term development policy more urgent worries exist and strategic foresight is not a fixed part of politics in the country. Furthermore, the climate change and its problems and solution strategies do not generate great publicity effects as they are too complex for rather superficial political talks. Nigeria's development plan does not recognize the economical threat caused by the climate change nor the menace of declining oil prices which could result from a reduced consumption of fossil fuels.
In the arid zones, droughts are getting worse and climate uncertainty is growing, Climate change is an

unprecedented and threat to food security. Arid and semi-arid areas in northern Nigeria are becoming drier, while the southern part of the country are getting wetter, Global warming means that many dry areas are going to get drier and wet areas are going to get wetter. They are going to be caught between the devil of drought and the deep blue seas of floods. However, "great tragedy" and Nigeria had played virtually no role in global warming; a problem was caused by economic activity of the rich, industrial countries. Unless climate change was tackled all the "best efforts" to help this great country could come to nothing. One of the biggest threats is growing climate unpredictability, which makes subsistence farming difficult. But a better planning to reduce the risk from disasters, together with developing agricultural practices that can withstand changing climates, have been shown to work and could help mitigate the impact if use more widely.

The impact of the change will be difficult to handle and it will be potentially very long lasting. "It is very serious," Two things, the scientific evidence on global warming is strengthening daily, and there are risks over and above those that are usually considered. The disproportionate impact on Nigeria will be for a combination of reasons. Global warming will be greater over land than over sea because land retains heat more than water. There is also increasing evidence that it will be particularly hit by the effect of vertical rises and falls in air currents. Climate change often appears very esoteric but in Nigeria, it's real. We already have an increasing incidence of disease, declining agricultural productivity, and a rising number of heat waves. There is glaring evidence that climate change is not only happening but it's changing our lives. Declining rainfall in already desert-prone areas in northern Nigeria is causing increasing desertification, the former food basket in central Nigeria is now empty, and people in the coastal areas who used to depend on fishing have seen their livelihoods destroyed by the rising waters. Adapting to climate variability and mitigating its impacts is something that we do in our everyday lives, but we have to understand what climate change is, that we contribute to it, and how we can adapt and reduce our vulnerabilities.

An urgent attention or something needs to be done about global warming and climate change.

2.0 Global Warming

Global warming is "the increase in the average temperature of the Earth's near-surface air and the oceans since the mid-twentieth century and its projected continuation." The scientific community has reached a consensus that global warming is real and that human activities are causing the warming trend. Global temperatures have steadily risen over the last century, and according to scientists, 2005 was the warmest year on record, and the warming trend is expected to continue through the 21st century and beyond. From various scientific researches, it has been estimated that average global temperature of the Earth surface increased 0.74 ± 0.18°C (1.33oF ± 0.32°F) during the 100 years ending in 2005. Scientific climate modelling projections recently summarised by the Intergovernmental Panel on Climate Change (IPCC) indicate that global surface temperature will likely rise a further 1.1oC to 6.4oC (2.0 to 11.5oF) during the 21st century. http://en.wikipedia.org/wiki/global_warming.

The direct effect of global warming is climate change, which means the disruption of climate pattern, and consequent impact on the environment and human life. Climate is the average state of the weather; it is fairly stable and predictable. Weather is the day to day state of the atmosphere; it is a chaotic non-linear dynamic system. In general climate means weather pattern that is, averages of variables like cold and hot, humid and dry, cloudy and clear, drizzles and downpour, breeze and blizzard, and other variables that can be measured at any given site.

Climate change refers to the change in the state of climate that can be identified by changes in mean or variability of its properties and that persists for extended periods, typically decades or longer. Climate change occurs when the amount of energy stored by the "climate system" is varied. The variation occurs when the balance, for example between energy received from the sun and the radiated energy is disturbed. This disturbance can be caused by a number of natural mechanisms such as variation in the earth's orbit, variation in ocean circulation, and changes in earth's composition. In recent times the disturbance is caused by human activities. http://en.wikipedia.org/wiki/climate_change

2.1 Causes of Global Warming and Climate Change

The Intergovernmental Panel on Climate Change (IPCC) and major scientific organizations of industrialized countries have concluded that the increase in global temperature since the middle of twentieth century has been due mainly to human induced (anthropogenic) greenhouse gases concentration via the green house effect; while the warming effect of natural phenomenon such as solar variation contributed a small warming effect from preindustrial times to 1950, and from then a reverse cooling effect.

The United Nations Framework on Climate Change (UNFCC) uses the term "Climate Change" for human induced change while the term "Climate Variability" is used for changes due to External Forcing. http://www.ipcc/ch. External forcing is climate change caused by change in the global energy balance owing to fluctuations in the Earth's orbit, ocean circulation and atmospheric composition.

2.1.*1 Greenhouse Effect*

This is the process by which radiative energy leaving a planetary surface is absorbed by some atmospheric gases, called greenhouse gases. The Sun is Earth's only external form of heat. It emits solar radiation mainly in the form

of shortwave visible and ultraviolet (UV) energy. As this radiation travels toward the Earth, about 25% of the radiated energy is absorbed by the atmosphere and about 25% is reflected by the clouds and other gases back into space. The remaining radiation travels unimpeded to the Earth and heats its surface. The atmosphere acts like the glass in a glass greenhouse, allowing much of the shortwave solar radiation to travel through unimpeded, but trapping a lot of the long wave heat energy trying to escape back to space. The greenhouse gases transfer the energy to the surface and lower atmosphere and it is reradiated in all directions, including down towards the Earth's surface. This process makes the temperature rise in the atmosphere just as it does in the artificial greenhouse.

2.1.2 The Earth's Natural Greenhouse Gases

In their natural state of occurrence the Earth's greenhouse gases do not constitute any danger to the environment. The Earth's natural greenhouse effect transfers energy to the Earth's surface and lower atmosphere; so that the temperature there is higher than it would have been if direct heating by solar radiation were the only warming mechanism. This process has a warming effect of about 33oC, without which the Earth will be uninhabitable. The major natural greenhouse gases are: water vapour which causes 36%-70% of greenhouse effect; carbon dioxide, CO2, 9%-26%; methane CH4 4%-9% and ozone with 3%-7%.

http://www.ace.mmu.ac.uk/eae/Climate_Change/Older/Greenhouse_Effect.html,

http://en.wikipedia.org/wiki/global_warming

2.1.3 Anthropogenic Human-induced Greenhouse Gases

Researchers have shown that the main cause of global warming and climate change is the continued increase in the level of CO2 as a result of emissions from fossil fuel combustion, deforestation and cement manufacture which are the major causes of CO2. Fossil fuel combustion and deforestation produce the most significant CO2 than cement production which is fingered as third largest producer of CO2. The global CO2 level will continue to rise due to continued burning of fossil fuel and land-use changes, especially deforestation. The rate of increase will however depend on economic, sociological and natural developments. See Tables 1 and 2

http://en.wikipedia.org/wiki/global_warming

2.2 Indicators of Global Warming

Global warming produces increase in global temperature which impacts directly on human life and the natural environment. Increasing global temperature is having serious effects and consequences for the world, including rising sea levels (fig.3), changes in climate patterns, change in the amount and pattern of precipitation, and more severe weather including stronger tropical storms, droughts, and heat waves, likely including an expanse of the subtropical desert regions. Other indicators of global warming include Arctic shrinkage and resulting Arctic methane release, shrinkage of the world's rainforest (already very damaged by deforestation from logging and farming), increases in the intensity of extreme weather events, changes in agricultural yields, glacier retreat, species extinctions and changes in the ranges of disease vectors. The recent natural disasters caused by tropical cyclones, hurricane; flooding in Bangkok Thailand, Australia and India; sea level rise, heat waves in Europe, coastal erosion and flooding due to high precipitations are attributable to global warming and associated extreme weather conditions. In the Sub-Saharan Africa, there had been persistent drought and desertification in recent years, and the trend is likely to continue.

http://en.wikipedia.org/wiki/global_warming

The effect of global warming is not uniform all over the planet, (fig1). The northern hemisphere has more landmass than the southern hemisphere therefore the greenhouse effect is more intense. Furthermore the countries in this region are more industrialised and generate more CO_2 and hence higher warming due to greenhouse effect. The United States of America is the largest emitter of CO_2. While the industrialised nations contribute more to global warming and have the capacity to adapt to its effects, developing nations which contribute less has no adaptive strategy to cope with climate change.

2.3 Response to Global Warming

Knowing to manage the territory, protect the environment, evaluate the cultural heritage The available options are: mitigation to reduce further emissions; adaptation to reduce the impact of global warming on the environment and human life.

2.3.1 Mitigation

This means that the measures must be taken by various nations to reduce rate and magnitude of global climate change caused by human activities. According to IPCC, the mitigation options includes reduction in burning of fossil fuels and reduction of greenhouse gases and soot from the energy sector; reduction of deforestation; increase in reforestation and afforestation; modification of agricultural practices to reduce emissions of greenhouse gases and build up soil carbon. Other mitigation options include: geo-engineering to reverse the effect of global warming by creating cooling effects which will offset greenhouse heating; and conceiving the development of technology for clean the greenhouse gases from the atmosphere. It has been estimated that at present the cost and benefit of mitigating global warming are approximately the same. In general, the IPCC concludes, without mitigation global warming will reach a point where it will be impossible for some natural systems such as ecosystem to cope and therefore may go into extinction. As for humans the cost of adaptation

will be so prohibitive that many will not cope. It is therefore essential to do a little of mitigation and a little of adaptation.

2.3.2 Adaptation

Adaptation means that we should take measures to reduce the adverse impact of global warming on human life and the environment. Some of the options that are available include: changing the cropping patterns; stopping further development on wetlands, flood plains, and close to sea level; developing crops that are resistant to drought, heat and salt; strengthening public health and environmental engineering defense against diseases; designing and building new water projects for flood control and drought management; construction of dykes and storm surge barrier against sea level rise (Holdren, 2010).

2.3.3 Which is the Better Option: Adaptation or Mitigation?

It is evident that mitigation alone cannot work because global warming is already occurring and cannot be stopped. Equally adaptation alone will not work because adaptation will get costlier and less effective as global warming grows. Therefore what is needed is enough mitigation to avoid the unmanageable consequences of global warming, and enough adaptation to manage the unavoidable. Both mitigation and adaptation will not totally eliminate the impacts of global warming; there will still be some of the impacts which cannot be treated under mitigation and adaptation, which humans have to suffer. Therefore to avoid the amount of suffering, a lot of effective mitigation and a lot of adaptation have to be done.

3.0 ENVIRONMENTAL ISSUES (ECOSYSTEM)

3.1 Evidence of Global warming and Climate Change in Nigeria

Developing countries like Nigeria are least prepared for the impact of global warming. Global warming is real and evidence abounds in the country. Although the country has been lucky not to have experienced major climate-change-induced natural disasters, the effect of climate change is evidenced by rise in sea level and erosion along the nation's coastline; the weather pattern is no longer distinct in the country, we have witnessed very hot weather conditions and high precipitations leading to flooding which ruined crops in parts of the country creating food scarcity, the latest being Jigawa State; gully erosion has sacked many communities especially in Edo and Anambra States; as a result of persistent drought, the Lake Chad has almost dried up, while there had been persistent desert encroachment in the north. The dearth of statistical data and non-collection environmental data in a systematic manner make it difficult to estimate in concrete terms the overall effect of climate change on: agriculture and food supply, flooding and erosion, health risks diseases spread, water resources, wildlife, level of CO2 emission and trends in temperature increase, and their effects on the social and economic systems of the country. A comprehensive audit of the environment is needed to quantify the effects of global warming and the level of degradation and loss of biodiversity, so that we can start to put in place some mechanism for responding to these challenges.

Climate change is also affecting Nigeria's energy sector profoundly. Conflict over the use of water resources among different economic sector has adversely affected the hydropower

plants in Kanji, Jebba and Shiroro which is the key to the security of electricity supply in the country and represent about one-third of the country's total installed electricity generating capacity. These plants have produced significantly lower energy leading to epileptic power supply as a result of excessive drought that lead to evapo-transpiration affecting water volume and the capacity of the power plants to produce optimally. Incessant power outage increases the cost of doing business and hampers the pace of industrialization in the country. Industries that are dependent on climate sensitive resources or conditions e.g. agro businesses, construction, infrastructure, transportation, pollution control are potentially vulnerable to changes in the climate. Conflicts with indigenous people relating to their displacement changes to their natural habitat (deforestation, pollution degradation etc), and influences on their ancestral customs and modes of economic production. Conflicts may also demand greater participation in decisions that affect the population directly.

Climate change is equally a major problem caused by the increase of human activities leading to several direct and indirect impacts on health. Disasters have a direct impact on local infrastructure and indirectly produce social conflicts affecting the access to basic needs of food, housing and health. These climatic changes will have wide-ranging harmful effects including increase in heat-related mortality, dehydration, and spread of infectious diseases, malnutrition, and damage to public health infrastructure.

It is anticipated that the impacts of climate change will lead to an increase in unemployment rates. There are no public policies to prevent climate change impacts on the labour sector. There could be some changes in this sector due to three main factors; Internal and external migration flows will trigger the need for groups of people to adapt both to a new territory and to new labour conditions.Also, as consequences of damaged infrastructure due to recurrence of natural disasters, it is estimated that there will be a period of mass unemployment in those sectors that rely on this infrastructure, until it has been rebuilt.

3.2 Environmental Sustainability

Sustainability is defined by the World Commission on Environment and Development (WCED, 1987) commonly called the "Brundtland Commission" as "development that meets the needs of the present without

compromising the ability of the future generation to meet their needs". Sustainable Development has also been defined as "a process of social and economic betterment that satisfies the needs and values of all interest groups, while maintaining future options and conserving natural resources and diversity" (IUCN,1980). Sustainable development is a dynamic process. To continually meet the needs of the present generation means that there must be continued economic growth. Economic growth in turn must ensure that minimum damage must be done to the environment. The major resources that determine the wellbeing and quality of human life are shelter, air, water, energy, food, raw material and the environment. These basic resources must be exploited in such a manner that the needs of future generation will not be compromised while satisfying the needs of the present generation. To achieve this knowledge and action are required. In the Nigeria context, like most developing nations, there is no adequate information on the location and state of resources, their rate of exploitation and socioeconomic activities and their impact on the environment. In other words resources are not being exploited in a sustainable manner. The current situation is exacerbated by climate change which is affecting the availability or quality of these resources.

3.3 Monitoring and Managing the Environment

The first step in responding to global warming and other environmental issues is to have adequate knowledge of the extent and nature of the effects of climate change on the environment. Thus before the environment can be meaningfully monitored and protected, all parameters defining the environment must be relatively and spatially located to create a spatial Global Warming and the Environment: Issue and Geoinformation Challenges Knowing to manage the territory, protect the environment, evaluate the cultural heritage database. Information about the status of these parameters can then be treated as metadata and linked to the database. In other words when we know the parameters defining the environment and the natural interrelationship which helps to maintain a balanced ecosystem, then we can start to put in place all measures to ensure that the initial balance is maintained by cautioning the activities of man; co-operating with and taking measures to check some adverse effects of some natural occurrences on man and the environment. Therefore adequate framework for monitoring and managing the environment must be put in place; which framework should be proactive in nature rather than correcting distortions of existing physical development planning. This means that actions should continually be taken to respond to the ever increasing environmental challenges and to plan ahead of challenges

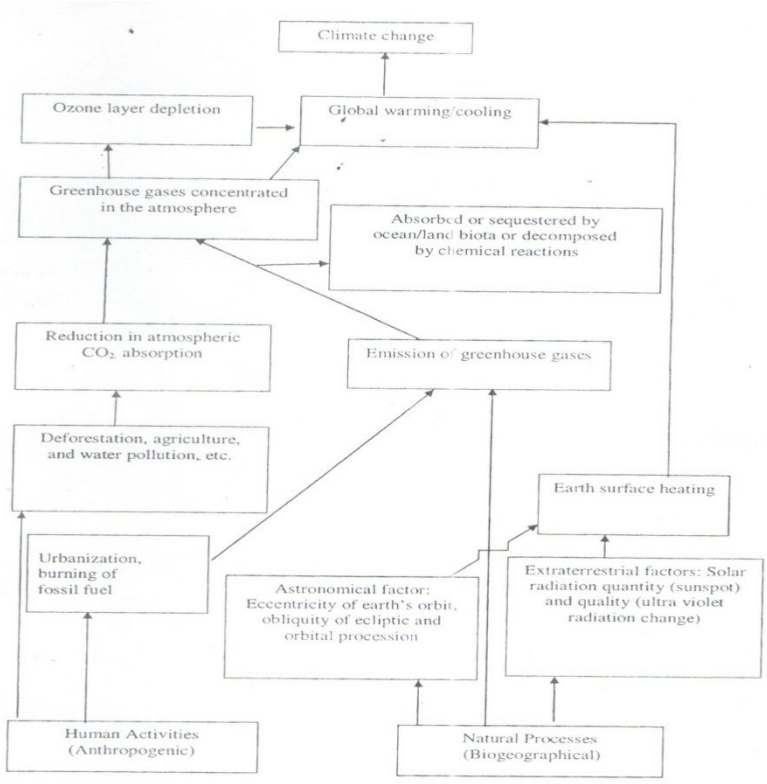


Figure 1. Causal factors of climate change.
Source: Odjugo (2010).

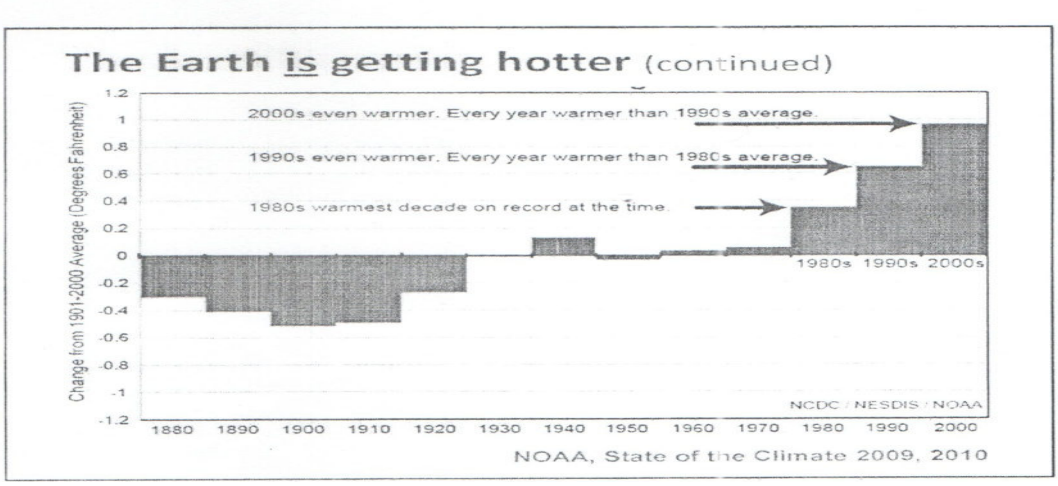


Fig 2 Average Climate Change over the Century (Adapted from Holdren 2010)

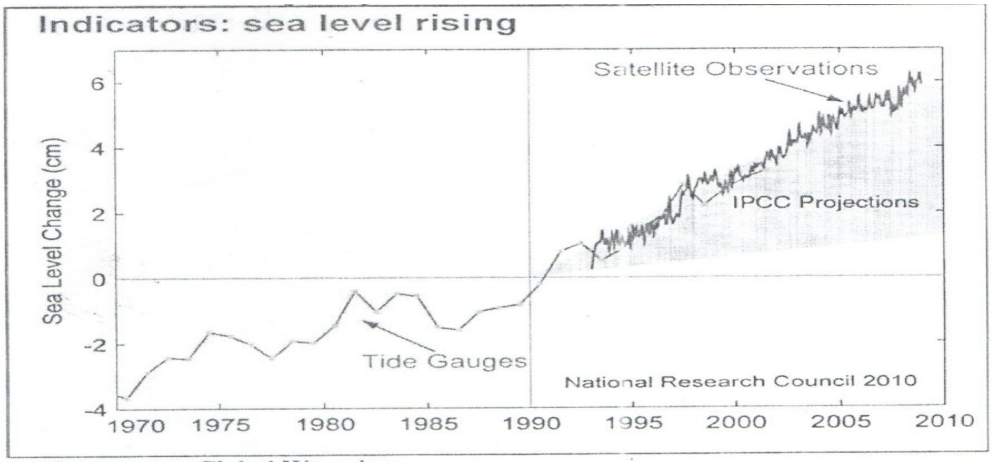


Fig 3: Sea Level Rising (Adapted from Holdren 2010)

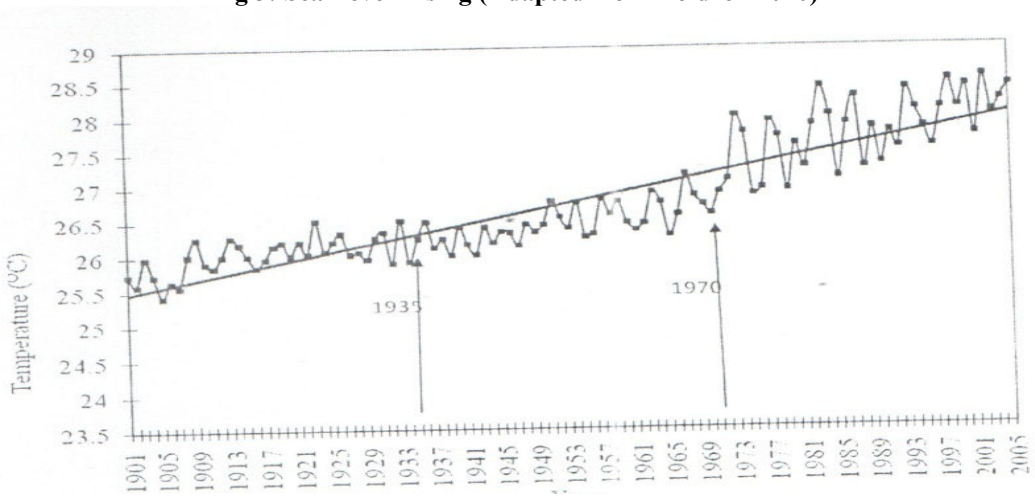


Fig 2: Air Temperature Distribution in Nigeria 1901-2005

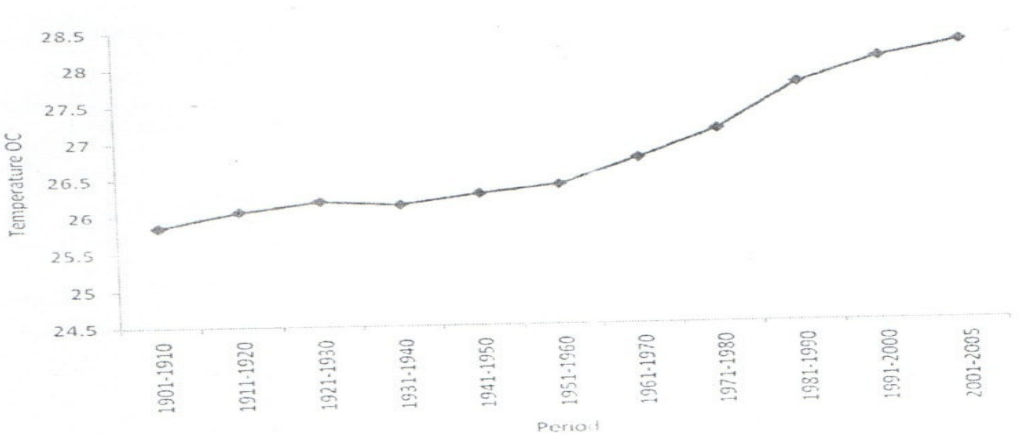
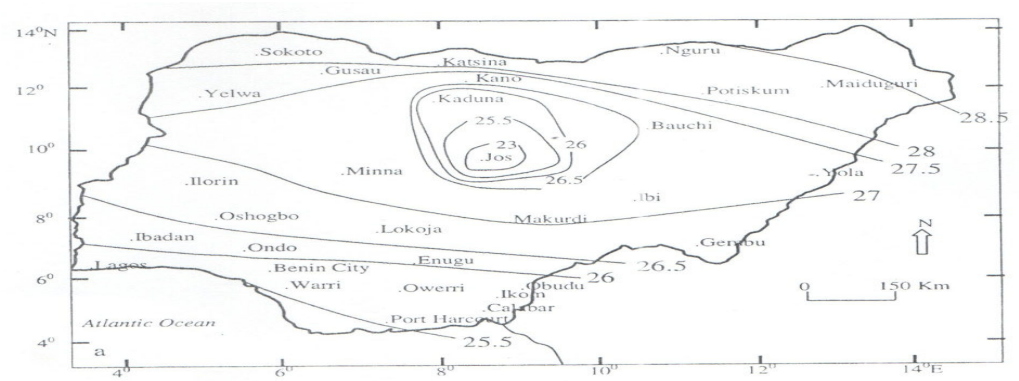


Fig 3: Decadal Temperature Variation in Nigeria Between 1901-2005

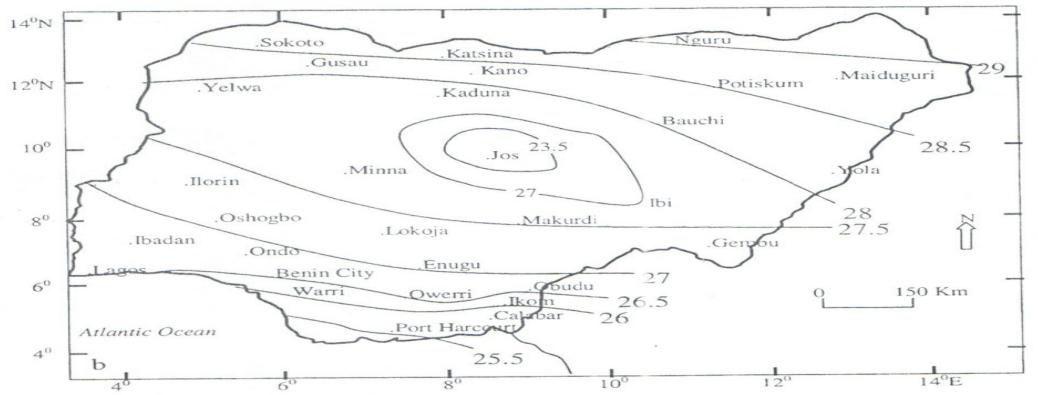
Table 1. Relationship in temperature variation between the three climatic periods.

	T1	T2	T3
T1	1.00		
T2	0.238	1.00	
T3	0.373*	0.463**	1.00

T=Temperature; 1=1901-1935; 2=1936-1970; 3=1971-2005 Climatic period
*Significant at $p = 0.05$; **Significant at $P = 0.01$



Spatial Pattern of Mean Air Temperature in Nigeria (1901-1935)



Spatial Pattern of Mean Air Temperature in Nigeria (1936-1970)

4.0 WHAT SHOULD WE DO?

4.1 How Should Nigeria Respond to Global Warming?

Global warming is a reality. Therefore the nation should be proactive in her response to the phenomenon and its challenges and should not wait until much damage is done which will be very costly to correct. Developing nations like Nigeria should not fold their arms and wait for international donor agencies and Research Institutes to provide wholesale solutions their global warming issues. They must take up the challenge and seek cooperation and collaboration with International Agencies in other to create opportunities for technology transfer. There are a number of adaptation and mitigation options that the country can embark upon
using the existing government institutions, which do not require any elaborate capital outlay

but the right political will to ensure enforcement and compliance. The Agriculture and Research Institutions should commence research into crops that are resistant to drought and heat. The River Basin Authorities should commence the study, design and construction of new water projects for drought management and erosion control. The Ministries of Environment should start addressing the rapid erosion of the nation's sandy coast by construction of dykes and storm surge barrier against sea level rise; while further development on wetlands, flood plains, and areas close to sea level, especially by the poor who are most vulnerable to disasters, should be stopped.

The mitigation options should start with the gas flaring and oil pollution in the Niger Delta which should be tackled with all the force of government and stopped forthwith. Deforestation should be reduced by encouraging mechanised farming and use of cooking gas instead of wood fuel, while concerted efforts should be made to address afforestation and reforestation. The Ministry of Science and Technology and Universities of Technology should start research into "Clean - Energy Technologies," Solar Energy, as an ultimate alternative to fossil fuel burning.

A National Climate - Change Adaptation/Mitigation Task Force with members drawn from various relevant Parastatal, Ministries, NGOs, Research Groups and relevant Institutions should be set up to address various responses to global warming as well as carry out national research programme on the effects of global warming on the country Government has organised two Global Warming Summit in the country should be commended for this. Other State Governments and especially the Federal government should take a cue from Lagos State to discuss global warming issues at the state and national levels.

However, as a starting point to the response of global warming the current impact ofphenomenon on the environment must be known by carrying out a national environmental baseline survey.

4.2 Environmental Baseline Survey

The nation should take advantage of the current debate and international attention to climate change to confront her environmental problems which are being compounded by global warming, by taking a holistic approach to her response to the impact of global warming and other environmental issues. The first step is to have adequate knowledge of the status of the nation's environment through the conduct of national environmental baseline survey.

4.2.1 Environmental Data

Information on the environment is essential to managing environmental problems. This information is obtained through the collection of relevant time series environmental data statistics – and the development of an environmental database. Environmental statistics is a set of variables on the environment systematically and multi-temporally collected to indicate changes over time, cause of change and effect of the change on the environment and human wellbeing. Thus two types of data are needed; these are the baseline condition and the timeseries

changes in the baseline condition.

4.2.2 Environmental Data Collection

Environmental data collection should cut across all aspects of the nation's socioeconomic

activities and therefore all stakeholders in the public and private sectors must be adequately involved. At present environmental data are been collected by various ministries, agencies, environmental NGOs, environment Consultants/Researchers, academic institutions and other private initiatives. The activities of government organs responsible for environmental issues in the country and the various agencies are not coordinated, despite the fact that the Federal Environmental Protection Agency had existed since 1988 and the Federal Ministry of

Environment was created in 1999. Thus, available data are not coordinated, standardized and comprehensive enough to be used for creating an environmental database.

Adeyinka et al, (2005) submitted that "there are a lot of environment-related data in Nigeria which are not readily available as they are usually scattered in the various Government Agencies/Departments in form of technical reports/publications or in files that are not easily accessible as a comprehensive database for this purpose is yet to be put in place." There is therefore the need for an environmental baseline survey of the country. This database will then form the basis of future measurements. The database must reflect all environmental indicators of climate change, biophysical environment, socioeconomic environment, natural disasters as well as appropriate policies and institutions.

REFERENCES

Atilola, Olusola. 2010. Global Warming and the Nigerian Environment: The Imperatives surveying and Mapping Services. Presented at the National Conference of the Nigerian

Union of Planetary and Radio Sciences (NUPRS) University of Lagos, Lagos State, 12th -15th October, 2010

Atilola, Olusola. 2005. Environmental Monitoring and Management: The Imperatives of Surveying and Mapping Services. Invited Paper, Survey Co-ordination and Advisory

Board on Survey Training Conference, Kastsina, Katsina State; 29th – 31st August.

Adeyinka, M.A., et al 2005. Country Report, Workshop on Environmental Statistics, Senegal, Feb. 28 – March 4.

http://unstats.un.org/unsd/environment/Nigeria
Atilola, O. 2003. Sustainable Development and the Built Environment – The Role of Surveyors. Paper Presented at the CASLE Pre-CHOGM Seminar, Abuja. 1st December.
Federal Republic of Nigeria, 2005. Report of the National Political Reform Conference,Chapter 3.
Holdren, J. P. 2010. Climate-Change Science and Policy: What Do We Know? What Should We Do? Keynote Address, Kalvi Prize Science Forum, International Cooperation in Science, Oslo, September 6,
Volpe, F. and Rossi, L. 2005. Mapping Towns from Quick Bird Imagery. GIM International, Volume 19, Issue 5.
World Commission on Environment and Development, 1987. Our Common Future.
Oxford Univ. Press, Oxford