

# EXECUTIVE SUMMARY OF FIVE MULTI-SECTOR SURVEYS ON NIGERIA'S VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

SECTORAL STUDIES OF VULNERABILITY AND ADAPTATION TO  
CLIMATE CHANGE ON:

- Health and Human Settlements
- Water Resources, Wetlands, and Freshwater Ecosystems
- Energy, Industry, Commerce, and Financial Services
- Agriculture, Food Security, Land Degradation, Forestry, and Biodiversity
- Coastal Zone and Marine Ecosystems

# NIGERIA CLIMATE CHANGE

A Joint Project of  
THE NIGERIAN ENVIRONMENTAL STUDY/ACTION TEAM (NEST), NIGERIA  
and GLOBAL CHANGE STRATEGIES INTERNATIONAL (GCSI), CANADA

MARCH 2004

## Canada-Nigeria Climate Change Capacity Development Project: An Overview

The Canada-Nigeria Climate Change Capacity Development Project (CN-CCCDP) was an initiative of NEST-Nigerian Environmental Study/Action Team of Ibadan, Nigeria and GCSI-Global Change Strategies International Inc. of Ottawa, Canada. The project was initiated in January 2001 and completed in May 2004. The Canadian International Development Agency (CIDA) provided funds to the project through its Climate Change Capacity Development Fund (CCCDF).

The goal of the project was to contribute to strengthening the capacity of Nigeria to participate in global efforts to combat climate change. The project focused on capacity building initiatives that assessed the risks evolving from climate change, determined options for managing the risks, and strengthened institutional capacities to ensure implementation of recommended measures. To achieve these objectives, strong public and political awareness campaign was implemented.

This project expected to develop an improved understanding of climate change science, the UNFCCC and Nigeria's obligations on behalf of the nation, the states and local governments. This is expected to identify and remove the barriers to effective implementation of climate change policies and programs.

The project focused its work in four areas:

- Strengthening Policy and Program Capacities of Federal Institutions
- Targeted Awareness Raising: Building a Support Base for Climate Change Action
- Greenhouse Gas Inventory and Mitigation Assessment Options
- Vulnerability to Climate Change Impacts and Adaptation Assessment for Nigeria

The project worked through a broad range of collaborating institutions (e.g., universities and non-governmental organizations) to complete various studies and develop useful tools that contributed to the overall goal of the project. In this way, a wide array of capacities and multiple strategic relationships were built.

Please contact NEST for a list of all publications completed under this project or see NEST's web site.



FEDERAL MINISTRY  
OF ENVIRONMENT, ABUJA NIGERIA



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This Publication has been based on the following five Reports:

**Vulnerability and Adaptation to Climate Change in the Coastal Zone and Marine Ecosystem of Nigeria**

by Prof. Effiom E. Antia – Department of Physical Oceanography, Institute of Oceanography, University of Calabar, Nigeria

**Vulnerability Assessment and Adaptation of Nigeria's Water Resources, Wetlands and Freshwater Ecology to Climate Change**

by Prof. G. S. C. Okpokwasili – Department of Microbiology, University of Port Harcourt, Port Harcourt, Nigeria and Prof. S. C. Anurigwo – Permanent Secretary, Imo State Ministry Of Works and Housing, Owerri, Nigeria in collaboration with Dr. J. N. Ogbulie and Dr. B. O. Chikere – School of Science, Federal University of Technology, Owerri, Nigeria and T. C. Akujobi – Imo State Environmental Sanitation Authority, Owerri, Nigeria

**Vulnerability and Adaptation to Climate Change in Energy, Industry, Commerce and Financial Services Sectors**

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**Vulnerability and Adaptation to Climate Change in Agriculture, Food security, Land Degradation, Forestry and Biodiversity**

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**Vulnerability and Impacts of Climate Change on Health and Human Settlements**

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## 1.0 INTRODUCTION

Radiation from the sun passing through the atmosphere is trapped by greenhouse gases (GHG) – principally carbon dioxide, halo-carbons, methane and nitrogen oxide. These naturally keep the earth warm enough to support life. With the emission of chlorofluorocarbons and the burning of fossil fuels, however, the global concentration of these GHG's has increased tremendously, leading to the warming of the atmosphere. Carbon dioxide is known to be 31% higher than its level during the pre-industrial era with a yearly increase of about 0.5%. Methane equally has increased from 0.7 parts per million by volume (ppmv) to 1.7 ppmv, while nitrous oxide has increased from 275 ppmv to 310 ppmv (Obasi, 1996, TAR, 2001).

Global warming has become a new reality, with deleterious effects: seasonal cycles are disrupted, as are ecosystems; and agriculture, water needs and supply, and food production are all adversely affected. Global warming (climate change) also leads to sea-level rise with its attendant consequences, and includes fiercer weather, increased frequency and intensity of storms, floods, hurricanes, droughts, increased frequency of fires, poverty, malnutrition and series of health and socio-economic consequences. It has a cumulative effect on natural resources and the balance of nature.

The impact of GHG's can be vast. In Nigeria, this means that some stable ecosystems such as the Sahel savanna may become vulnerable. As well, the country's aquatic ecosystems, wetlands and other habitats will also be negatively affected. These consequences will create overwhelming problems for an already impoverished populace.

This project was undertaken to assess the vulnerability and adaptation of various sectors of the Nigerian economy to climate change. Nigeria has already shown evidence of the effects of this global problem.

The Intergovernmental Panel on Climate Change (IPCC) has taken the lead on providing direction in addressing the global issues of climate change. The Canada-Nigeria Climate Change Capacity Development (CN-CCCD) Project was set up in response to IPCC reportage on climate change in Africa. The Project is being jointly implemented by the Nigerian Environmental Study/Action Team (NEST), Nigeria and Canada's Global Change Strategies International (GCSI).

Studies of the vulnerability and adaptation of the various sectors of the Nigerian economy to climate change were conducted by NEST and GCSI. The sectors evaluated were based on seven natural and human systems identified by the IPCC, and condensed into five. They are:

- human settlements and health;
- water resources, wetlands, and freshwater ecosystems;
- energy, industry, commerce, and financial services;
- agriculture, food security, land degradation, forestry, and biodiversity; and
- coastal zone and marine ecosystems.

Vulnerability issues facing each sector were identified; current status of each sector in relation to climate change together with current adaptation strategies, was assessed; current and envisaged obstacles were identified, and gender implications noted. Recommendations were made that address the future implications of climate change emanating from these studies in the hope of mitigating the negative impact the phenomenon will have on Nigeria and its people.

## 2.0 VULNERABILITY AND ADAPTATION: DEFINITIONS AND ISSUES

The IPCC defines "vulnerability" as "the extent to which climate change may damage or harm a system" (Second Assessment Report), adding that vulnerability "depends not only on a system's sensitivity but also on its ability to adapt to new climatic conditions" (Watson et al, 1996). A "highly vulnerable system is one that is highly sensitive to modest changes in climate and one for which the

ability to adapt is severely constrained" (Watson, IPCC, 2000a).

Adaptation involves a process of adjusting. In relation to climate change, it includes behavioural (societal) and economic adjustments to anticipated or actual changes in climate conditions. The IPCC defines adaptation as having "the potential to

reduce adverse impacts of climate change and to enhance beneficial impacts, but [adaptation initiatives] will incur costs and will not prevent all damages” (Third Assessment Report). Some of this adaptation, the IPCC asserts, is done autonomously by human and natural systems.

Many proponents of climate change argue that it is necessary to focus on current problems and adaptation to climate change in order to develop strategies that will adequately respond to anticipated changes in climatic conditions. The IPCC (Third Assessment Report, 2001) says: “Adaptation to current climate variability and extremes often produces benefits as well as forming a basis for coping with future climate change.”

Vulnerability analysis, as related to climate change, refers to the degree to which an exposure unit is disrupted or adversely affected as a result of climate effect (Carter et al, 1984). Adaptation, on the other hand, refers to all those responses to climate change that may be used to reduce vulnerability. It can also refer to a set of actions designed to take advantage of new opportunities that may arise as a result of climate change.

The IPCC (1995) has described 228 different adaptation measures, eight of which are commonly applied in Nigeria:

- bear the losses;
- share the losses;
- modify the threat;

- prevent the effect;
- change the use;
- change the location;
- research; and
- educate, inform and encourage behavioural change.

Vulnerability is classified as low, medium, high and critical, and is cross-tabulated with impact categories of people affected as a percentage of the total population on the one hand, and people probably at risk per 1000 of the population, on the other.

The climatological baseline selected is in accordance with two criteria:

- a) as representational of the present day or recent average climate in the study region; and
- b) data and information which are of sufficient duration to encompass a range of climate variations, including a number of significant weather anomalies (e.g. severe drought or cool season).

In projecting future conditions, data was gleaned from literature using available studies and information on Nigeria. Scenarios based on three dimensional models that try to explain/predict climate by the combined functioning of the oceans and the atmosphere (general circulation models) were not utilized in view of their having not been tested, applied or modified for West Africa.

### 3.0 OBJECTIVES AND SCOPE

Assessment studies were conducted for the vulnerability and adaptability to climate change of various economic sectors and their activities. The terms of reference focussed on characterizing the level of sector vulnerability regarding climate change, documenting current adaptation strategies being used (if applicable), suggesting necessary adaptation strategies and mechanisms under different scenarios of climate change and for all sectors, documenting current and future gender implications and present and envisaged obstacles to adapting to climate change under various conditions.

Put simply, there was a four-step approach to the vulnerability and adaptation analyses:

1. Defining the scope of the problem and the assessment process.
2. Defining and describing the scenarios underlying the assessment,
3. Determining biophysical impacts regarding the various socioeconomic sectors.
4. Evaluating alternative practices and technologies for adapting to these impacts.

## 4.0 METHODOLOGY

The primary tool used for the vulnerability assessments was “information”, information that was required from all of the sectors studied on climate change. This information was culled from various sources: existing data already published or from on-going studies, reviews, papers, and reports. Additional “field” data was obtained by means of a questionnaire designed to be relevant to the assessment of popular perceptions of vulnerability and adaptation to climate change in Nigeria. The questionnaires/surveys were structured to elicit as much information as possible in this regard.

The survey was distributed based on six geo-political regions: south-south, southeast, southwest, northwest, northeast, north-central. The sampling was designed to canvass 150 people per geo-political zone with 50 to a rural setting (village), 50 to a semi-urban setting (local government headquarters), and 50 to an urban area (state capital). Care was taken to capture geographical diversities and micro-climatic variations within the regions. The response rate was 62%, with the highest rate being in Lagos, Sokoto and Jos (74%, 73%, and 73% respectively). This suggests a higher sensitivity to climate change issues in those areas. Kano recorded the lowest response rate of 44%.

A number of weaknesses were, however, identified in the questionnaire structure and in its administration, including the following:

- The letter with which the questionnaire was introduced to the respondents lacked an appropriate research approach and language that would promote spontaneous response in the absence of more detailed explanations by the Field Assistants
- There is no information on how particular respondents were selected in the six geo-political zones at the three levels of investigation (namely, village, semi-urban and urban) in the absence of a sampling frame
- There should, in future, be no category as “uneducated” listed on the survey for soliciting information on the educational level of respondents. A more appropriate categorization might be: “Did not receive formal education.”
- Changes in the cost of staple foods may not necessarily be a function of fluctuations in agricultural output. There could be some other extraneous reasons, like changes in transport cost, general inflation, etc. contributing to the pricing costs.
- In introducing issues related to land degradation, the assumption is made that respondents know what it means, and its implications. Without putting the topic in the proper context, respondents with insufficient knowledge/education may give misleading responses. The same applies to other sub-sectors such as biodiversity.
- Some questions simply required the respondents to say yes or no without further comment, additional detail that would enrich or elucidate the response (e.g. “Are there some non-timber forest resources that are currently produced in comparatively lesser quantity than before?”).
- There is no information on gender consideration in the distribution of the questionnaire. The fieldwork activities did not reflect gender consideration. All 13 Field Assistants were male. There is no guarantee that women had an equal opportunity of being interviewed by an all-male team of researchers. As well, religion and cultural reasons prevented some women (in the north, for example) from participating. For the same reasons, certain important questions in the survey were not responded to.
- An election period compounded the task of data gathering; respondents viewed the Field Assistants with suspicion- Fuel scarcity during the same period aggravated transportation and general travel costs related to data acquisition- There was a lack of remote sensing (satellite) data.

## 5.0 CURRENT AND FUTURE VULNERABILITY

The study determined that virtually all of the sectors analyzed manifested some evidence of vulnerability to climate change. None were unaffected, nor will remain unaffected in future by changes to climatic conditions.

### 5.1 Human Settlements and Health

There are many ways in which climate change could affect human settlements and health. Some of the impacts will be direct, others will be indirect. Urban populations are growing and contributing to environmental degradation, loss of biodiversity, environmental decay, and water/air/environmental pollution

Human settlements in Nigeria will be affected by climate change in a variety of ways. Urban and rural population concentrations will be disrupted, particularly along the coast due to sea-level rise and related phenomena. Some settlements are known to have already relocated farther inland from their original sites in response to sea incursion over some decades. Population displacement and migration from, and to, various human settlements will arise from either or both of drought incidence in the northern states of the country and accelerated sea-level rise in the coastal regions. Rises in sea-level will also threaten urban and rural infrastructure facilities in low-lying coastal regions

Extreme climate conditions such as high wind, heavy rainfall, heat and cold can result in wide-ranging scenarios such as tropical storms, floods, landslides, droughts and sea-level rise. Climatic catastrophes induce populations to be displaced (or decimated by death), which in turn can lead to conflict and civil unrest. As well, the public health infrastructure would be eroded if resources are diverted from its maintenance to disaster recovery. Communities and government would be burdened with having to make reparations to individuals for property damage and loss, unemployment, clean-up, and reduced socioeconomic viability of the communities affected.

Pests and diseases are implicated in climate change. Significant climatic conditions such as temperature, precipitation, sunshine and wind can affect and accelerate their dispersion and their increase. Food crops are affected by their presence (creating economic problems because of low agricultural yields and food shortages, as well as human population problems such as malnutrition)., Pests and diseases

can adversely affect animal husbandry (reducing meat supply); they cause human suffering (malaria, cholera, typhoid fever and dengue, for example) which in turn affects the effectiveness and productivity of Nigeria's labour force.

A number of indirect impacts of climate change on human health were identified. As Nigeria's inhabitants already suffer from nutritional imbalances (poor nutrition and malnutrition), climate change will only have a deleterious effect on food security. A shift could occur in the location of some vector-borne diseases, such as malaria (mosquitoes), sleeping sickness (tsetse fly), etc. in response to shifts in the patterns of rainfall and temperature; mosquitoes currently thrive in locations where water logging and poor drainage typify the landscape. High flood frequency and water-logging due to climate change in ecozones hitherto unassociated with malaria, will enhance the breeding of mosquitoes and thus the spread of malaria. Malaria will also increase due to the preponderance of stagnant pools of water resulting from sea-level rise related flooding.

Direct impacts include health problems induced by increasing incidences of heat waves. These could lead to more cases of cerebro-spinal meningitis (CSM), which today is found to correlate positively with the highest maximum mean temperature of the northern winter season, and inversely with absolute humidity to a lesser, although still significant, extent. Currently, this health condition is a feature of Nigeria's dry belt represented by the Sudan Sahelian region of the country, and occurs in the peak of the dry season. The occurrence of skin cancer from direct ultra-violet radiation could become more common, as could increase incidences of cardiovascular respiration disorders.

There are gender considerations in assessing vulnerability. Women do most of the farming in some parts of the country (rural Anambra, Benue, Cross River; urban Lagos; urban and rural: Kwara, Ogun, Imo, Ondo, Oyo and Rivers), as well as fishing. Recent studies (Folorunsho, 1992 and Ojo and Folorunsho, 1993) found that 90% of women involved in fish processing in urban areas use firewood or wood products in their activities. Fuel wood is also used extensively in food processing, and in domestic activities that are dominated by women. Collection of firewood under conditions of heat stress could impact more on the health of women and children who are more involved in this activity than men.

## 5.2 Water Resources, Wetlands, and Freshwater Ecology

Changes in weather and climate have been known to profoundly influence water resources, a factor that increases the vulnerability of man to infection.

Generally, water resources involve all forms of fresh water needed for life's necessities, ranging from domestic needs involving drinking, washing and cleaning, to agricultural needs involving food processing and irrigation, to other general needs.

Water for drinking comes from three sources (EP-HSE, 1995), generally: atmospheric water in the form of rain, snow or hail, and ultimately the source of drinking water in most rural areas of the third world countries where water is scarce (Okafor, 1985); surface water classified as rivers, streams, lakes or reservoirs and ponds (Duru, 1991 and EP-HSE, 1995); and ground water obtained from boreholes sunk into water-bearing rocks, or aquifers, or water that gushes out from rocks such as in springs (Enger et al, 1983 and ELE, 1992).

Water is indispensable. Its uses can be classified into five major categories (Enger et al, 1983 and Okafor, 1985): domestic use; agricultural use (the major consumptive use of water); in-stream use (for hydroelectric power, recreation, and navigation); industrial use (for cooling industrial machines and equipment); and other uses (as a food source, for example).

Nigerians do not enjoy adequate water supply. This problem is more prominent and severe in the northern areas of the country that have limited sources of water and harsh weather conditions.

The low-lying nature of Nigeria's 800 km coastline from Lagos to Calabar makes the region vulnerable to climate change. It is prone to sea-water intrusion into coastal fresh water resources. There is a high frequency of coastal erosion and flooding both climate change-induced forms of land degradation.

Drought – the total absence of rain for a very long time to the detriment of agricultural and other water-related activities – is of concern. It leads to a distortion of seasonal patterns (which drastically affects agricultural yield) and increased incidence of soil erosion caused by excessive flooding and sporadic storm. It also kills livestock (two drought incidences in Nigeria in the 1960s and 1970s led to the death of millions of cows, goats and sheep, while the production of foodstuff such as cereals and other products were long affected). An increase in soil

erosion clearly affects water resources as siltation affects the level and volume of stream, lakes and ponds. Other factors such as increased desert encroachment and excessive heat have an inescapable impact on humankind and water-use.

The impact of changes in water resources will be overwhelming. It is obvious that rainfall variability, climate, soil, agrochemicals and diseases have a direct impact on water resources. Climate change has brought about changes in rainfall patterns, variability in rainfall, changes in water level, changes in the water level/volume of ponds, lakes, rivers and streams, and frequency of storms and drought. With increasing global warming and higher temperatures, a number of phenomena associated with water bodies in different ecological zones of Nigeria were identified. Prominent among them are the following:

- reduced water volume in streams and rivers, arising from different scales of water diversion for rudimentary irrigation activities, siltation of stream beds due to deposition of materials by water run-off, as well as evapotranspiration;
- drying up of water sources due to increased evapotranspiration, and loss of vegetation in head waters (the primary role of vegetation in head waters being to collect water which feeds the stream; climate change diminishes the performance of this function);
- deficiencies in freshwater availability will worsen the already poor sanitary and health conditions in these areas; as well, uncontrolled disposal of wastewater and human wastes will result in a deterioration in water quality leading to high organic levels in surface and ground water thereby increasing epidemics of water-borne diseases such as cholera, hepatitis, typhoid and malaria;
- reduced stream velocity due to loss of gradient from siltation;
- rapid rate of siltation of river/stream beds due to transport, and deposition of eroded materials from heavy rainfall-induced flooding, etc.

Wetlands comprise a wide range of coastal and marine habitats such as estuaries, flood plains, freshwater marsh, peat lands, swamp forests, open coasts and lakes with water depths not exceeding 6m at low tide. With increasing global warming and climate change a number of phenomena will emerge:

- rise in sea-level which results in the flooding of low-lying areas, inundation of coastal wetlands, beach erosion, changes in sedimentation, and biodiversity loss;

- salt water intrusion into coastal fresh water resources;
- decline in species (flora and fauna), especially in the wetlands (currently home to over 2,000 species of plants and animals);
- reduction in the biological productivity of the wetlands due to increased weather/heat stress, as well as progressive desiccation;
- greater frequency and intensity of thunderstorms and floods that threaten coastal ecosystems
- rapid rate of siltation of river/stream beds due to the transport of terrestrial materials into streams, arising from heavy rainfall-related overland flow and flooding, frequency of storm, drought, flooding, etc.

### 5.3 Energy, Industry, Commerce, and Financial Services

#### ENERGY

Hydropower generation is the energy source most likely to be affected by climate change. It is sensitive to the amount, timing, and geographical pattern of precipitation, as well as temperature. There is the potential for more intense rainfall events (which would require more conservative water storage strategies to prevent flood damage), greater probability of drought (less hydroelectric production), and less precipitation (less water available during warm months); all of which point to less hydroelectric capacity at current powerhouses.

Reduced flows in rivers and higher temperatures reduce the capabilities of thermal electric generation. Higher temperatures also reduce transmission capabilities. Hydropower generation will be affected by increased run-off (and consequent siltation). Excessive drought will lead to higher evapo-transpiration, which adversely affects water volume, and will thus reduce hydroelectric capacity. Excessive drought, which is likely to affect forest cover, will also pose problems for fuel wood supply. Oil and gas production, especially in coastal areas, will be negatively affected by increased wind and wave action, heavy precipitation, and shoreline erosion. It will also be affected by the loss of oil and gas extraction infrastructure due to sea-level rise and coastal inundation. Climate change-induced extreme weather events such as windstorms, floods and tornadoes (which can topple transmission towers and hundreds of kilometres of power lines) will exacerbate the rate of failure of transmission systems of electric utilities. The cost implications are prohibitive. Yet

demands for both space-cooling and space-heating can only increase, placing further dependence on this already burdened industry.

#### INDUSTRY

Two categories of industries were identified as being vulnerable to climate change: (1) industries with activities that are dependent on climate (construction, transportation operations and infrastructure, energy transportation and transmission, offshore oil and gas production, thermal power generation, industries, such as paper mills, that depend heavily on water, pollution control, coastal-sited industry, and tourism and recreation), and (2) sectors in which economic activity is dependent on climate-sensitive resources (agro-industry, biomass and other renewable energy production).

Industries, generally, may be exposed to direct or indirect impacts of climate change. Such potential impacts of climate change will depend on a number of factors, which include:

##### 1. The geographic location of such industries.

Industries located in the coastal zone will suffer the negative impacts of sea-level rise and attendant coastal inundation and flooding. Significant sea-level rise will, for example, virtually eradicate beach-based tourism and recreation industries, as well as disrupt oil and gas exploration and extraction activities in the region. Industries located in the northern dry belt will be exposed to the effects of warmer climate on water supplies that make process cooling and environmental processes more difficult and unduly expensive. This belt is equally prone to occasional devastating thunderstorms, floods and windstorms that can destroy industrial infrastructure, giving rise to cessation of activities and incurring costs for expensive repairs to damaged facilities.

##### 2. The nature of resource inputs used by the industry.

Industries that rely on inputs which are climate-dependent (such as agrosources) become vulnerable when those inputs experience any moderate or severe changes in production due to climate change. Harvest failure, for example, would directly impact the fruit juice manufacturing and food-processing industries.

##### 3. The dynamics of consumer behaviour.

Consumers respond to changing atmospheric temperatures in the clothing they choose to wear or buy. Industries that produce clothing may have to alter their production profile by producing more or less of warm/cool weather clothing in response to changing demands dictated by either rising or

falling temperatures. Similarly, industries may have to design and produce more wind/storm-resistant umbrellas in both the northern and southern ecozones in response to rising incidence of severe windstorms. Other industries affected by climate change will have to adapt or fold up. The telecommunications industry, for example, is affected by heavy storms that fell cables. Sales slump under such circumstances and can seriously affect the industry as a result.

4. **Government policies pertaining to climate change.** The imposition of carbon taxes, for example, would increase the cost of production inputs.
5. **Other industries:** such as construction, housing, transportation, energy generation and distribution, are all affected by the incidence of extreme weather and weather-related conditions. All economic activity is affected, as is quality of life and patterns of human settlement. Increased and higher rainfall days will damage roads and increase road maintenance costs. The southeastern ecozone will be the most vulnerable given the sedimentary rock profile of the area, its heavy rains, and its susceptibility to rapid soil wash and erosion. Total vehicular accidents nationwide will also be expected to rise, given a scenario of higher and more intense rainfall rates. At the same time, given a scenario of excessive temperature conditions associated with warmer climate, serious problems would also be experienced with the road infrastructure. Such high temperatures are usually known to soften asphalt roads, explode or buckle concrete roads, warp railroad rails, close airports because of lack of "lift" in extremely hot air conditions, and increase mechanical failures in automobiles and trucks. Adverse weather conditions have equally been known to cause flight delays, flight cancellations, and flight re-routing, with attendant heavy financial losses to the airline industry.

## COMMERCE, AND FINANCIAL SERVICES

Financial services comprise private and public institutions that offer insurance, banking and asset management services. Within this sector, the property insurance industry is potentially the most vulnerable to the effects of climate change since it is already vulnerable to variability in extreme weather events. Anticipated changes in weather-related events are likely to increase actuarial uncertainty in risk assessment, and thus in the functioning of insurance markets. As it is, weather-related losses stress insurance companies to the point of bankruptcy with elevated consumer prices, withdrawal of insurance

coverage, and rising demand for publicly-funded compensation and relief. An increase in uncertainty regarding the frequency, intensity and spatial distribution of weather-related losses will increase the vulnerability of the insurance sector and complicate adaptation efforts.

Property located in potentially high risk areas (such as Bar Beach in Lagos) will attract disproportionately higher insurance premiums, or outright denial of insurance for such property. This will be in addition to difficulties encountered by property owners in such locations to sell, or use their properties as collateral. The possible collapse of the oil and gas sectors and the subsequent shifting of Nigeria's trading partners to greener energy sources will spell doom to the national economy. Extreme weather events will disrupt inter-regional trade, especially between the northern dry belt and the humid south, each of which currently enjoys comparative advantage in the production distribution of staple agricultural products. Climate change-induced drought in the Sahel will lead to considerable loss of livestock, especially cattle and goat in that region, thereby causing upward changes in the prices of such livestock and meat. Tourism and leisure industries and associated businesses will also be adversely affected by climate change, as will the banking industry. Investable funds kept by banks on behalf of insurance companies face the risk of withdrawals for settlement of claims arising from property damage due to weather-related occurrences.

## 5.4 Agriculture, Food Security, Land Degradation, Forestry, and Biodiversity

### AGRICULTURE

A variety of food crops are produced in Nigeria, all dependent on rainfall, so that where rain is abundant (from the coast up to the Middle Belt, for example) crops dependent on rain are planted, and in drier parts of the country, crops that do not require much rain are cultivated. Food production on the whole has not kept pace with Nigeria's population increase.

Climate change phenomenon affects agriculture in a number of ways. For example, uncertainties in the onset of the farming season, due to changes in rainfall characteristics (early rains may not be sustained, and crops planted at their instance may become smothered by heat waves) can lead to an unusual sequence of crop planting and replanting which may result in food shortages due to harvest failure. Extreme weather events such as thunderstorms, heavy winds, and floods, devastate farmlands and can lead to crop failure. Pests and crop

diseases migrate in response to climate changes and variations (e.g. the tsetse fly has extended its range northward) and will potentially pose a threat to livestock in the drier northern areas.

## FOOD SECURITY

Changes in climate and atmospheric composition can seriously affect agricultural production and therefore, food security. Nigeria, at present, does not enjoy food security and is therefore more vulnerable to the effects of climate change. The vulnerability of and threats to food security are due to:

- **Extreme weather events (drought, floods, etc.),** known to create food insecurity. In the years of drought in the Sahelian zone in the 1970's and 1980's, harvest failure was remarkable throughout the region. The situation led to the intensification of crop irrigation as a response mechanism. Close to one million livestock were lost, affecting meat and dairy supply throughout the country. Flood hazards in both the north and south of the country consistently posed a danger to farmlands and hence, to food security;
- **Variability in the onset and cessation of rainfall and rainfall amount.** This phenomenon undermines the age-long ability of farmers to predict when to plant their crops. Unpredictable changes in the onset of rains in the last 20 to 30 years have led to situations where crops planted with the arrival of early rains get smothered in the soil by an unexpected dry spell that can follow early planting. That, coupled with the late arrival of rains due to climate variability, results in harvest failures in the different ecosystems where rain-fed agriculture is practiced;
- **Proliferation of pests and crop diseases.** This can hinder storage when the necessity arises. Pests and diseases can also depress crop and animal production; and
- **Effects of high temperature.** High temperatures with the current warming trend may hinder livestock production and reproduction by reducing animal weight gain, dairy production and feed conversion efficiency. As well, livestock are usually subjected to long treks to find water and grass in the more southerly areas of the country during the dry seasons. Warming trends also depress the production of grain crops such as maize, guinea corn, millet, and rice, and makes storage of root crops and vegetables difficult.

## LAND DEGRADATION

Land degradation reduces the quality and productivity of land. Factors affecting it can be grouped into climatic, pedological, topographic, and anthropogenic elements. Causes of land degradation include water and wind erosion, drought and desertification, acidification and salt accumulation, mineral extraction and heavy metal contamination. The linkage between land degradation in Nigeria and climate change is not very clear. However, human activities are probably what drive both land degradation and climate change. Deforestation, for example – a human activity – is a well-known factor causing land degradation by erosion. Also contributing to the problem are population pressures, failure to implement appropriate technologies, poverty, constraints imposed by recent international trade agreements, and local land-use policies.

All forms of land degradation in Nigeria occur in different scales, but no part of the country is safe from ecological degradation. As aforementioned, the low-lying nature of Nigeria's 800 km coastline from Lagos to Calabar makes the region vulnerable to climate change. It is prone to the incidence of sea level rise/salt water intrusion into coastal fresh water resources. There is equally a high frequency of coastal erosion and flooding, all of which are climate change-induced forms of land degradation. In the Sahelian zone, the most pronounced climate change-related forms of land degradation are wind erosion and related sand dune formation, drought and desertification. Sheet erosion – which results in the complete removal of arable land – is Nigeria's biggest threat to agriculture.

The following are indicators of land degradation due to climate change:

- deforestation, characterized by accelerated loss of forest cover due to changing climatic conditions. It is exacerbated by human intervention;
- scorched and retreating forests, due to atmospheric warming and increased evapo-transpiration;
- irrigation-induced salinization of cropable lands;
- reduced soil productivity in some places due to the removal of soil nutrients by massive soil wash/soil erosion; and
- farmlands devastated by heavy rainfall-induced soil erosion, as in the southeastern ecozone.

## FORESTRY

Prevailing climate is critical in controlling the ecosystem structure. Forests provide important goods and services which include food, non-timber forest products, timber, firewood, regulation of biochemical cycles, genetic resources, soil and water conservation, carbon reservoirs, recreation, and cultural and spiritual values. Forests play a key role in the functioning of the biosphere and indirectly affect the provision of many other goods and services. Changes in climatic and atmospheric composition will likely have an impact.

The vulnerability of the Nigerian forestry sector was identified as follows:

- diminishing forest cover. For example, the northern limits of the tropical rain forest have been degrading into derived savanna. The situation seems to be more of deforestation by anthropogenic factors than climate change. Given the sensitive nature of the forest ecosystems, not only in the forest estates but also in the watersheds and high altitude areas, forest resources have become highly vulnerable to even slight changes in the climate systems. Thus, changes in temperature, precipitation and water cycle dynamics can lead to marked forest-cover loss;
- decreasing forest density and floristic richness. Though illegal logging in Nigeria has exacerbated the decline in both density and floristic richness of the forests, changes in climatic conditions affect all productivity indicators of forests such as net primary production, net energy production and net biomass production. With the progressive and rapid disappearance of the most popular indigenous timber species, attention has now shifted to virtually every other tree species to meet the rising demand for wood;
- poor tree growth and development. While this is not likely directly caused by climate change, still, changes in climatic conditions can affect nutrient cycling by influencing soil microclimate. This, in turn, can modify tree growth and development.
- reduction in the availability of non-timber forest products such as spicy vegetables and mushrooms, etc. A combination of their unsustainable exploitation and the diminishing forest cover are factors threatening the availability of non-timber forest products;
- increased incidence of pests and diseases that attack and decimate forest trees;

- climate stress exacerbating exploitation pressure to depress forest regeneration

## BIODIVERSITY

Biodiversity – a natural treasure – can be disastrously affected by climate change. Yet to date, the vulnerability of biodiversity to climate change has barely been given any heed in Nigeria. Babier, Burgess and Folke (1994) note that the cumulative impact of climate change on biodiversity arising from GHG emissions is one potentially disastrous contemporary event with no historical precedent. The impact of increased CO<sub>2</sub> emissions is much greater on micro-organisms and plants than on humans or animals. It has been demonstrated that if atmospheric CO<sub>2</sub> is doubled, plant biomass will increase by 33% (Kirstein, 1994). The IPCC's Third Assessment Report (2001) on vulnerability to climate change and reasons for concern indicates that some unique and threatened systems may be irreversibly harmed by changes in climate beyond certain thresholds.

The vulnerability of biodiversity to climate change has been evident for some time. Many species of plants and animals are rapidly becoming extinct. Tree density and floristic richness is decreasing. Rarely are new species of plants and animals showing up in the ecosystems. Other indicators of the negative effects of climate change on biodiversity include:

- the disruption and reduction of the fruiting intensity of some trees;
- aberrations in animal mating habits, changes in bird and animal migratory patterns (due to the need for new habitats or new food sources) and changes in fish spawning patterns;
- the increasing extinction of rare and endangered species of plants and animals.

## 5.5 Coastal Zone and Marine Ecosystems

The coastal zone is an amalgamation of a variety of ecosystems, the most notable being the Niger Delta. Other distinguishable ecosystems are fluvial, estuary, lagoon, creek, mangrove swamp, beach and surf zones, and offshore. All of these areas offer sanctuary and habitat for diverse biological life. This rich biodiversity of the inshore coastal systems and offshore counterparts are likely to be sensitive to climate change in different respects.

With increasing global warming and higher temperatures, a number of phenomena associated with water bodies in different ecological zones of

Nigeria were earlier identified (#5.2). In addition to those, the following apply particularly to the coastal zone:

- beach erosion and coastal flooding are widespread due to higher waves generated by onshore storm winds;
- mangroves adjoining estuaries are receding due to wave incursion and beach breaching; their ecosystems largely sustain the rich biodiversity of the coastal zone;
- the receding shoreline coupled with the 30 to 60 km tidal excursion length around the Niger Delta suggests increasing salinization of upland ground water;
- sea-beds reworked by storm waves threaten the integrity of offshore buried oil pipelines leading to rupture and oil spillage; and

- integrity of coastal engineering infrastructure and many industrial facilities are undermined by storm wave scouring and wave run-up, leading to possible closure of operations and job loss.

Three principal “end-products” of future sea-level rise will critically affect the vulnerability ratings of this sector. Land inundation (incorporating groundwater salinization, biodiversity loss, infrastructure destruction and ultimately land loss), ocean productivity scenario (incorporating sea surface storminess and processes that enhance the productivity of offshore waters, such as vertical mixing and nutrient enrichment), and circulation pattern sequences (involving events such as increased storm surges and flooding, coastal erosion and threats to property and biological resources, and ultimately, enhanced poverty levels) all have a myriad of linking effects that are visible, with vulnerability rankings of high to critical.

## 6.0 GENDER IMPLICATIONS

Women not only reproduce, thereby sustaining and contributing to population growth; they are also the main custodians for the youth of society, and the future of the nation. Women in Nigeria are even more integral to that society.

By virtue of their societal role, Nigerian women are involved in several water-based industries and occupations, and of course, rely heavily on water for household chores. Generally, in the southern and northern parts of the country, Nigerian women are involved in the exploitation of water, land and forest resources. In most communities where urban migration by adult males is common, women see to the provision of virtually everything needed on the domestic front.

The female labour force in Nigeria is sizeable both in urban and rural areas. Unfortunately, women also contribute greatly to environmental degradation, their methods being a cause for much concern. Attributable to them in particular are problems related to pollution, deforestation, and related problems, all of which affect climate considerably.

Farming is one of their main activities, as is the cultivation of land. On average, women perform most of the activities related to agriculture (land cultivation, weeding, harvesting, etc.). Fishing is another activity common to the women of Nigeria, much of which involves fish processing and the use of firewood or

wood products. Nigeria destroys close to 600,000 hectares of her forests annually whereas her efforts at afforestation replenishes the loss by a mere 4% annually.

Certain forms of food production (such as the aforementioned fishing, and water-related agricultural products) are entirely the duty of women and girls. They are involved in the processing and oftentimes marketing of the product. Women constitute a significantly high number in the labour force in Anambra, Benue, Cross River, Imo, Kwara, Lagos, Ogun, Ondo, Oyo and Rivers states. In agricultural activities, women play an obvious role in cassava production, vegetable farming and general food processing.

Significant, too, is the role of women in domestic duties. Aside from the use of firewood, the reliance on freezers, fridges, gas cookers, and washing machines contribute to GHG's, as do the use of luxury cars and similar items for the more upwardly mobile.

Generally, though, women have a lower social status in Nigeria compared to their male counterparts. Socio-cultural norms and practices discriminate against them to the point of harmful practices. There have been few considerations for gender issues in policy formulation, program planning and implementation.

Yet women continue to affect climate change and be most affected by it. Climate change will deplete most of the water-related foods. And when serious water crises sets in, women and young girls will be the most vulnerable in view of their need for water and high hygiene (compared to males), thus placing a greater

demand overall on water supply. Reference has already been made to the disproportionate stress placed on women, who do most of the collection of both water and firewood, in the event of climate change making any of these chores more tedious.

## 7.0 CURRENT AND SUGGESTED (FUTURE) ADAPTATION STRATEGIES

There is evidence of human adaptability in the face of climate change, in the various sectors just discussed. Current sectoral adaptation strategies have been reported as they apply to the individual, household or community. Whereas some stakeholders are adapting to some degree, others are still adopting natural resources management strategies that might very well exacerbate the future likely adverse effects of climate change.

### 7.1 Human Settlements and Health

Individual, legislative, and technological strategies exist that can mitigate the negative effects of climate change. Adaptive policy measures can be taken at the population level, and at the personal level, although the former is probably more effective. Population level public policy adaptation measures include (McMichael et al, 1996):

- the reduction of heat-related mortality and morbidity through various measures (insulating buildings and planting more shade trees in urban areas, for example)
- the reduction of transmission of vector-borne diseases through various means including promoting repellent use and undertaking education campaigns
- the reduction of agricultural stresses (less reliance on mono-cultural farming, land reform, and developing climate-adjusted plant varieties or species and animal breeds)
- the reduction of the impacts of extreme weather events and sea-level rise
- the reduction in general population vulnerability.

Personal adaptive steps that could be taken to counteract the ill effects of climate change include:

- 1) increasing hydration and mineral intake during hot weather
- 2) reducing skin cancer risk by avoiding sun exposure and wearing protective clothing
- 3) behavioral adaptation measures (using sunscreen, hydration, etc.)

- 4) migration in response to local climate changes (although that creates new problems)
- 5) immunization (a public policy on immunization against cerebro-spinal meningitis), treatment of disease, bed nets (although this, too, creates problems of its own).

Adaptation options include preventative measures such as:

- judicious application of insecticides (many pests are becoming drug-resistant);
- developing efficient and safe water treatment systems as well as reducing the demand for water, where possible;
- constructing architecturally heat-resistant housing and limiting work hours for outdoor workers;
- data gathering and archiving of diseases associated with climate change and their seasonal and inter-annual variations; and
- technological or engineering strategies such as genetic or biological pest management systems.

### 7.2 Water Resources, Wetlands, and Freshwater Ecosystems

A number of strategies were identified for each of the sector areas.

For individuals, households, and communities, the following were suggested:

- use of better water storage system such as underground, plastic (surface) and other surface tanks;
- improved rain catchment strategies;
- clean-up and protection of natural streams, rivers and lakes;
- improved water treatment plants;
- domestication of water treatment systems; and
- creation of community water resources for humans or animals.

Government responsibilities could include:

- improving municipal water sources;
- commissioning rural water schemes;
- enacting laws to protect streams, rivers and lakes from pollution;
- improving medical facilities to treat those with water-based, water-washed and waterborne diseases; and [water-borne diseases]
- better water resources management.

Public/regional initiatives could create more water resources; restrict the use of rivers, streams and lakes; ensure good water management.

Other adaptation strategies include: water gathering/harvesting from rain; recourse to underground water/boreholes; building of covered barriers around houses amenable to flooding; outright abandonment/shunning of flood from area; evacuation of flood from compounds using water pumps; construction of drainage channels; tree-planting to combat erosion menace; irrigation of agricultural lands; government should organize relief package for flood victims; government/community to set up an emergency response team to face the problems; research activities in different institutions to study, monitor and control the impact of climate change on water resources.

Adaptation should address such problems as aquifer recharge through the protection of the forest cover in head-stream areas and banks of rivers and streams. All levels of stakeholders should be involved including the populace, local governments, the states and the federal government. There should be a popularization of effective and efficient rainwater harvesting, at both the household and community levels. There is also a need to put in place a training program for potential victims of flood disasters on Emergency Response Strategies (ERS) against extreme weather-related adverse events and effort should be made to integrate local response measures into national Early Warning Systems against water-related environmental hazards. Government should encourage the sinking of private bore-holes; the water is exploited by owners who sell it to the disadvantaged, particularly women.

### 7.3 Energy, Industry, Commerce, and Financial Services

In the short and long terms, effective adaptation strategies are critical to meeting the challenges of climate change at all levels of society in these sectors. Relevant measures will include the following:

1. **Planning and design strategies:** New construction activities should be designed for increased resilience and flexibility with respect to climate change; this implies that clients and contractors for various categories of engineering works must incorporate into their prescription and design concepts, respectively, the possible present and future impacts of climate change; it will ultimately be less costly, for example, to design and build flood works oversized in the beginning, than to rebuild and expand their capacity at a later period. Advantage should be taken of replacement schedules for assets with short life-spans (motor vehicles, space heating/cooling gadgets) which will be replaced several times in the course of a few decades, to introduce more energy-efficient consumer goods. Property development in high risk areas, such as flood plains, hillsides and shore lines, should come under effective zoning and property development control laws; this, along with proper landscaping, will be an integral part of designing with nature as an effective strategy for curbing flood-related losses (Rabinovitch, 1998). Economic activity, especially in Nigeria's oil and gas-dependent economy, should be diversified against possible collapse, in the event of an international shift to greener energy sources. Building designs should aim at operational techniques that reduce cooling and lighting demand through electrically-powered gadgets.
2. **Management strategies:** More efficient management of water supplies and market-like mechanisms should be instituted to further stretch water supplies. Action at relevant levels should be taken to set up early warning systems and emergency preparedness to face the challenges of climate change. Integrated neighbourhood response and material assistance systems and measures should be put in place, especially at the local level. Steps should be taken to popularize climate change and enhance awareness of its impacts on all the inter-related sectors of human activity. Timely engineering works that protect shorelines, roads, coastal infrastructure, etc. should be undertaken.
3. **Institutional framework:** An "adaptation-friendly" institutional framework should be put into place. There should be strict compliance with environmental management laws at all levels of society, and a mechanism to ensure unrestricted flow of information on climate change research, as well as adaptive strategies, should be established. Community-based organizations and NGOs should be recognized as vital instruments

for translating climate change issues at the local levels, thereby building institutional capacity in environmental management.

## 7.4 Agriculture, Food Security, Land Degradation, Forestry, and Biodiversity

### AGRICULTURE

Agricultural production could be increased by doubling the crop areas or by investing in agriculture management and technology. Producing genetically drought-resistant crops would help, as would better water resource management, more efficient storage systems, improved processing methods, better pest management. A number of government policies aimed at enhancing the agriculture “industry” could be instituted (for example, providing all-season access and feeder roads and establishing markets for products, to name a few). Other strategies aimed at removing the constraints posed by climate change to increasing agriculture productivity in Nigeria are:

- the use of cover crops that are nitrogen-fixing; this ensures the nutrient enrichment of the soil for succeeding cropping seasons;
- enhancing information flow between research institutes and farmers, so that research results get practical application;
- exercising discretion in planting with the arrival of the earliest rains in the season;
- creating water reservoirs in dry areas such as the Sahel;
- mixed farming practices;
- altering ways of doing things (for example, preserving forage, sharing basin management, etc.);
- efficient multiple-cropping system; this maximizes the utility of the land; and
- the practice of mulching as a water-conservation mechanism, as well as a device to minimize the growth of weeds, which are not productive, but rather consume or waste soil nutrients.

### FOOD SECURITY

Individuals and communities need to adopt behaviours or policies geared at restoring and conserving the environment. Increased self-reliance, avoiding forest exploitation, planting appropriate tree species, protecting water sheds, using agroforestry and organic farming, and maintaining adequate food supplies will lessen the vulnerability to food security. So, too, will maintaining water levels so that fish can spawn, planting drought-resistant crops, draining

wetlands for rice cultivation, and reforming land tenure and land management policies. Government initiatives such as greater support for research, establishing adequate reserves, improving transportation, repudiating foreign debt, offering subsidies and other protective trade devices, according high priority to soil and water conservation should also be considered as adaptive measure. Also recommended are:

- local by-laws against letting animals (e.g. goats) loose onto [onto] farmlands which leads to massive crop destruction and harvest failure;
- erection of contour bunds around farmlands as a safeguard against soil erosion and flooding
- the practice of multiple cropping;
- the adoption of agroforestry;
- the use of disease-resistant, quick-maturing crop and plant species (cassava sticks, fruits and nuts);
- proper preservation of seeds and plant seedlings to ensure healthy germination in the succeeding farming season; and
- the dissemination of research findings to farmers, such as the popularization of a Cassava variety that is resistant to the Cassava Mosaic Disease (CMD) by the International Institute of Tropical Agriculture (IITA), Ibadan.

### LAND DEGRADATION

The following are recommended actions for managing land degradation:

- the avoidance of monocropping in preference for mixed cropping;
- the construction of run-ins and catch-pits to prevent water-logging, erosion and flooding the adoption of agroforestry;
- the use of organic manure, as preferable to chemical fertilizers;
- the establishment of wood-lots at the community level; the wood-lots are composed of fast-maturing plant species that yield domestic fuel wood for community members, thereby forestalling encroachment into forest reserves for the extraction of fuel wood;
- the minimization/abolition of bush burning; and
- the construction of contour bunds round farmlands to prevent erosion and flooding.

(Engineering works in the Bar Beach area of Lagos are keeping the surging waters of the Atlantic Ocean at bay.)

Also recommended are:

- avoidance of frequent changes in agricultural policy;
- ensuring long-term stability of agricultural institutions;
- reducing grazing and deforestation;
- controlling the spread of animal diseases;
- utilizing coal more effectively and reviving and effectively applying the Mineral Act to ensure adequate land restoration in all mining and quarrying sites;
- halting the flaring of natural gas and develop an alternative to renewable energy resources;
- instituting and enforcing tough legislation against oil spillage;
- limiting access to eroded and erosion-prone areas, and initiating and stringently enforcing anti-erosion laws;
- continuing education of the public on the menace of land erosion and the public's role in tackling the problem.

## FORESTRY

Adaptation can be successful if there is a shift to small-scale animal husbandry (snail farming, poultry, rabbitry, etc) as alternatives to protein sources, previously derived in abundance from now-dwindling forest ecosystems, and homestead mushroom farming and fruit tree orchards using improved varieties. Rather than depend on uncertain wood supply from the forests, forest-dependent ventures such as the timber industry should be encouraged, through incentives, to invest in tree growing.

## BIODIVERSITY

No adaptation suggestions were put forward, however, some of the suggestions in other sectors overlap with biodiversity and can be seen to be related.

## 7.5 Coastal Zone and Marine Ecosystems

There are a variety of sustainable adaptation strategies that can be adopted, some of which are already practiced. Beach nourishment to halt erosion (an activity in Bar Beach, Lagos), shore embankments using sheet piling and moles (Lagos Marina) and with sandbags to shore up individual dwellings (Niger Delta region), pole-raised houses (Lagos Lagoon), floating houses (Niger Delta), retreat and abandonment of coastal property (Bakassi), buffer or set-back lines are effective against coastal erosion and flooding.

Water and land-use adaptation strategies include using river or stream water as drinking sources, or collecting water for drinking at ebb-tide, discharging wastes (human or animal) at high water time to be flushed out to sea, using motor bikes for transportation, deploying boats at high tide, using beaches for large recreational gatherings, utilization of mariculture, fishing activities targeting migrational patterns.

Future adaptation methods should include the following:

- selective shore line stabilization;
- defining and enforcing a set-back line for land development (currently some developments take place too close to shore lines and river/stream banks);
- prohibiting beach-sand mining in favour of river-sand mining,
- land reclamation to enhance the land resources of the nation, since its supply is generally fixed
- wetland re-vegetation and restoration;
- mariculture and aquaculture intensification,
- high sea-level rise scenario adaptation strategies (plans to abandon permanent structures, land reclamation for temporary development, designing flexible and mobile coastal infrastructure, and emphasizing deep offshore development technology); and
- the institution of early warning systems against extreme coastal events.

## 8.0 OBSTACLES TO ADAPTATION

Obstacles to adaptation include the following:

- the existence of land tenure and land management systems that do not favour food security;
- widespread poverty which induces heavy and total dependence on the immediate environment for a livelihood;
- reluctance among some stakeholders to accept the reality of climate change;
- inability and reluctance to adopt new farming strategies;
- lack of information (awareness) and knowledge (education) on the phenomenon of climate change;
- lack of government preparedness and insensitivity to climate change;
- lack of dedicated research institutions;
- population growth;
- land scarcity, leading to adoption of unsustainable farming practices; and
- inadequate public policies that target adaptation at relevant stakeholder levels.

Obstacles are itemized for specific sectors below:

**WATER:** the inability of some traditionalists to accept that the river/stream water s/he has been using over the years is polluted; the *purdah* system which, where practiced, limits access to water for women and what they can do in societies; the lack of personal "ownership" in the upkeep of streams and lakes which are communal and the increased siltation, nutrient overload and pollution of these water sources as a result.

Envisaged obstacles are: lack of government preparedness (the Nigerian government does not take the problem of climate change seriously enough); hunger/malnutrition (as water-based farming activities are presently practiced by the old, illiterate members of the society, products such as fresh water fish, sea foods, and some water-based agricultural products will be depleted with time); population growth (which may worsen the impact of climate change).

**AGRICULTURE:** Taboo and tradition (for example, some southern farmers believe that fertilizer defiles the ground), the existing land tenure system, government policies (for example, the 1978 Land Use Decree), difficulty in adopting new methods.

**FORESTRY:** heavy dependence on forest resources, dependence on environmentally-unfriendly energy sources, lack of public awareness and education.

**FOOD SECURITY:** inefficient transportation of perishable foods to urban centres, weak land ownership rights, exploitation of large tracts of fertile land for export crops, land tenure and management systems that do not favour food security, promotion of more vulnerable exotics over drought-resistant crops, lack of improving/maintaining the distribution infrastructure, growing population, poor management and pricing policies and corruption, and large foreign debts and unfair international trading practices.

**LAND DEGRADATION:** lack of or insufficient funding, lack of political will, lack of development impact assessments, mining and quarrying disturbances, poverty, unplanned urbanization, deforestation, over-cultivation of grasslands and steep slopes leading to soil erosion and the formation of gullies, intensive grazing by domestic animals, intensive tourism.

**BIODIVERSITY:** lack of knowledge (and this is true for all sectors), insensitivity of the younger generation, development, land scarcity, and using alternative resources such as synthetic materials and imported food.

**COASTAL AND MARINE ECOSYSTEMS:** pollution, gas-flaring practices, oil spillage in the marine environment, depressed economy, low technology level, high population growth, cultural beliefs, lack of livelihood opportunities, loss of holdings, youth development and aggression issues. Technological advancements could help to overcome some of these obstacles, however, as this appears to be a low government priority, there is insufficient funding to encourage it.

## 9.0 CONCLUSIONS

The health impacts of climate change on the Nigerian population will be far ranging. Health sciences and related disciplines must provide new and better methods for studying the relationship of population health to natural climate variability and to human-induced climate change. Collecting and monitoring data, as well as accurately quantifying the historical and current diseases dynamics, is essential for applying quantitative models to disease incidence and vector density in Nigeria.

The impacts of climate change on water resources will affect all facets of life. Human health would be vulnerable when the impact on water resources affects food production, lives, agriculture, etc. Indeed, the worst impact of climate change can be said to be on water resources. There is a need to go beyond the present terms of reference to extensively study the impact of climate change on the biology and physicochemical quality of water and determine the possible impact on the functionality of water and the critically deepening water crisis. Obviously, the cumulative impact of climate change is bound to affect water quality. This will have an inestimable consequence on the individual, his/her existence, occupation, on property, etc. Studies in this direction would help to unravel more of the impacts of climate change and further research should be directed towards this area. Also, it is important to note that vulnerability and adaptation are multifaceted, calling for an interdisciplinary approach to climate change studies.

With respect to land degradation, it should be noted that certain forms of land preparation for agriculture (such as those involving excessive tillage) which destroy soil architecture, constitute a form of land degradation. In the process, this releases sequestered carbon dioxide which may exacerbate the atmospheric accumulation of GHG's, contributing to global warming.

Increased incidences of flooding is a significant risk to coastal areas, and will affect business and commercial activities (through damage and relocation costs), as well as the insurance industry and financial systems. The economic impact of disruption to Nigeria's power supply (due to climate unpredictability) will be significant.

It is obvious that climate change will have a significant effect on all aspects of Nigerian society, affecting each and every socioeconomic sector. Yet the present level of research and knowledge on climate change in Nigeria is hardly advanced. As a result, a lot of conclusions and inferences drawn by scholars, particularly with respect to vulnerability and adaptation, appear highly speculative. More work and expanded research efforts, and improved monitoring, are therefore required to bridge the gap between speculations and realities on the ground. As well, much is left to be done in the area of understanding and characterizing the strands of complementary or synergistic relationships between and amongst the various sub-sectors of the economy vulnerable to climate change. Investigation of an integrated adaptation approach that can be operationalized in the field should be urgently undertaken..

The disregard of climate change issues by the present administration of Nigeria cannot be over-criticized. There can be no talk of reducing the use of firewood and other fossil-based sources of fuel when the natural gas resources are being flared, and while kerosene and cooking gas are not available. Mass orientation on the role of citizens in contributing to climate change is also vital to addressing the problem. The present government should be seen to be concerned about climate change phenomenon and its possible impacts on man and the ecosystem. Alternatives should be created which would serve as adaptation strategies for the citizens of Nigeria. It is imperative that the government institutes policies that will address all aspects of climate change, and especially, that will effectively plan for and understand the long-term response measures required to address all aspects cited in this paper. What is urgently needed **at present is the political will to pursue a proactive approach to climate change and its impact on Nigeria.**

## 10.0 RECOMMENDATIONS

It is recommended that the following actions be implemented immediately or supported by government policies aimed at addressing vulnerability and adaptation to climate change in the five sectors cited in this paper:

1. Improvement of the transfer of knowledge from the scientific community studying climate change and weather forecasting to the relevant sectors;
2. Advance the understanding of the relative global and regional vulnerability and adaptability of sectors to climate change.
3. Explore the range of possible financing arrangements to cover the cost of adapting to climate change.
4. Recycle and reduce wood waste; establish gene banks to prevent forest species extinction; introduce domestication programs and legislation in the forestry sector.
5. Research, in depth, various aspects of climate change, with a multi-disciplinary approach, to generate reliable empirical data.
6. Institutionally strengthen (capacity-building) the relevant government authorities in the various sectors.
7. Enforce a properly conducted environmental impact assessment as a precondition for approving projects in the various sectors.
8. Enforce extreme care in introducing exotic species to Nigeria which, like the *Nypa* palm, can turn out to be a menace.
9. Incorporate strategies to include the private sector and the public in bearing the financial burden of dealing with climate change phenomena; the government cannot bear the brunt.
10. Initiate domestication programmes for various forest species to reduce pressures on the forest ecosystem.
11. Update forest legislation.
12. Ensure all international agreements relating to climate change adhered to by Nigeria are rigorously enforced.
13. Use as many adaptation strategies as possible to mitigate the adverse effects of climate change on agriculture and food security.
14. Reduce pollution levels.
15. Initiate more research into the agricultural/food security sector to develop effective strategies that will reduce the country's vulnerability to food shortages.
16. Prompt the use of fuel-efficient stoves which can increase wood use by one-half, and give grants to women to buy stoves and gas cookers.
17. Change the institutionalized land-holding system to make land available to landless farmers (particularly women).
18. Institute early warning systems which can predict and monitor a variety of disasters.
19. Institute government policies to effectively plan for and understand the long-term response measures to coastal land loss and inundation due to sea-level rise.
20. Plan government rehabilitation centres and job creation measures for communities requiring relocation away from the coastal zone.
21. Explore biotechnology options and agroforestry systems to help mitigate the effects of climate change.
22. Address all of the obstacles noted herein, including the depressed national economy, poor technological development, high population growth, youth underdevelopment, lack of understanding of the dire problem.