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LIVING IN A SEVERELY ALTERED WORLD

By

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Professor of Geography

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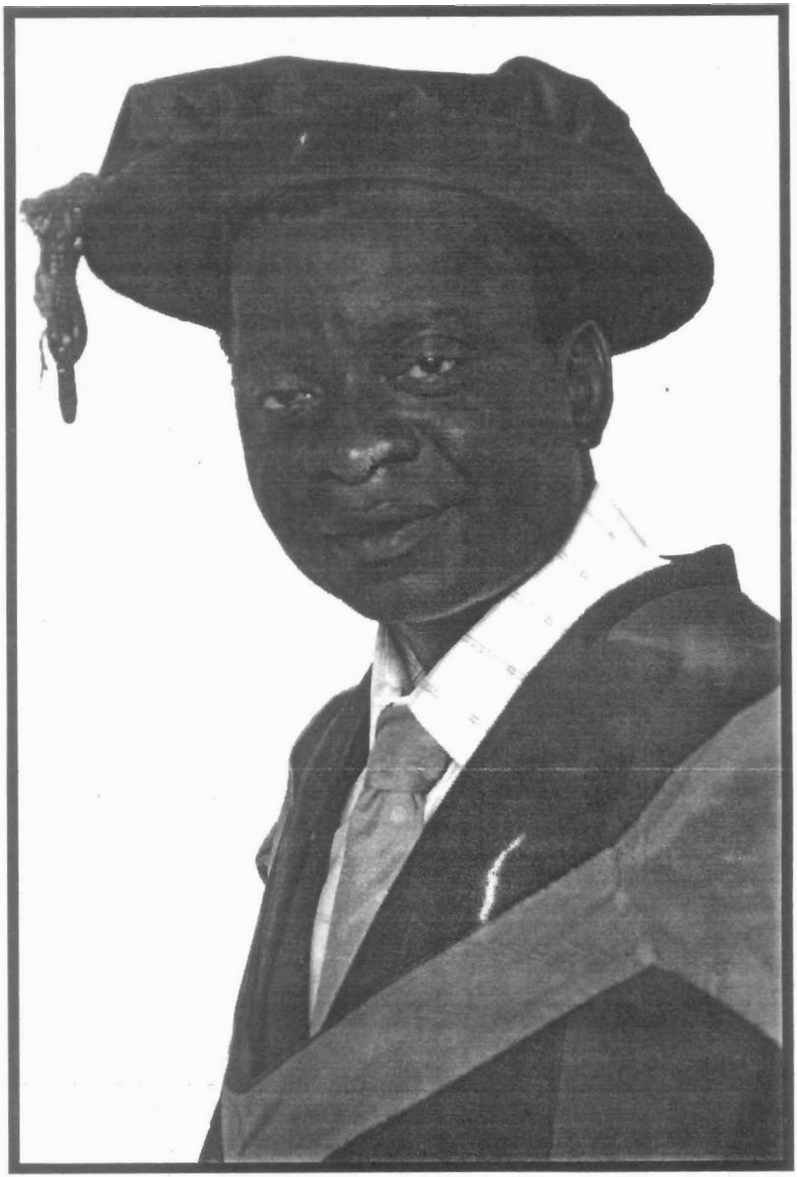

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1. INTRODUCTION

Whichever way one chooses to look at the environment, change is everywhere. The more obvious and undeniably intimidating changes which everyone appears to think about are those that relate to everyday living such as mode of dressing, music, foods and feeding habits and various forms of human organizations. Changes in the physical environment i.e. in those features that are natural hardly attract our attention. Yet they are fundamental as they provide the basis of human existence. Today a most critical change is occurring in the earth's climate system and is so significant that it has become a global political and economic issue - political because the community of nations has to organize itself to address the emerging issues, and economic because the causes as well as the proven actionable responses to the consequences of the changes touch on the economies of nations.

Change has always been part of the society and it is often said that the only thing that does not change is change itself. For instance, about one and a half centuries ago, Reverend Henry Lyte, apparently reacting to the deterioration of things around him had expressed some sense of serious changes when in his famous hymn "Abide with me" he noted "... change and decay in all around I see; O thou who changest not, abide with me" (Osbeck 1985). It is most probable that the change Lyte saw then was only a child's play compared with what obtains now. What is there for us to learn is that we must necessarily show a greater concern today about the environment as the inner cities rust away and the luxuriant vegetations around us disappear. After all, "The earth is the Lord's and the fullness thereof". If we remain careless with it, the Owner has the final say. The crux of the matter is that the world of today is far from being what it was; it has changed so much from what most people even in their twenties are familiar with and we have to responsibly live in it.

The crisis of climate change is best captured by the proverbial Yoruba saying that if the sky were to crash no one, rich or poor will be able to secure a cover for his head. A full scale climate change which now appears

inevitable, will obviously affect everyone. This is why the world economic leaders have taken the issue with utmost seriousness. For instance, in 2007, the German Presidency made the fight against climate change the priority for the year. The Japanese have adopted a similar approach for 2008.

2. CARBON AND GLOBAL ACTION

The main culprit in the whole saga is carbon, the preponderance in the atmosphere, of which is causing the earth to heat up, leading to fundamental changes in the earth-atmosphere system. It is now clear that in the spirit of the famous Kyoto Protocol, the way out of the problem is ultimately to cut back on carbon emission particularly from fossil fuel burning in cars and industries, (and in a country like Nigeria, from the millions of stand alone diesel and petrol powered generators) to a level at which the world can eventually, at the minimum, reduce the present level of degradation. The global rise in the cost of crude oil has in recent months somewhat, aided the drive towards carbon cut as more and more people in the rich nations of the world abandon their fuel guzzling cars for more fuel efficient ones, or further still withdraw from the use of private cars altogether. Rapid carbon cuts, can as evidenced in IPCC report of 2007, assuage the gliding of the earth towards a precipitous collapse.

Since the Rio Summit of 1992, the global community has engaged in the implementation of a wide range of responses to avert or at least minimize the dangerous consequences of climate change. This has been significantly through the United Nations Framework Convention on Climate Change (UNFCCC), which is a major international structure dedicated to addressing the change. It has the ultimate objective of stabilizing "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (human-made) interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

Mr. Vice-Chancellor Sir, the activities that have brought the global community to where it has found itself today are connected with the use and misuse of environmental resources. There is now a real threat to the gains of the many centuries of civilization and economic development.

In July 2008 Sir, the eleven desert frontline States in Nigeria namely Adamawa, Bauchi, Borno, Gombe, Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto and Yobe met as usual, to think through the ways to approach the challenges of failing rains and crop failures. The grim face of desertification was visible as many communities were still praying for the first rains in July! Among other challenges, States like Yobe and Borno had lost close to fifty percent of their land to sand encroachment due to declining rains, poor farming practices, fuelwood extraction and grazing. Like in some recent years, the rains arrived rather late. However, less than a fortnight after the first rains on July 16, 2008, the heavens opened in Katsina State. Na-Kellu village in Ingawa Local Government Area was flooded with loss of life and property. This trend of events has become characteristic of the changing climate. It involves many crises following each other in rapid successions (in this case flood after drought), leaving the peasants in particular, little or no opportunity to recover from one crisis before another sets in (Adesina et al 2008).

Despite the devastating consequences of what is happening around as illustrated above, and the global sensitization on climate change as exemplified by Al Gore's *Inconvenient Truth,* there is an aura of lack of concern and or poor understanding of what dangers are looming around the corner in this country. I have therefore sir, chosen to speak on "Living in a severely altered world" with specific reference to Nigeria as a reflection of some of my research concerns in the last two and half decades. I also feel highly privileged to dedicate this unique opportunity to talking about climate change from the environmentalist perspective and so drum some of the burning issues louder beyond the rhetoric of politics.

3. THE THRUST OF THE LECTURE

A study of the history of inaugural lectures revealed useful ideas about this important academic event. First is that, the lectures are usually delivered once, and they normally have a thesis not entirely extraneous to the interests and concerns of the inaugurator, or his hearers. Second, they may contain the inaugurators' thoughts for future engagements based on their previous studies, or they may be a distillation of ideas from the authors' many years of research. Third, they provide the lecturer models along which he could pattern his presentation.

In general, at least three types of inaugural lectures are common: the sublime, the prophetic, and the familiar (e.g. Temp, 1954). I am of the opinion that Adejuwon's (1974) lecture and that of Jeje (1986) for example, belonged to the first category given the nature of the discourses presented and the depths of prognosis that they projected as distinguished Nigerian Geographers. I have chosen to stand in the middle of the last two types not for a fear of attempting the oversized shoes of the distinguished men who taught me the rudimentary of spatial research but rather because of the nature of the subject I have chosen to speak on which is both "prophetic" and "familiar". I have also found inspirations for the choice from the immediate relevance of such lectures as that of Adewuyi (1993) on Demography which focused on Nigeria's census as "an unending search for truth". Really, my choice should not be any different having been brought up with strong Christian ethics (which place premium on decorum that is needed to address climate change) by my humble parents, and of course with my deep conviction that God holds the earth in His palms, He knows the begining and end of everything and He created the earth and all in it for His own glory.

Although climate change is already here, the magnitude and direction of the changes when they are fully established are still difficult to define with any finality. I have chosen to reflect on some aspects of our studies over the years in the context of a better understanding of the genesis of the phenomenon and how we might hope to live with its reality in Nigeria.

Permit me Mr. Vice-Chancellor sir, to say a few words about the discipline called Geography that has provided me with the platform for my studies.

4. THE STUDY OF GEOGRAPHY

It is difficult to give an all-encompassing definition of Geography but most practitioners and patrons of the discipline agree that Geography deals with such things as the art of map making, man's adjustment or reaction to his environment, what is where in what quantities, what is changing in the environment and what is responsible for the changes (e.g. Sempel 1911; Hartshorne 1939; 1958; Adesina 1989). This of course had given the impression, and, strongly expressed too by critics of the discipline, that geographers study just anything since everything has spatial characteristics and expression. However, the trend since the middle part of the last century has been on the training of geographers in skills that can directly impact on socio-economic development (e.g. Mabogunje 1986) as well as those who can recognize specific environmental challenges and articulate some framework within which they can be addressed by specialists from various fields (Jeje 2007).

Two approaches to the study of Geography have been dominant over the years. These are the regional and the systematic approaches (Dikshit 2004). The regional approach rests on a premise that every part of the earth's surface can be classified into one region or the other. Consequently, it advocates the study of the various areas as parts of well defined regions with distinctive characteristics and delineable boundaries. It has, however, been criticized as unrealistic in nature. Proponents of the approach believe that geographical difference among, is larger than within, a region, but this is usually not the case. The environment is a complex of several physical and human parameters and regions are usually meaningful as distinctive organic units in terms of some specific parameters of the environment that are of interest. For instance, it is possible to have two regions with comparable climates but with different vegetation types because of variations in edaphic characteristics. It is also true that physical

regional characteristics do not have direct relationship with socio-economic progress or technological advancement.

Despite the weaknesses of the regional concept, it has provided a useful tool for examining changes in the environment and determining their impacts as well as planning appropriate response strategies. Indeed a major actor in the development of the discipline (Hartshorne, 1939) suggested that despite its criticisms, the regional concept provides the "aperture" with which geographers should view the world and provide answers to the myriads of emerging questions pertaining to man and his rapidly changing environment. To a large extent, this has proved useful in the global responses to issues on the environment.

The systematic approach, which has been the main alternative approach, emphasizes the study of specific elements or subject matters such as agriculture, water resources, plant cover, transportation or settlement. It seeks to understand the processes which influence such elements and the spatial patterns which they cause. Since the 1950s, the systematic approach had taken the central stage in geographic studies and has been strengthened by the quantitative revolution in the discipline (Chorley and Hagget, 1967).

5. CLIMATE CHANGE

I am of the view that it has taken the human race too long a time - and one hopes it is not too late- to discover that the consequences of the misuse of the environment are not simply phenomena like environmental degradation, environmental decay, air and water pollution, drought/ desertification, depletion of natural resources or in general a "threatened environment" (e.g. NEST 1991) among others. Of course, these are some of the most obvious impacts and so have invariably dominated our view of the alterations in the physical environment. One certainly does not require any soothsayer for example to know that the immediate environment of Lake Chad is no longer able to sustain the life and livelihood it previously supported; that the Lagos lagoon now suffers from what one may describe as "first degree" pollution; that the once

flourishing and species-rich ecosystem of the Hadejia-Nguru wetlands on the Komadugu-Yobe basin in north eastern Nigeria is now a shadow of its old self, or perhaps much more familiarly, that the environment of the Niger Delta is, to say it mildly, devastated. While all of these are true and profoundly challenging, these impacts had actually been creating more serious extra-terrestrial effects on the earth's atmosphere. Scientists now know that the many centuries of exploitation of the earth's resources which was interpreted as human progress or development have had damaging consequences on the fundamental attributes of the environment i.e. the climate system - that guaranteed life on the earth *ab initio* and man's persistent survival. It is now appreciated that since the industrial revolution of the late 1870s, large volumes of CO_2 have daily been pumped into the atmosphere from the huge industrial plants that litter Europe and America. It is estimated that CO_2 concentration in the atmosphere increased from about 280 parts per million (ppm) in the late 17th century to close to 400ppm in year 2000 (Figure 1a,1b). The figure for year 2000 has been projected by IPCC (2007) to reach 855ppm by year 2100.

The prevalence of CO_2 and other gases which are collectively referred to as green house gases (GHGs) is largely responsible for global warming. Other significant GHGs include sulfur hexa-flouride (SF_6), nitrous oxide (N_2O), chlorofluorocarbons CFC-11 (CCl_3F) and CFC-12 (CCl_2F_2) and methane (CH_4) to mention a few (see Table 1). These gases cause "radiation forcing" by creating a "blanket" around the earth's atmosphere which prevents the out-going heat from the earth's surface from escaping into space, causing the earth to heat up (Figure 2). This is the greenhouse effect. As the earth heats up, climatic processes are adversely impacted resulting in extreme weather events (particularly floods and droughts), sea level rise, altered stream regimes, thawing of the polar ice, rise in sea surface temperatures, violent winds and storms, and threats to food securities among others. Africa, which has contibuted the least in the generation of GHGs that had brought the deleterious changes is unfortunately, suffering, the most from the impacts. This is largely due to her weak adaptive capacity arising from poor economic development and deep-rooted poverty (Unmüßig and Cramer 2008).

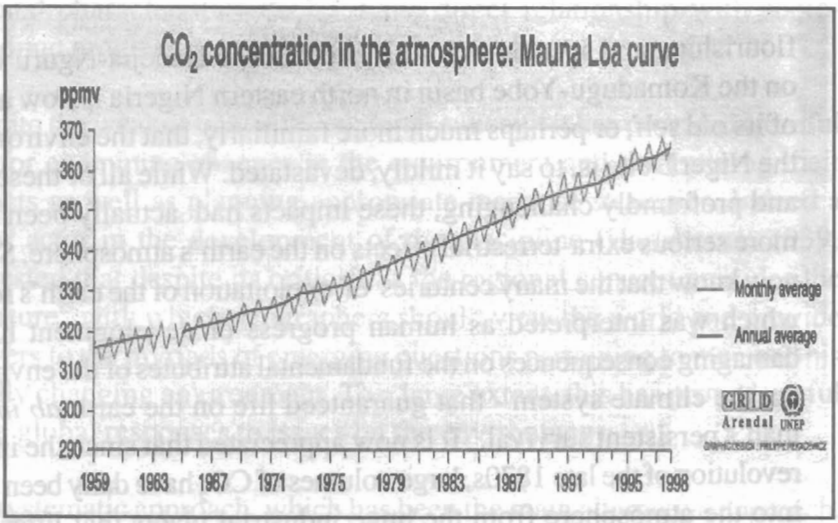

Figure 1a: CO_2 Concentration in the Atmoshpere: Mauna Loa Curve

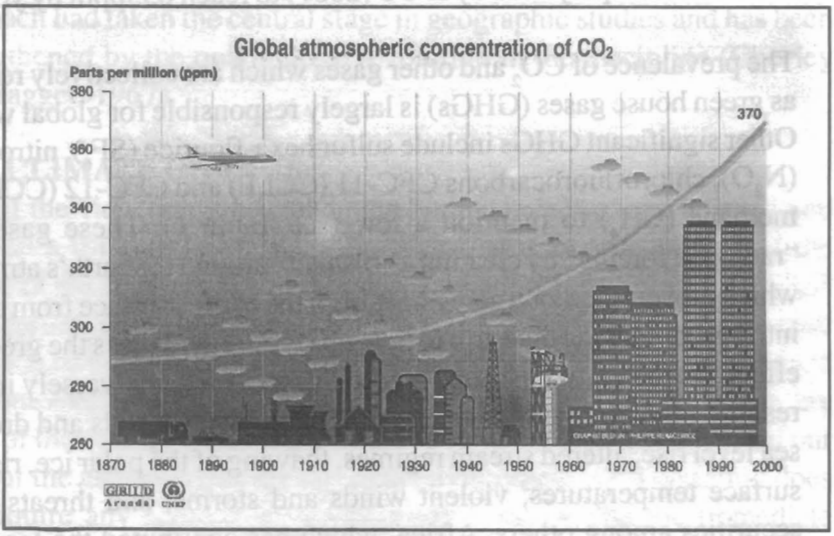

Figure 1b: Global Atmospheric Concentration of CO_2

Table 1: The Main Greenhouse Gases (GHG)

Greenhouse gases	Chemical formula	Pre-industrial concentration	Concentration in 1994	Atmospheric lifetime (years)***	Anthropogenic sources	Global warming potential (GWP) *
Carbon-dioxide	CO_2	278 000 ppbv	358 000 ppbv	Variable	Fossil fuel combustion Land use conversion Cement production	1
Methane	CH_4	700 ppbv	1721 ppbv	12,2 +/- 3	Fossil fuels Rice paddies Waste dumps Livestock	21 **
Nitrous oxide	N_2O	275 ppbv	311 ppbv	120	Fertilizer industrial processes combustion	310
CFC-12	CCl_2F_2	0	0,503 ppbv	102	Liquid coolants Foams	6200-7100 ***
HCFC-22	$CHClF_2$	0	0,105 ppbv	12,1	Liquid coolants	1300-1400 ***
Perfluoromethane	CF_4	0	0,070 ppbv	50 000	Production of aluminium	6 500
Sulphur hexa-fluoride	SF_6	0	0,032 ppbv	3 200	Dielectric fluid	23 900

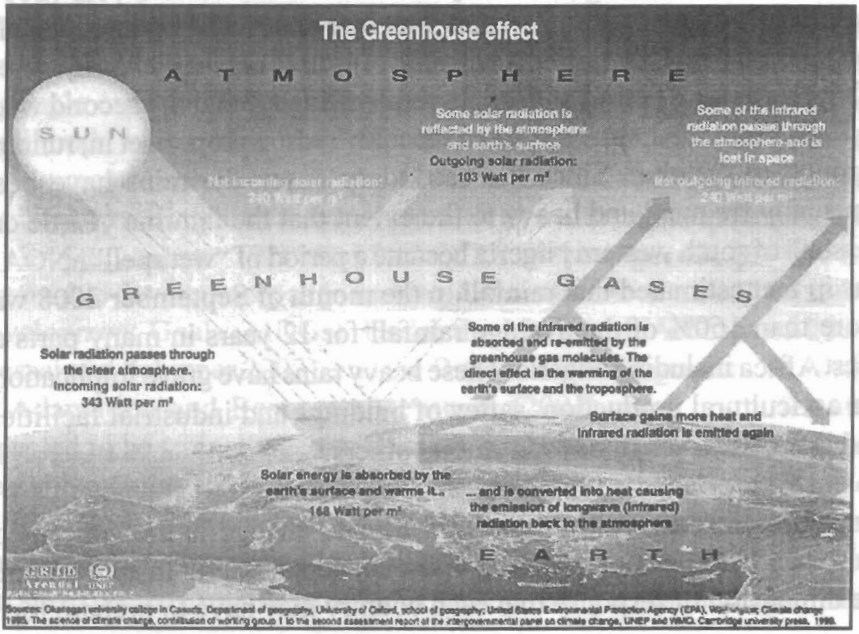

Figure 2: The Greenhouse Effect

Consequences of Climate Change

The consequences of climate change are enormous and a full scale change would compel us to change from doing things in the more familiar manner or probably do them in the right ways. It would affect all sectors of the economy and human security in general (Schellnhuber et al. 2007). In a major National Conference held in Lagos in 1993, a note of warning was sounded that "climate change will produce significant change in ... physical and human environment and we must be prepared to face the challenges that the change ... will elicit" (Adesina and Adejuwon 1994). Geographic ranges of certain diseases may change as temperature changes and rainfall regimes become complicated; health care practices including the facilities used will require reviews to adjust to changing weather and climatic demands; and agricultural belts may shift or disappear completely, resulting in loss of biological productivity.

In Nigeria, the ensuing change may not lead to a reduction in the annual volume of rainfall. However, as has been experienced in recent years i.e. up to 2008, rainfall may be concentrated in a few months and long intra-seasonal droughts may be more prominent. In the current year (2008) for instance, the onset of the rains was fore-shadowed by an unusually long period of steady rainfall (between February and early April). There after, there was a period of drought terminating around the second week in June. From then, what appeared the rainy season proper set in, running through to October. Since the secondary onset, the rains have been unusually frequent and heavy to the extent that the familiar "Little dry season" of south western Nigeria became a period of "wet spell". NOAA has in fact estimated that rainfall in the month of September 2008 was more than 160% of the average rainfall for 12 years in many parts of West Africa including Nigeria. These heavy rains have grave implications for agricultural production, saftey of buldings and industrial facilities, and infrastructures like roads among others.

Critical to discussing the issues of climate change is the concept of vulnerability. The understanding of the concept is useful in appreciating the dimension of response that each country may have to prepare for

Vulnerability is the extent to which change in climate may damage or harm a system which may be anthropogenic or natural (IPCC Second Assessment Report). This can be aggravated by the effect of other stressors such as armed conflicts, political instability and weak implementation of socio-economic development programmes. It is crucial to know how much danger the nation will be exposed to as a result of climate change. For Nigeria the exposure is simply enormous ranging from the toments of coastal erosion to the water shortage of the northern parts of the country.

Climate Change Response

Responding to climate change is a very big issue and is being addressed from three main perspectives. First is research into the science of the change to engender a clearer understanding of what the critical issues are. This has included the development of Guidelines for National Greenhouse Gas Inventories (IPCC 2006) for estimating GHG emissions at the national levels with the aim of planning activities to control emissions. Second is about mitigating the change by adopting technological, economic and behavioural strategies that can assist in halting or slowing down the process of change. Third is adapting to the change. With respect to the latter, emphasis is on enhancing livelihood of people especially in developing countries. The logic is that viable livelihoods will enable the individuals to cope better with adverse environmental conditions. Under the UNFCCC, developing countries like Nigeria are required to engage in activities that will help them adapt to climate change. This simply implies more vigorous pursuit of sustainable development as in making effort to achieve the Millennium Development Goals (MDGs). Under the Marrakesh Accords of 2001 (Dessai and Schipper 2003), and the Buenos Aires Programme of Work on Adaptation and Response Measures (2004), such countries are expected to be strengthened to develop adaptation strategies to reduce their vulnerability to climate change. Negotiations in the UN Conference on Climate Change in Bali (2007) further underscored this. African countries are now excluded from all commitments to emission reduction and are expected to continue to focus on improving adaptation to climate

change. Further negotiations could facilitate transfer of funds to these countries for adaptation activities.

A major challenge that Nigeria faces is effectively addressing sustainable development issues. Of course the country is committed to doing this through the pursuit of the MDGs as frequently expressed in various fora and platforms including those of the African Peer Review Mechanism. The desire is also reflected in the Seven-Point Agenda of the Yar'dua's Administration. The gap to my mind is, a lack of proper articulation of the strategies that can make life worthwhile for the average Nigerian. Such strategies which should enforce measurable improvement in every sector of the nation's economy on a quarterly basis (because time is not on our side), must be situated within the context of the reality of a vastly altered Nigeria's environment in which survival for the majority has become far more challenging than before. The farmer dare not eat any good harvest from his farm if he must survive! Nothing goes free again. Even stems of cassava which were free two to three decades ago are now paid for.

For the rest of the lecture, I intend to review some of our studies showing the changing climate and environmental deterioration as well as potential responses. I shall conclude by highlighting some actions that must be taken to effectively cope with the changes.

6. SOME EVIDENCES FROM NIGERIA'S DATA SETS

In the climate change study group based in the Department of Geography (Adesina et al 2006; 2007) we have attempted to verify with available daily records of weather data, to what extent the climate of Nigeria might be changing by analyzing trends in extreme climatic events for a period of 40 years using the RclimDex software. It is useful to underscore the point that the global climate is a unified system. Consequently, whatever affects a part affects the whole.

The frequency and pattern of occurrences of extreme weather or climatic events are powerful indicators of the dynamics of the climate system.

Extreme events are deviations from the typical patterns and so normally occur rather infrequently - sometimes very rarely. The Iowan's flood of 2008 is said to occur for example, once in 500 years! When extreme events begin to occur more frequently in fairly systematic patterns, they indicate that something fundamental is happening to the system. Extreme events are specific in terms of the dominant climatic parameters in which they manifest and their consequences can be significant on local environmental processes. The manifestations include, among others, heavy rainfalls within short periods, bouts of dry spells during growing seasons when certain crops require moisture critically at field capacity, heavy rains when short dry spells are crucial for crop ripening (Ojo et al., 2001), delay in onset and early retreat of rainfall and change in temperatures to below or above "normal" values for specific periods of the year. In general terms, extreme climatic events are capable of causing upsets in many important environmental parameters such as water balance which may damage agricultural productivity. When farmers respond to a false start of rains, crop failures are inevitable and can be tragic. Even in the practice of "dry farming" in the dry belt of Nigeria (e.g. Nyong et al 2004), such false onset of the rainy season cause great losses to the farmers.

The indicators of extreme climatic events evaluated were monthly highest daily minimum temperature (TNx); percentage of days when daily minimum temperature is less than 10th percentile (TN10p); percentage of days when daily maximum temperature is less than 10th percentile (TX10p); percentage of days when minimum temperature is greater than 90th percentile (TN90p); percentage of days when maximum temperature is greater than 90th percentile (TX90p); monthly mean difference between maximum and minimum temperature (DTR); monthly maximum consecutive 5-day precipitation (Rx5day); maximum number of consecutive days with rainfall less than 1mm (CDD), R95p - Annual total PRCP when RR>95p, PRCPTOT - Annual total PRCP in wet days (RR>=1mm).

The results of these analyses gave indications about the changing pattern of Nigeria's climate. For example, the monthly highest daily minimum temperature i.e. TNx showed a significant steady rise for Ibadan whereas the rise was not significant in other locations studied. The monthly lowest daily minimum temperature i.e. TNn has also been on the increase in Ikeja. The rise was not significant in other stations. TN10p i.e. percentage of days when TN<10th percentile is significant in Ikeja and Ibadan. They suggest increasingly fewer cold days indicating a warmer environment. These results in relation to other parameters enabled us to conclude that temperatures have been on the increase between 1961 and 2000 i.e. the period that our data covered and the trend may have continued. The report of IPCC (2007) underscored this as it showed that significant spatial variations will obtain in the direction as well as the dominant consequences of climate change. Some areas may become wetter while others drier. We intend to explore these trends further to get more accurate picture of the trends within the Nigeria's environment.

The conclusion reported above is strengthened by the results of another study just concluded in the Nigeria's section of the Lake Chad Basin (Dami 2008). The precarious conditions of Lake Chad are all too well known. Some sixty years ago, the Lake was flourishing as one of the largest inland water bodies in Africa, supporting large populations of farmers, fishermen and herdsmen. Then it had a surface area of about 25,000 square kilometers. Today, it is estimated that the surface area of the lake may only be about 5000 square kilometers and an overwhelming percentage of the population it supported gone (Dami 2008). Climatic data from weather stations in the basin confirmed this. For example, in Mao located on Lat. $11^0 36^1$N and Long. $15^0 17^1$E, rainfall data (Figure 3) showed a decline between 1960 and 2002 with the exception of some peaks reached in 1972 and 1978. Thus, there had been a growing increase in aridity in the station which has become typical of the Sahelian region.

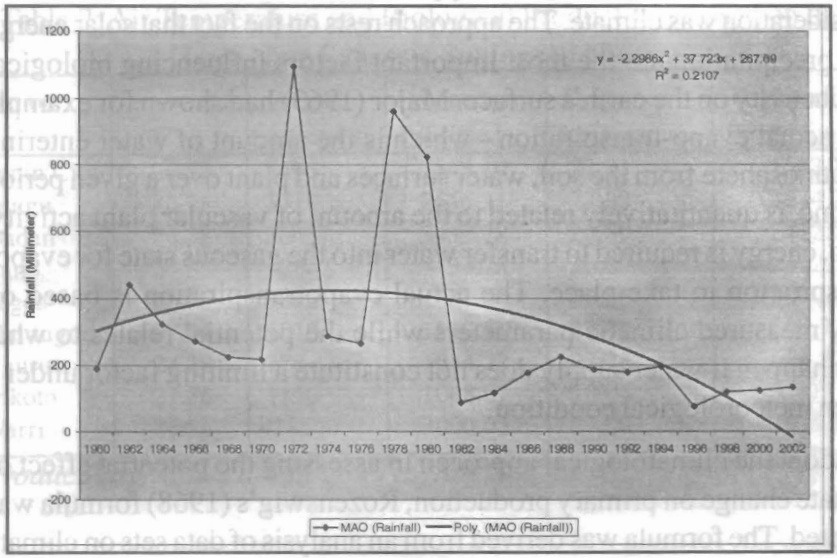

Figure 3: Rainfall in MAO, Lake Chad basin

7. CLIMATE CHANGE AND BIOMASS PRODUCTION

One factor of the environment on which climate change impact most is vegetation. In trying to address preparedness for impacts in this area, we have sought to estimate variations in vegetation productivity that may occur due to climate change in Nigeria (Adesina and Adejuwon 1994; Adesina 1995). Biological or primary productivity measures the biological resourcefulness of the various parts of the earth. It is the harvestable yield in a specific quantity per hectare at a given location in a growing season, and gives an indication of the ability of the environment to facilitate vegetation (including crops) growth. The methods of measurement include the harvest method, the gas exchange method and the radio-active tracer method. Apart from all these, there are quantitative procedures that are based on established relationships between climatological properties and primary productivity.

We used the climatological approach because the issue under consideration was climate. The approach rests on the fact that solar energy and precipitation are the most important factors influencing biological productivity on the earth's surface. Major (1963) had shown for example that actual evapo-transpiration - which is the amount of water entering the atmosphere from the soil, water surfaces and plant over a given period of time, is quantitatively related to the amount of vascular plant activity. Also, energy is required to transfer water into the gaseous state for evapo-transpiration to take place. The actual evapotranspiration is based on truly measured climatic parameters while the potential relates to what may happen if water supply does not constitute a limiting factor under a given meteorological condition.

To adopt the climatological approach in assessing the potential effect of climate change on primary production, Rozenswig's (1968) formula was adopted. The formula was derived from an analysis of data sets on climate and productivity from the various parts of the world. The data sets were transformed into common logarithms. The log-normal data were then subjected to a linear regression model relating productivity to evapo-transpiration. The predictive equation is given as

$$\text{Log}_{10}\ \text{NAAP}=(1.66+/-0.27)\ \text{Log}_{10}\text{AE} - (1.66+/-0.07).$$

Where NAAP is Net Annual Above Ground Productivity, and AE is Actual Evapo-transpiration.

Adopting this relationship the actual productivity was estimated for nine synoptic stations located across the country, including those in Benin, Enugu, Ibadan, Kano, Lagos, Maiduguri, Nguru, Sokoto and Warri, using 35-year average temperature values for each of the stations. Assuming a temperature rise of 0.5°C over the next five decades (IPCC 1992), we also estimated potential productivity in the various stations. These are presented in Table 2.

Table 2: Air Temperature and Biological Productivity based on data from Nine Synoptic Stations in Nigeria

Station	Temperature (°C)	Actual Productivity	Productivity Predicted	Estimated Temperature	Predicted Productivity
Benin City	26.83	3495	2544.19	27.33	1533.12
Enugu	26.78	3418	2645.21	27.28	1634.22
Ibadan	26.38	3043	3433.78	26.89	2422.79
Kano	26.39	2284	3433.78	26.89	2422.79
Lagos	26.06	3892	4101.04	26.56	3090.05
Maiduguri	27.44	1010	1310.7	27.94	299.71
Nguru	27.28	778	1634.22	27.78	623.22
Sokoto	27.56	1156	1068.07	28.06	57.07
Warri	26.56	4185	3090.05	27.06	2079.06

Productivity values are in g/m²/yr (Adesina and Adejuwon, 1994)

The expected productivity in the event of a rise in temperature of up to 0.5°C ranges from 57.07 g/m²/yr in Sokoto to 3090.05 g/m²/yr in Lagos which represent a general decline. The correlation coefficient deriving from the linear regression between productivity and evapo-transpiration is -0.79 with a p-value of 0.01, suggesting a significant negative relationship and indicating that the higher the temperature becomes, the less the biological productivity that would be obtained in the different parts of the country under the subsisting rainfall intensities and regimes. Moreover it indicates that in general the biological productivity could decline in a warmer Nigeria.

While this may be inconclusive, it does give a signal of the possible implications of the change in climate for vegetation development and crop production under rain-fed agriculture. It could affect for example the availability of fodder for games and livestock. Experts are already focusing attention on the development and or identification of hardier variety of crops that would tolerate a drier environment and an altered climatic regime (e.g. Rosenzweig and Hillel, 1998)

8. VEGETATION CHANGE AND CHANGE AGENTS

Vegetation change almost always means degradation or outright loss of vegetation cover. Exceptions are found in places where unusual events such as prolonged armed conflicts as in the case of the Democratic Republic of Congo (DRC), prevent sustained exploitation of vegetal resources such that vegetation covers continued to assume something close to their original status. This explains the presence of large patches of near-pristine rainforest in parts of DRC.

The impacts of the degradation manifest in many ways. One is in the growing difficulty of obtaining logs of favoured timber species. This has become so serious that in many parts of the country, particularly in areas that had large tracts of the tropical rainforest, tree species which no one would consider of any relevance as sawlogs some two to three decades ago, are now fell as logs. For instance, wood of *Artocarpus communis* (known locally as breadfruit) which was grown primarily for its fruits in the past is now logged for timber. The danger of that development is obvious: the supply of the fruits for which the tree is known can no longer be guaranteed. To make the matter with logging worse, there are now sawmilling equipment that can break into planks logs that a few years ago will be considered undersized. Thus, size is no longer a constraint to logging trees even if they would not ultimately fulfill the purpose for which they were logged adequately.

Apart from its negative effects on the structure and species composition of vegetation units, human-induced changes even if they do not amount to outright clearance of vegetation also impact negatively on the soil, alter climates at various scales and destroy habitats of valuable plants and animals. Few plants and animals are able to cope with the "new" habitats that emerge. In this way, several plants and animals have been lost.

Vegetation degradation in the tropical forests were subtle when they were due to extraction of fuelwood from broken branches and dead trees and when the human populations exploiting the forests were low. The tropical forest is understood to be resilient under such conditions as it is able to recover from modest perturbations (e.g. Richards 1989). Consequently the changes were minimal and unnoticeable. The nature of the contemporary "drivers" of change such as land clearing for agriculture, mineral exploitation, road construction and other development activities are however overwhelming. Thus, vegetation covers wherever they remain, are usually degraded both in flora and physiognomy as well as the wildlife that originally inhabited them.

We studied vegetation changes along the forest-savanna boundary (Adejuwon and Adesina 1988; Adesina 1989) following the earlier works of Keay (1952) and Moss and Morgan (1977). At the boundary which is essentially transitional, forest naturally gives way to savanna in response to decreasing annual rainfall. Boundaries between vegetations types are hardly sharp or linear except they coincide with geological formations whose boundaries are sharp. The transitional zone is about 10 kilometers in width and is located towards the northern part of the forest belt. The vegetation in the zone is transitional, not in the sense that it represents a distinct vegetation type that is different from forest and savanna, but in that units of the two vegetation types are mixed. This formation is commonly referred to as an ecotone and is in Figure 4 in a part of western Nigeria (Moss and Morgan 1977).

Forest and savanna are different in fundamental ways. The most obvious is the sheer bulk. As shown by Nye and Greenland (1962, p 25), the oven-dry material in high grass savanna that is undisturbed for more than 20 years is less than 27,000 kg per hectare, which is barely 8% of what is obtainable in forests of similar maturity. More than 75% of the bulk comes from the trees. The bulk thus increases with the volume of wood in the systems. Apart from the bulk, the vegetations can be differentiated by the characteristics of trees found in them. Savanna trees

have fissured and flaking barks which make them tolerant of the frequent dry season fires in the savanna.

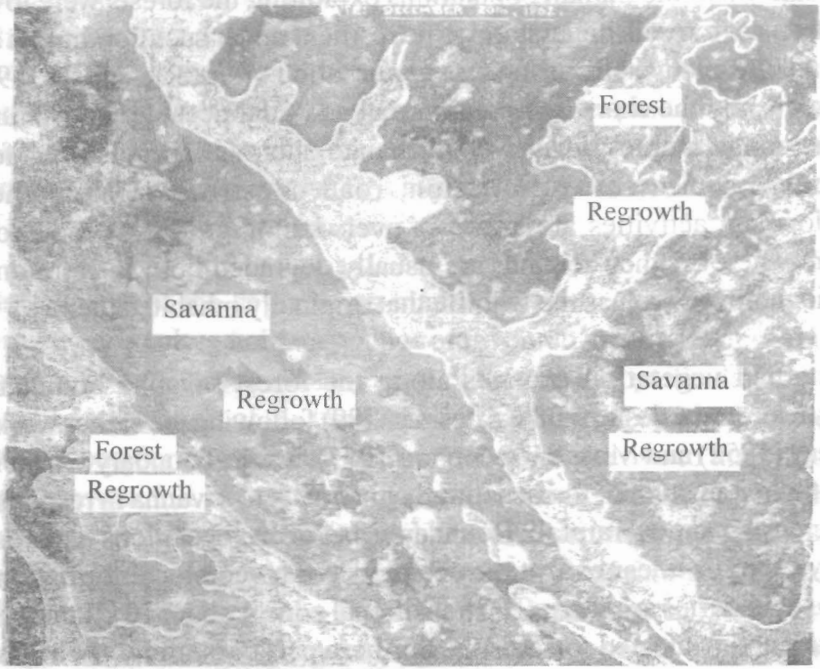

Figure 4: Aerial photo of a part of the forest/savanna boundary in Western Nigeria (Moss and Morgan 1977)

Data analyses with various ordination techniques revealed that the units of vegetation along the boundary were not pure stands of savanna or forests but rather were composed of mixtures of fire-tender forest species and fire-tolerant savanna species (Adejuwon and Adesina 1988; 1994; Adesina 1989; Adesina and Adejuwon 1997). In the drier parts dominated by savanna units, *Elaies guinensis* which is a forest plant occurred with savanna trees above ground layers of grasses. In other locations, savanna species such as *Annona senegalensis, Daniellia oliveri* and *Ficus capensis* grew with forest trees such as *Celtis zenkeri, Morinda lucida and Ficus exasperata.*

We interpreted these variations in species combinations as reflecting impact of man on the vegetations. For example, the sites in which palm trees dominate the tree layers were interpreted as representing an advanced stage of conversion of forest to savanna which implied degradation. More burning or clearings of such units for cultivation would eventually eliminate the palm trees therein and establish savanna vegetation fully. Units of vegetation with a mix of forest and savanna species without grassy ground layers suggested to us vegetation units at relatively advanced stages of recovery from savanna. Withdrawal of farming activities and reduction of annual burning (if these were possible) would support more vigorous growth of forest species which would eventually crowd out savanna species in the formation. Of the two possible processes that we described, the former is the most active because of rising population, and growing demand for land for various purposes.

Virtually everywhere in the country today, vegetation degradation is visible. It is hard to come by any true rainforest patches outside the forest reserves. The estwhile large patches of forest separating Ile-Ife and Ilesa in south western Nigeria for example are almost gone. Even the cocoa and kola farms which gave some feelings of forest conditions in the past are fastly giving way to houses, schools, gas stations etc. The trend is to say the least frightening (see e.g. Salami and Balogun 2006; Adesina et al *in press*). According to FAO (2006), deforestation rate of primary forests in the country is one of the highest in the world. It is estimated that between 2000 and 2005 alone, the country may have lost 55.7 percent of its primary forests i.e. forests with no visible signs of past or present human activities.

ERGO (1994), in a major land use analysis of the country (Table 2), had given indications to the likelihood of the figures provided by FAO quoted above. It projected that by year 2000, forest cover would just be about 5% of Nigeria's land area and would decline to less than 3% by 2020. It is significant to note that most of the losses will go to cultivation and settlement which are two dominant indirect drivers of land use in Nigeria. They are indirect because the real driver is population coupled with

careless management of available land resources. One should also remark that the projections had little or no consideration for changes that may be associated with a drier climate which could extend the southward reach of arid and semi-arid conditions. A drier climate would impact on the sizes of various land use categories particularly settlement, cultivation, and forests.

Table 3: Projected Landuse for Nigeria (ERGO 1994)

Landuse type	1990	1992	1994	2000	2020
Cultivation	31.92	33.20	24.49	38.58	50.65
Grassland	5.63	5.36	5.10	4.38	2.37
Scrub	11.93	11.64	11.34	10.62	7.27
Woodland	41.30	40.74	40.16	38.36	29.75
Forest	5.91	5.65	5.39	4.67	2.63
Mangrove	1.01	1.00	0.98	0.94	0.73
Settlements	0.81	0.92	1.05	1.55	5.12

The change is obvious everywhere. The Figure 5 below is from a part of Niger, north of Nigeria but very relevantly depicts what has been going on in the northern part of Nigeria.

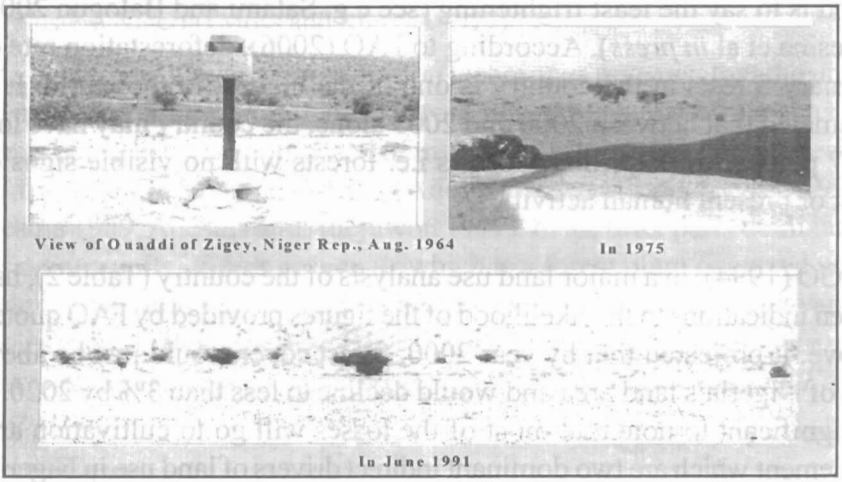

Figure 5: Environmental Change in a part of Niger (Gworgwor 2008).

Implications of vegetation degradation

The loss of vegetation has far-reaching consequences in Nigeria. The reason is that vegetation resources provide the basis of livelihoods of a large majority of Nigerians. For instance, people depend on the timber, herbs, animal protein, fruits, fodder and fuelwood, among others, that come from the natural vegetations. The degradation of vegetations thus affects everyone but more fundamentally, the poor who live directly on nature.

Of the many valuable products from the plant cover, fuelwood is perhaps the most important to the majority of people. More than half of households in the country depend on fuelwood either as firewood or charcoal for domestic cooking. It is particularly significant as alternative sources are poorly developed or inaccessible (Adesina 1992; Adesina et al 2008). In many rural communities, fuelwood is usually the only source of domestic energy. Even in urban areas, the use of wood for cooking cuts across the various strata of the society. The loss of vegetation cover thus touches on the survival of many. All these as earlier noted, also go further to impact on the climate system. For instance, the loss of vegetation impairs the capacity of the natural system to hold back carbon and so add to the greenhouse effect which is responsible for the global warming.

Change and the Bush fallowing system of farming

Vegetation degradation has also affected traditional agricultural systems which relied on the natural processes of vegetation regrowth for sustaining soil fertility. The bush fallowing system of farming that was dominant in the humid and subhumid parts of the tropics (Beneh, 1972; Ruthenberg 1980), is particularly threatened. The system involves rotating the farmland between food crops and fallow regrowths. During the cropping phase, the fertility of the soil declines sometimes quite rapidly, depending on the intrinsic properties of the soil and management practices. The fallow period provides a 'resting' period for the land to recuperate for another round of farming.

When the system functions properly, no fertilizer input is required to maintain soil fertility. This natural process is most desirable as it prevents the negative effects associated with the use of chemical fertilizers. Toxic chemicals in such fertilizers sneak into the food chain via vegetables and drinking water ultimately causing grievous health effects. Fallow plants also help to eliminate pests and diseases that may have affected the last crop before the land went into fallow. Thus under the system also, herbicides that are now creating concerns are not needed. However, growing populations and the accompanying rise in demand for farmland has continued to shorten fallow lengths and in many areas, to a level inimical to the sustenance of the system. In some areas land is so much in short supply that fallowing is technically impossible if everyone that needs to farm does so.

A long period of 'resting' is normally required for an adequate restoration of the soil to take place and woody plants are crucial in the process. The woody plants use their long roots to pump up nutrients held inside the soil (Nye and Greenland 1962; Aweto 1981; Ekanade et al 1994; Isichei 2007). But such plants take a long period of time sometimes up to seven years or more to develop sufficiently to be able to function in this way. This is a major challenge for the maintenance of the fallow system as "resting period" shortens.

Equipped with this understanding of the functioning of fallows, researchers on tropical agriculture have focused on how trees can function better in the fallow system. Trees would be more efficient if they can grow more rapidly and produce larger amount of litter. One approach that evolved very early in the 1970s was the alley cropping in which crops are grown in alleys created between leguminous trees such as *Leucaena leucocephala* (Wilson and Kang 1981; Lal, 1987). The system allows more or less continuous cultivation by combining the cropping and the fallow phases on the same piece of land. The alleys provide avenue for the cropping phase while the hedgerows of selected trees, the fallow. The hedgerow trees are pruned and their leaves and

twigs used as mulch under the system. This improves soil fertility and enhances the soil's ability to support crop growth and development. Hedgerow trees can be leguminous or a mix of types. For example, in the experiment reported by Kang et al. (1999). *G. sepium* was mixed with *Alchornea cordifolia* and *Dactyladenia barterii*.

We have contributed to the study of cultivated fallows by assessing the role of one of the fast growing leguminous trees in fallow enrichment. (Adesina 1988; 1990; 1992; 1994; 2004; Adejuwon and Adesina 1992). Our goal was to determine whether such trees which are able to fix atmospheric nitrogen through the activities of *Rhizobium* bacteria living in their roots, can be encouraged as fallow trees for soil fertility restoration, and the production of fuelwood as well as fodder. The strategy was to look at the behaviour of the tree of interest during fallow succession in terms of its effects on soil and wood productivity and compare these with what obtains in self-propagated fallows of comparable ages. The anticipated advantages of the cultivated tree as the dominant fallow candidate were estimated to manifest at the point at which the two fallow types begin to show significant differences from each other with respect to certain predetermined soil and wood parameters.

Gliricidia sepium (Jacq.) Walp. was used as a case study. *G. sepium* is a leguminous tree of the Papilonideae family. It originated from tropical South America but is now found throughout the tropics. Its leaves are rich in protein, enhancing the quality of the organic matter they can add to the soil. The tree grows quickly, is easily established and managed, and tolerates a wide range of ecological conditions. The bole is straight and thornless, and the wood tough and hard when matured. It is also known to be good as fuelwood with a calorific value of 20.5 MJ kg^{-1} (National Academy of Sciences 1980) and burns excellently well when dry.

G. sepium is popular on farms in many areas as stakes for training yam vines. Of course, because it is able to develop heavy foliage quickly it is also a favorite for protecting young cocoa trees in the cocoa growing

areas. From its use for training yam vines, it coppices and grows on with other wild plants as the fallow commences after the cessation of a round of farming. Also, because it is a fast growing tree, *G. sepium* soon becomes the dominant fallow tree, but generally able to grow along with other trees in the fallow succession.

Results from the study showed that from about two years of fallow, soil fertility become higher in *Gliricidia* than in self-propagated fallows (Figure 6a &b). *Gliricidia* fallows also produced larger volume of wood than self-propagated fallows. The findings suggested however, that *Gliricidia* trees retain considerable nutrients in their biomass. It was thus suggested that mulching of the litter from the tree may be important as demonstrated in experimental measurements under alley cropping (Kang et al. 1999), to ensure higher return of nutrients to the soil. As some of the nutrients may be held in the woody part of the tree, some fairly regular harvesting of the tree may be important to reduce nutrient immobilization.

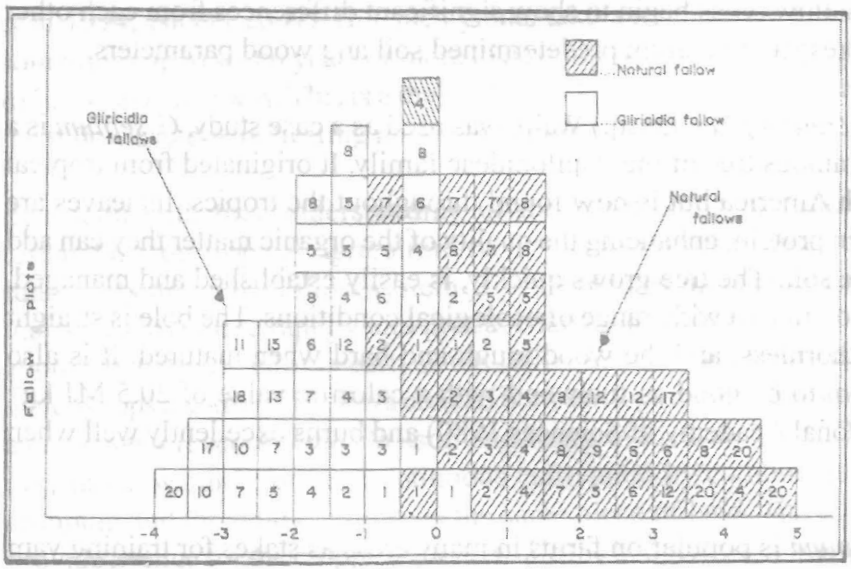

Figure 6a: Discriminant Canonical ordination of Natural and *Gliricidia fallows*

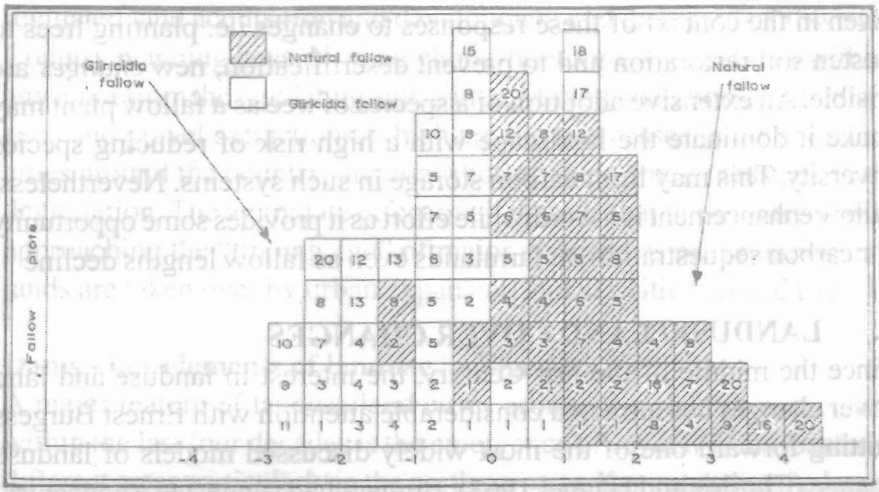

Figure 6b: Discriminant Canonical ordination of Natural and *Gliricidia fallows*

The benefits of planted fallow trees which may also include improvement in biomass development on the farmland could make the fallow environment suitable for certain other local plants to grow. However, fallow trees may become weeds inhibiting the growth and development of other plants and creating 'new' communities of plants that may not be culturally and economically acceptable.

The concept of planted fallows is analogous to that of planting shelter belts in the "roll back the desert" project designed to prevent the northern part of West Africa from being overrun by the Sahara desert. The principal idea involved deliberate growing of certain trees in three to six rows along dominant wind directions in various locations. Of all the trees that have been tested, *Azadirachta indica* (Neem) has proved to be the most effective in terms of coping with extreme water stress. In the West Africa sub-region, the tree does well as far north as Niamey in Niger. However local people now complain about the tree because of its allelophatic effect which prevents other plants from growing around it.

Even in the context of these responses to changes i.e. planting trees to hasten soil restoration and to prevent desertification, new *changes* are visible. An extensive adoption of a species of tree as a fallow plant may make it dominate the landscape with a high risk of reducing species diversity. This may limit carbon storage in such systems. Nevertheless, fallow enhancement is a worthwhile effort as it provides some opportunity for carbon sequestration on farmlands even as fallow lengths decline

9. LANDUSE/ LAND COVER CHANGES

Since the middle of the last Century, the interest in landuse and land cover changes has attracted considerable attention with Ernest Burgess putting forward one of the most widely discussed models of landuse change (Chorley and Hagget 1967). Burgess had suggested a concentric land development model with a core area which may be a commercial area as the focus. Later studies have shown that while Burgess' model is logical and demonstrable, many landuse features and their drivers defy common explanation of the model. What is clear is that landuse is changing dramatically in different parts of the world and is understood to be significant in carbon dynamics.

Many researchers had thought that an understanding of landuse change would help to slow down the frightening changes taking place traceable to landuse. If they had in Europe and America because of the negative effects of industrial revolution, they have not in most of the developing countries.

Studies in different parts of Nigeria have shown that rapid changes are taking place in landuse patterns with far reaching implications (Adesina and Amamoo-Otchere 1994; Oyinloye and Adesina 2006; Dami and Adesina 2003; Gueye and Adesina 2008). For instance, city growth is a major land use change issue and the story is the same from Maiduguri to Lagos and from Sokoto to Port Harcourt. Across the country, cities are expanding at terrifying rates. The loser in all cases is the rural land i.e. whatever is left as natural areas and the land used for agriculture. Urban spread into the adjoining rural lands is due to many factors such as ill-

regulated land acquisition and development and disregard of Town and Country planning laws. New neighbourhoods grow sometimes without any input from the regulating authorities. Mining operations, particularly sand and gravel extractions, which are big businesses in the sprawling cities around the country, are contributing in no small measures to the degradation. The aggregate effect of all these is that the country may be approaching the "tipping end" of major disasters as prime agricultural lands are taken over by urban expansion and activities related to it.

Dams - key elements of landuse in Nigeria

A major feature of landuse/land cover around the country particularly within the last four decades is the emergence of several dams located in different areas particularly in the northern parts. Kano state has the largest area of impounded fresh water surfaces with two of the largest dams - Challawa and Tiga (Aminu-Kano1997). The positive effects of these dams are not in question. For instance, Kano has received more rains than the surrounding locations in recent times and this has been linked to the presence of large fresh water surfaces in the State (Odekunle et al 2008). The Dams also have potentials for meeting industrial and domestic water needs as well as providing opportunities for fresh fish production among other things. Nevertheless, many of the dams in the country are sitting on large expanses of land which hitherto were used for cultivation. They are also responsible for the drying up of many natural wetlands downstream. The loss of the valuable resources of the Hadejia-Nguru wetlands resulting from the building of Tiga and Challawa dams is an example of the negative impacts of dams on the environment that cannot be ignored. Dams can also pose threats to life and property. In the event of a failure or collapse due to poor engineering work, expiry of the lifespan of reservoirs or poor maintenance, extensive damages to life, properties including farmlands, water supply and sanitation can occur (World Commission on Dams Report, 2000).

From the above, it is clear that dams are expensive if the costs of construction are added to those of the vast agricultural land they occupy, the flooding that may come in times of heavy and persistent rains and the

misery and tales of woes that may trail their failure. Consequently, it is most reasonable to seek to optimize the potentials of the dams. Unfortunately, these huge water resources are poorly utilized. Very commonly, the hydro-electric power (HEP) potentials of the dams are not tapped and only a small fraction of the stored water is used even for supplementary irrigation (Adesina et al. 2008). A full-scale review of the use of these water resources will be needed in responding to the changing climate in Nigeria

10. THE ROLE OF THE FORESTRY SECTOR

The understanding of the processes of vegetation change, and our earlier work in agroforestry helped to prepare grounds for a rewarding collaborative study with other experts on some aspects of climate change response. This was in relation to reducing carbon in the atmosphere as a national strategy in addressing climate change (Adesina et al. 1999; Adesina 2001; Siyanbola et al. 2002; Pelemo et al. 2003). The study focused on forestry and landuse sector with the aim of making forests more able to function as a natural carbon "sink" through efficient forestry practices. It was premised on the principles of sustainable development and so attempted to increase forest covers to enhance carbon sequestration without compromising the need to meet the national wood demand for socio-economic development. Consequently, the study employed the end-use scenario. Five categories of dominant wood products were considered: fuelwood, poles, pulp, saw logs and veneer. The production of these wood products was modeled under afforestation i.e. deliberate planting of trees and agroforestry

The results showed that if well maintained, both agroforestry and afforestation efforts have a lot of potentials for sequestering large metric tonnes of carbon annually. The rates of storage would increase as the bulk density of the forest increases. The increase of course depends largely on the characteristics of the trees encouraged, the age and the forestry option adopted. For instance, with afforestation, about 400tC/ha would be stored with an average annual increment of 1.63tC/ha in the production of veneer. Using the agroforestry option on the other hand, 344.3tC/ha which is about 15% lower than what obtained under afforestation could

be stored for the same wood product. However, Agroforestry model has a higher Net Present Value which is far higher than $102.6 per hectare estimated under afforestation. Higher values estimated under agroforestry are expected since the farmer can begin to have tangible benefits in terms of crop harvests from the very first year of the project. The conclusion from the study is that forestry can be better developed to address the country's wood needs. At the same time it can be made significantly more effective as a natural carbon "sink" in the spirit of reducing global atmospheric carbon. We intend to continue our studies in this area focusing attention on how forestry practices can be more effective in Nigeria.

Table 4: Carbon Pool and Total Benefits for the Different Wood Products for Mitigation Options

		Fuelwood		Poles		P ulp		Sawlog		Veneer	
		AF	AGF	AF	AGF	AF	AGF	AF	AGF	AF	AGF
Carbon Pool (tC/ha)	Baseline	67.2	67.2	98	98	133	133	133	133	133	133
	Mitigation	93.1	79.6	187	128	172	150	331	224	399.6	344.3
Costs ($/ha)	Initial Cost	495	344	520	335	513	335	520	335	455	335
	Total Cost	655	504	680	623	673	628	680	623	615	620
Benefits ($/ha)	Baseline	150	150	200	150	200	200	200	200	200	200
	Mitigation	652	2191	667	1589	2069	2211	468	3428	479	1511

AF=Afforestation; AGF=Agroforestry

11 REMOTE SENSING AND GIS HELPING THE PROCESS

Monitoring and managing of the environment are without doubt enormous tasks becasue of the nature of the data sets required. To complete the soil survey of Central Western Nigeria, it took a large team of experts and workmen more than a decade, using the ground survey methods (Smyth and Montgomery 1962; Moss R.P. 1988 personal communication). Advances in Remote Sensing and GIS have changed the tone substantially but the challenges are still there.

Remote Sensing application has had a great boost from the progress in satellite technology. With the launching of NigeriaSat-1 in 2003, Nigeria has, in some modest way, joined the space age. The potential benefits of this feat and that of the proposed NigeriaSat-2 are enormous, particularly with respect to planning and managing land resources.

Over the past five years, the Department of Geography has made a most daring effort in establishing two Masters programmes in geoinformation – Master of Geographic Information System (MGIS) which is a Professional Masters and Masters in Remote Sensing and GIS (MSc RS &GIS), designed to create opportunities for advanced degrees in the field. We have worked with the Regional Centre for Training in Aerospace Surveys (RECTAS) and African Regional Centre for Space Science and Technology Education – English (ARCSSTE-E) both of which are located within the University Campus, at various levels in actualizing these programmes.

Starting off the programmes in year 2003 as the Head of the Department of Geography, was for me a daunting task. It was like swimming against the currents because the required resources were just not there. We were encouraged however, by the conviction that it was the right direction to move, having originally drafted the papers that were approved by the Senate of this University for the programmes. It should be put on record too that the University was particularly supportive in ensuring that the programmes took off despite the financial challenges at that time. The programmes are now in their sixth year, and we have trained scores of graduates many of whom are already making impacts on geoinformation development in the country. It is sufficient to mention that many of the products did their final projects and theses on the application of Remote Sensing and GIS in the study of various phenomena that are impacting on the climate. As a matter of fact, the first graduate of the programme - Anthony Dami, had just concluded his PhD applying geoinformation tools in evaluating environmental changes in the threatened Lake Chad Basin.

Among other things GIS facilitates an organized management of the earth resources in such a way as to enhance rational decisions about them. With the tool it has become possible to do meaningful analysis of the environment and, among other things, develop scenarios of what the future might look like. It is thus a key tool for evaluating climate change and for preparing appropriate responses. Based on the well known capabilities of GIS to interpret different kinds of data (images, maps, descriptions, ground survey data, etc) from various sources and time, one can even re-visit previous studies, combine these with current observations and extrapolate future scenarios. We therefore intend to further our research on climate change in the Department of Geography by applying Remote Sensing and GIS in the various dimensions of our studies.

The turning around of Abuja city through the driving force of Abuja GIS, is a good illustration of what this tool can do. It is gratifying to note that one of our graduates is a technical staff of the Abuja GIS. Our challenge and indeed that which the entire country has to face is about making appropriate investment in providing the backbone needed for the GIS and remote sensing to be fully operational. When this is done, it would become feasible to implement State GIS, to extend the benefits of orderly development taking place in Abuja now, to the other parts of the country.

12. WE HAVE TO COPE WITH THE CHANGES

The issue about surviving in a severely altered world borders largely on a wholesome development plan that is rigorously and transparently pursued. This should be done taking into consideration the consequences of the development on the environment. Many communities, we should remember, gladly conceded their lands to Mining companies some decades ago, only to regret ever making that decision. It is a combination of these consideration that can help the nation contribute to slowing down the process of change and at the same time protecting her citizens from

the adverse consequences of the change that are already visible. In this closing section of the lecture, I intend to discuss five of the key areas that must be given attention in coping with the change at the local and at the national level.

i. Efficient Landuse Control

One of the greatest challenges of development and therefore survival in a changing environment in Nigeria is poor or lack of awareness of, and to some extent, refusal to accept the fact that the land resource of the country is limited. Consequently, a lot of damages is being inflicted on the country's land resources. It appears that everyone just does what he wants with the resources. This simply cannot continue if we would ever make meaningful progress in socio-economic development.

The brazen abuse of rural lands in building gas stations, country homes and reckless establishment of dumpsites for waste among other things, without considerations for those whose livelihoods are debased in the process, must be curbed. The laws on Environmental Impact Assessment are there but its use is difficult to prove in many of the so called developments that we see around. "Turning bush to town" which is commonly flaunted as an indicator of grassroots development is far from being a development process. It is in fact the contrary as it usually accelerate the degradation of the remaining natural areas.

It is also often not appreciated that the value of land is not determined merely by its size but rather by its ability to sustain livelihood. This is the sense behind the concept of "carrying capacity". ICT and globalization notwithstanding, the carrying capacity is a function of the resourcefulness of a given location. Seen in this perspective, it can be understood that a sizeable proportion of land in the country is of marginal value. Increasing population pressure in the semi-arid areas of northern Nigeria as well as rising aridity is expanding the area of marginal lands in the country. It does mean that utmost care must be taken to ensure optimal use of the remaining prime lands in the country.

Furthermore, Governments at all levels must genuinely take steps and urgently too, about setting limits to the growth of all settlements in the country as a means of putting a check in particular, on the monstrous

growth of cities and towns. Cities such as Ibadan, Enugu and Kano are growing out of control, partly due to population increases but also as a result of poor physical control. With respect to the latter, green belts hardly exist, frog-jumping of urban features onto rural land is consequently rife, and new physical development is poorly coordinated with "planning" of new areas left sometimes in the hands of private individuals.

There is an inherent disregard of specifications as to the type of houses that can be built and how they should be constructed. There appears as well, to be no functional control with respect to where private individuals and organizations can "develop". Yet all of such considerations are now crucial to ensuring that buildings and neighbourhoods are safe as storms and other unfriendly weather events become rife.

There is also the need to demystify single ownership of parcels of urban land. The idea of joint ownership of land for dwelling units must go down to the grassroots as a means of restraining the seemingly uncontrollable wave of expansion of cities. Something has to be done about all these if we will be able to cope with the challenges of a changed world. Government must provide necessary legal backing and infrastructures to make these happen.

The rising incidences and severity of floods have been strengthened by increasing areas of paved surfaces especially in the cities (e.g. Olatubara and Adesina 2001). Such surfaces force practically all water from any rainfall event, to drain away as runoffs and so increase the potential for floods downstream. In the same vein, infiltration of water which is needed for ground water recharging, is impeded. This reduces water availability especially in wells. We need to enforce the planning regulations to reduce such surfaces.

ii. Efficient storage and utilization of water resources need to be emphasized

As already discussed, Nigeria's water sector is underdeveloped and its resources poorly exploited. Yet in the changing environment, water supply is going to be a most important issue as rainy period shortens, rainfall

events bunched up in fewer months in many areas and intervening dry spells during growing seasons become more frequent. The water sector thus deserves a far greater attention than it presently enjoys. Rainfall vagaries would pose no threat to food production if there is water for supplementary irrigation during dry spells or full scale irrigation in areas with long dry seasons. Water and fodder would also be adequately available for livestock all year round. In the same vein, afforestation efforts which have often failed for poor water supply will be enhanced.

Two issues are important to my mind in this respect. First is the need to improve water storage such that larger volumes of water can be retained during the shortened rainy seasons. This will require expanding water storage facilities by developing new dams of small to medium sizes. Such sizes minimize water loss through evaporation. Loss of water through evaporation usually increaseswith rise in air temperatures and large dams dis-proportionally lose more water than small ones (Sellers 1965). Such rain water harvesting studies in which some of our colleagues in this university are involved (Faborode 2005), need to be intensified towards this goal. More emphasis should be placed among other things, on how to minimize the loss of the harvested water during the hot dry season. Many of the storage dams in the country require de-silting to enable them retain raw water at their optimal capacities. Also, the viability of these dams in terms of safely retaining water should be assessed from time to time to reduce the risk of failure, especially as they approach the limits of their lifespan. In general, all dams must receive better care to prevent silting or at least reduce the rate at which this takes place. Heavy sediment loads are transported by rivers especially after rains and these end up in the dams (e.g. Adediji et al 1995). The protection of catchment areas from erosion must therefore attract greater attention.

The second issue has to do with the infrastructures needed to distribute water into farms. Presently, only a fraction of irrigable land is connected with water sources. Of course, some previous irrigation efforts have failed with losses. Such schemes like the Southern Chad Irrigation Project (SCIP) deserve an appraisal . New projects must avoid the mistakes of the earlier ones that have failed. Also, in a drier environment the channel

form of irrigation which is common today will become less and less efficient and we must develop or adopt more efficient irrigation methods.

iii. The Population factor is critical in climate change response

Population is a major factor of environmental degradation and a determinant of the severity of disasters that may arise from climate change. The larger the population affected by an extreme event, the greater is likely to be the scale of the disaster. Demands for environmental resources are also population driven. Among other things, sizes of herds of cattle and other livestock kept in free ranges in different parts of the country also relate to population. The country must of necessity, address the population factor in the development process to reduce the shear impacts of population on the environment. The National Policy on Population (FGN 2004) spells out a wide range of activities and programmes that need to be focused to reduce the rate of growth of population in the country, to less than 2% by 2015. This Policy should be implemented and monitored. The achievement of a reduction in population growth would go a long way in strengthening our ability to cope with the adverse consequences of a rapidly changing environment.

iv. The Forestry sector deserves a greater attention

As already indicated, virtually all the natural forests in the country are gone. Even in the many government forest reserves spread across the country, true forests remain largely confined to Strict Nature Reserves (SNR) (e.g. Oyinloye 2008). Given the overwhelming significance of forests in the natural environmental processes and their relevance as a basis of livelihood, it is important to develop aggressive forest recovery plans even as the demands for land for other purposes increase. The very first step to take is to ensure that what ever is left as forest in this country is protected at all costs. Once lost, forests in the true natural form may be lost for ever.

Furthermore, I want to suggest that all Local Government Areas be compelled to acquire and *maintain* a sizable area of land under forest. The word "maintain" is important because it is not enough to designate an area as forest. Areas so designated must be planted to trees and

protected from all forms of exploitation. They must be mapped and given legal protection from future conversion to any other uses. Under the scheme, urban LGAs that have no rural lands would be duty-bound to locate their own forest holdings in any part of the country where they can secure sufficient land for the purpose. Such LGAs will ensure that the forest is properly acquired, maintained and protected. In this way, community involvement in forestry development would be strengthened and the nation will be better for it. The rich should also invest in forestry. It is certainly more rewarding to the individual and the society - and we need to further educate ourselves on this - to develop forest estates even within the city rather than build mansions that may never be inhabited.

Owning a tree in the spirit of making the environment livable is becoming a fairly well accepted practice in many parts of Africa. This needs to be taken to the grassroots in Nigeria. Trees can be planted to mark important events like the birth of a baby or as in this case the inauguration of a chair in the University. Small-scale farmers should also be sensitized to grow and maintain trees on their farms. This will be important in increasing the densities of trees across the country. Quite clearly, individual or stand alone trees do not make a forest but their aggregate effects make positive impacts on the environment in very many ways. They provide shade, fruits, wood and shield the city against storms.

v. The issue of adequate energy supply

To keep our forests alive and at least maintain jobs in our industries, the issue of adequate energy supply cannot be over stressed. The awareness of Government about the need to effectively address the issue is commendable. However, we need to go beyond that and focus properly on programmes that will realistically help improve energy supply for all sectors of the economy. We must invest on research on alternative energy sources and adapt proven functional technologies from the other parts of the world in this regard. Our Centres of Excellence in Energy Research must continue to provide the leadership and Government must provide the support. Research should also address making what is already available cheaper and at the same time more efficient. For instance, the increasing number of efficient wood burners for domestic cooking is in the right direction. This technology must however, be expanded and

managed to provide better results and the beacon is on an Agency such as the National Centre for Technology Management (NACETEM), to continue to provide research leverages to domesticate these technologies and develop appropriate framework for making them affordable.

In all these, the significance of multi-disciplinary approach to the various issues cannot be over stated. The scientists might argue for example that firewood stove should stopped completely to protect the forests but the social scientists would be quick to know that cooking with firewood is deeply entrenched in local practices and would require a transition period to move people to new ways of doing things. This kind of sharing of ideas makes research efforts readily relevant and acceptable to people.

13. CONCLUSION

Mr. Vice Chancellor Sir, I have tried in the course of this lecture to raise some issues that relate to the changing climate and living with its impacts. I will like to conclude by noting that the responsibility of slowing down or possibly halting climate change and coping with the impacts rests on every one of us. Everyone has a role to play. We need to be adequately informed about the things we do that are injurious to the environment and we need to know also what to do to make the environment better. Furthermore, those in the business of governance need to rise up to the challenges of the looming danger. It is so important that necessary infrastructures are built and maintained. Coping will be impossible if poverty remains vicious as it is today, and one sure way of reducing poverty is to keep the infrastructures functional.

I want to give all the honour and glory to God, for giving me the opportunity to say a few words that may help us keep the earth alive for a little longer. On behalf of my wife and children I thank everyone here present for your patience. May God attend to all your needs as the year runs to an end.

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