

# Climate Change Adaptation Strategy Technical Reports – Nigeria (CCA STR)

Infrastructure Sector  
Agriculture Sector  
Natural Resources Sector  
Health and Sanitation Sector  
Cross-Sectoral Issues

A Compendium of Studies Commissioned and  
Published by Building Nigeria's Response to Climate  
Change (BNRCC) Project

Coordinated by:  
Nigerian Environmental Study/Action Team (NEST)  
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## Preface and Acknowledgements

The heightened impacts of climate change in Nigeria and other developing countries, which are likely to intensify in the coming years, have overwhelmed local and traditional knowledge and technologies, leaving many people with inadequate information and little means to deal with the challenges. In addition, there are too few government policies and strategies to address climate change impacts. To tackle these issues, the 'Building Nigeria's Response to Climate Change' (BNRCC) project, was implemented between 2007 and 2011, by the consortium of ICF Marbek and CUSO-VSO and by the Nigerian Environmental Study/Action Team (NEST), with financial support from the Canadian International Development Agency (CIDA).

The BNRCC project components included research and pilot projects, policy development, communication and outreach as well as youth and gender initiatives. The research projects involved community-level socio-economic and future climate scenario studies, while the pilot projects engaged partners and communities in all of Nigeria's ecological zones. Mainstreaming gender equality was integrated throughout all components, and communications activities built awareness at all levels, from the communities to government agencies. Lessons and knowledge generated from the project components fed into the development of the National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN), which was prepared in partnership with the Special Climate Change Unit (SCCU) of the Federal Ministry of Environment, and other partners.

Publications that have emerged from the BNRCC Project include: the *National Adaptation Strategy and Plan of Action on Climate Change for Nigeria* (NASPA-CCN); the *Climate Change Adaptation Strategy-Technical Report* (CCASTR), which is a precursor to the NASPA-CCN; *Climate Change Scenarios for Nigeria: Understanding Biophysical Impacts for Adaptation Strategies*; *Gender and Climate Change Adaptation: Tools for Community-level Action in Nigeria*; and *Learning from Experience – Community-based Adaptation to Climate Change in Nigeria*, a practitioners' guide to climate change adaptation based on BNRCC's experience with pilot project in vulnerable communities. In addition, BNRCC produced two documentary films on climate change in Nigeria: *Water Runs Deep* and *In the Red Zone*. All publications and films are available on-line at [www.nigericlimatchange.org](http://www.nigericlimatchange.org) and [www.nestinteractive.org](http://www.nestinteractive.org).

The Climate Change Adaptation Strategy Technical Report (CCASTR) is a collaborative effort involving 22 researchers providing a broad perspective of recommendations on climate change hazards, impacts, vulnerability, adaptation options and policy for five sectors and 18 sub-sectors. CCASTR was supported by the BNRCC project. Document editing and collating was completed by Nigerian Environmental Study/Action Team (NEST) Chair, Professor David Okali and NEST staff Robert Ugochukwu Onyeneke, Ellen Woodley, Brent Tegler and Sarah O'Keefe. NEST and BNRCC would like to acknowledge the extraordinary effort made by all of the authors for their contributions to individual sectors and sub-sectors of the report. Also deeply appreciated are those people in the public and private sectors, including NGO representatives, who assisted in various capacities during the five years of the BNRCC project. All of these efforts – and sacrifices – and the resources expended will enhance Nigeria's capacity to adapt to climate change and we expect they will be of benefit to the service of humanity.

<sup>1</sup>The Reports in this compendium, including the opinions and recommendations presented, are the sole responsibility of the named authors. The BNRCC project, its Canadian Executing Agency, ICF Marbek and CUSO-VSO, NEST and the Canadian International Development Agency, which financially supports the BNRCC project, bear no responsibility for the content of the reports, including the opinions and recommendations expressed by the authors.

# Introduction to Climate Change Adaptation Strategy Technical Report

The objective of the Climate Change Adaptation Strategy Technical Report (CCASTR) is to assess the vulnerability of Nigeria to climate change and identify adaptation options. The CCASTR documents climate change hazards and impacts and assesses these in the context of the vulnerability of Nigerians. Subsequently recommendations are outlined for adaptation options that should be considered in the development of appropriate policy options, strategies and programs for all sectors of Nigeria. The goal is to provide a document on climate change adaptation that will serve as a basis for the synthesis of national strategies, priorities and policy interventions on climate change adaptation in Nigeria. The CCASTR underpins the development of Nigeria's National Adaptation Strategy and Plan of Action (NASPA); one of the key outcomes of the Building Nigeria's Response to Climate Change (BNRCC) project.

Adaptation to climate change requires an adjustment in natural and human systems in response to actual or expected climate changes, such that negative impacts are moderated or positive impacts are exploited (IPCC, 2007). In general, a broad range of adaptation options are possible including behavioral, technological, regulatory, institutional, or financial measures.

The need for adaptation to climate change in Nigeria derives from the existing and predicted future impacts of climate change. Nigeria is considered highly vulnerable to negative impacts of climate change due to the following two factors:

1. Nigeria's physical location is characterized by a long coast line of 853 km on the Atlantic Ocean along the Gulf of Guinea. Coastal areas represent the region of the country with the majority of Nigeria's industrial, petroleum and export facilities. As well, the coastal area has large urban and rural populations. These areas are vulnerable to flooding, storm surges and sea level rise, which have a negative impact on the biological diversity of the area, which includes mangrove, freshwater swamp and tropical rainforest communities located within vast low lying lands of the Niger River Delta.
2. The second factor is the poor socioeconomic status of a significant proportion of Nigeria's large and growing population, which makes them particularly vulnerable to the adverse impacts of climate change. According to the United Nations Development Programme's (UNDP) report of 2009, with respect to Millennium Development Goal (MDG) 1 "Eradicate Extreme Poverty and Hunger", in Nigeria 35 out of 100 people live in extreme poverty and 30 out of 100 children are underweight. Nigeria is making slow progress towards the MDGs in general and the majority of its people are very vulnerable to climate factors because most of the livelihood activities are climate-dependent. These factors among others have informed aspects of Nigeria's Vision 20:2020. There remains a need to include issues related to climate change and in particular the capacity at all levels (national, regional, local) to develop and implement adaption policies and strategies.

The CCASTR examines climate change adaptation in the following five sectors:

- **Infrastructure Sector** (sub-sectors of Energy, Transport, Communications and Housing, Industry and Commerce);
- **Agriculture Sector** (sub-sectors of Crops and Livestock);
- **Natural Resource Sector** (sub-sectors of Coastal Resources, Water Resources, Fishery Resources, Forestry Resources, Biodiversity);
- **Health and Sanitation Sector** (sub-sectors of Human Health, Domestic and Industrial Sanitation and Waste); and
- **Cross-Sectoral Issues** (sub-sectors of Finance, Disaster Management, Migration and Security, Urban and Rural Settlements and Livelihoods, Vulnerable Groups, and Education).

The report for each sector includes an analysis of current and future trends in regard to climate change hazards, impacts, and vulnerability and provides a range of adaptation

options. Additional consideration is given to issues of gender, economic impacts and costs, and governance. Based on the analysis, recommendations are presented for policies, strategies and programs needed to support climate change adaptation in Nigeria.

The sector reports were written collaboratively by several authors who received input from a wide variety of sources including Nigerian researchers, government workers and private consultants. The authors explored a wide variety of available information and data on Nigeria including published journal articles and books, government and non-government reports and communication with persons working directly in the various sectors. Findings of the BNRCC-supported community-based adaptation pilot projects and research carried out across all ecological zones of the country were also referenced.

Most of the CCASTR authors are also participating in the development of the National Adaptation Strategy and Plan of Action on Climate Change in Nigeria (NASPA-CCN). They were selected to be members of the Multi-Sectoral Working Groups (MSWGs) working under the guidance of the NASPA Secretariat and Multi-stakeholders Forum (MF). Authors and editors worked under the consistent guidance of the Chair of the MF, Prof K. Ologe, and the Chair of NEST, Prof David Okali.

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# Climate Change Adaptation Strategy Technical Report

## Infrastructure Sector

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## Introduction to Infrastructure Sector

Climate and its effect on infrastructure have been central in shaping socio-economic conditions in Nigeria. Climate-related impacts are evident in the disasters that occur annually throughout the nation particularly during the rainy season. For example, Nigeria experiences wind gusts, torrential rains, flash floods and bursting of irrigation dams and in northern Nigeria there is unpredictable rainfall and prolonged droughts. Climate change is leading to more frequent and more severe climate-related impacts. A major challenge of climate change is for government to provide appropriate policy interventions to mitigate the effect of climate-related impacts and to help citizens develop sustainable adaptive measures within an overall national development policy.

The impact of climate change across different ecological zones of the country is varied and has a greater impact on the most vulnerable groups. The challenges of climate change are multifaceted (social, economic, environmental) therefore its impact on infrastructure will be significant because infrastructure provides a critical platform for the effective functioning of the Nigerian economy. Whether in terms of energy consumption, modes of transportation, the level of industrial developments or housing needs, adaptation of infrastructure to climate change is critical in achieving sustainable livelihoods for Nigerians. As an example, in the Sahel region where climate change results in higher temperatures, greater variation in rainfall and more frequent and prolonged drought, it is critically important that infrastructure is adapted to meet increased energy and water supply needs, alleviate heat stress, and control flooding (DFID, 2009).

In the coastal regions, flooding and sea level rise have been instrumental in disrupting economic activities particularly in the areas of Lagos and the Niger Delta where substantial infrastructure investment exists. The region is particularly challenged due to the large population living in vulnerable areas and the relatively poor quality of buildings which makes them susceptible to flooding and sea-level rise hazards. In this region, the existing coastal infrastructure to protect property includes detached breakwaters, floodgates and tidal barriers as well as salt water intrusion barriers, periodic beach nourishment/replenishment, seawall revetments, and bulkheads among others. Where infrastructure in coastal regions is well built, it can mitigate the impact and vulnerability of residential, industrial and business properties that may otherwise be affected by ocean storm surge and tidal wave action. This in turn promotes efficiency and effectiveness in manufacturing operations leading to wealth creation, as well as social and economic development.

In the Sahel and Savanna ecological zones, variation in climatic conditions and continued population growth have led to the degradation of natural resources that support livelihood opportunities. Infrastructure can help mitigate the impact of climate change through the adoption of modern technologies such as solar power for electricity production or food processing, wind power and energy efficient wood burning stoves. As this region faces particular issues of food security and water shortages, the role of infrastructure can be important to supporting industrial and commercial initiatives that provide alternative livelihood opportunities as well as improved processing for local products.

Climate change considerations have largely been left out of policy discussions up to now in Nigeria, but this condition is no longer tenable. Policies need to be reviewed in light of the current understanding of climate change and based on the anticipated future effects on infrastructure, livelihood and human well-being. Climate change adaptive strategies for the infrastructure sector, anchored in appropriate government policies, are considered below in order to help shape a more prepared and resilient nation.

*"Ogun...Abeokuta Flood Disaster: The Day After"*  
Guardian newspaper (August 1, 2010)

The Guardian reported that "a week after a massive flood sacked residents of a section of Abeokuta, Ogun State, most of the victims and others affected are yet to come to terms with the reality of the fate that has befallen them". It described the extensive damage to buildings, roads and bridges, a result of floods from the torrential rains.

*"NEMA aids Jigawa Flood Victims"*  
Daily Independent newspaper (August 24, 2010)

The National Emergency Management Agency (NEMA) assessment team visited Yakasawa, Auramu, Tsuhuwa, Siltilmawa, and Gabarin villages and Debi town all in Ringim Local Government of Jigawa State.

*"Water dams worsen flooding in Jigawa as hundreds flee their homes  
Agony reigns still in Jigawa"*  
Guardian newspaper (August 29, 2010)

The Guardian carried a full-page article including pictures of a large compound almost fully submerged in the flood; roads, homesteads with only the tip of roof visible and adjoining farmland completely covered; and hordes of people being taken to safety in a boat as others await rescue. The disaster was caused by the release of water from the Hadejia-jama'are River Basin Development Authority's Challawa Gorge and Tiga dams which were under threat due to heavy rains in the region. In the coverage, it was reported that this disaster came *"on the heels of an earlier flood caused by heavy rains in Jahun Local Council of the state which swept through many communities, destroying buildings and property worth hundreds of millions of naira."* The Guardian also listed 14 affected villages which were all on the bank of River Hadejia. It also reported the Emir as saying that the area was notorious for flood incidents, and the Chairman of the Ringim Local Council was reported to have said that all the people in the affected villages were safely evacuated by the Council with canoes and boats. Jigawa State Emergency Relief Agency estimated about N50 million required to temporarily rehabilitate the victims whose farmlands of more than 2,500 hectares had been destroyed in the flood

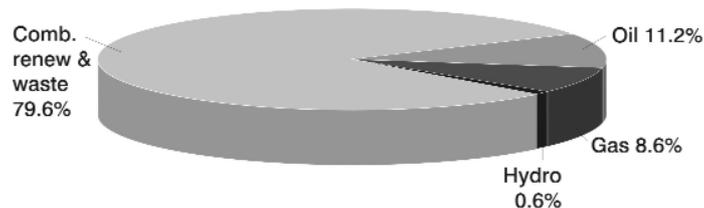
# Sub-sector 1: Energy

## Introduction

Nigeria has considerable fossil fuel and renewable energy resources. Total fossil fuel energy reserves amount to approximately 14.5 billion tonnes (crude oil 31.1%; tar sands 29.2%; natural gas 26.7%; coal 13%). Renewable energy resources include: Large Hydro Power (LHP) installations of 10 GW; Small Hydro Power (SHP) installations of 734 MW; fuel-wood in the form of 13.1 million hectares of forest land; animal waste at the rate of 61 million tonnes per year; crop residues of 83 million tonnes per year; solar radiation at the rate of 3.5 - 7.0 kWh/m<sup>2</sup> per day; and wind in the form of 2-4 metres per second average (surface winds from south to north) (ECN, 2005; ECN, 2007).

The pie chart representing the sources of Nigeria's Total Primary Energy Supply (TPES) of 105.08 million tonnes for 2006 illustrates the dominance of biomass energy resource in Nigeria (IEA Energy Statistics, 2009): By 2008, the TPES had slightly increased by about 6% to 111.16 million tonnes of oil equivalent (Mtoe) (IEA Key Statistics, 2010). Noteworthy is the fact that 80% of the population still largely depend on biomass-based fuels resulting in an average fuel-wood consumption of 0.5 tonnes per capita. This is the main cause of the extremely high deforestation rate of about 350,000 ha/yr. Deforestation is a key driver of increasing desertification in Nigeria which exacerbates other increasing environmental degradation issues such as erosion, flooding, and drought (Obioh, Fagbenle & Helio 2009).

Sources of Nigeria's Total Primary Energy Supply in 2006, (IEA, 2009).



Despite the fact that biomass energy is by far the dominant and primary energy source for Nigerian's, the vast majority of energy infrastructure and investment is in the oil and gas energy sectors. There is a smaller investment in electric power generation and distribution and in the promotion of fuel efficient wood burning stoves despite the fact that these have the potential to reduce consumption of biomass-based energy sources. Investment in oil and gas infrastructure is related to the fact that Nigeria has the 7th largest natural gas reserves in the world and is the world's 8th largest oil exporter. In addition, oil is the largest foreign exchange earner for the country. Therefore, energy infrastructure for oil and gas in Nigeria is a multi-trillion dollar investment which includes the multinational and joint ventures of oil, gas, petrochemical and liquefied natural gas (LNG) infrastructure; the public sector national power utility infrastructure; some private sector power utility infrastructure; and some renewable energy infrastructure. The infrastructure of all these energy technologies is affected by climate change and is at high risk from climate change related impacts. Nigeria also has tar sands and coal energy reserves that constitute 42% of the total fossil energy reserves and while currently undeveloped there are long term plans for coal development in Nigeria.

The President Yar'Adua Power Sector Reform Committee Report of May 2008 identified the following infrastructure-related funding requirements in the electrical power sector in the short term (2007-2009), medium term (2010-2013) and long term (2014-2020) totaling N9.81 trillion (Table 1). The total electrical power generation projections for the short, medium and long term in the report are 7,365 megawatt (MW), 10,000MW and 50,000MW respectively. The Committee proposed long-term electric power generation investment along the following lines: government – 30.63%; joint ventures - 8.49%; and independent power producers – 60.88%.

**Table 1** Funding Requirements in the Electrical Power Sector 2007 to 2020

Plans	Funding Requirements (billions of naira)				Total
	Generation	Transmission	Distribution	Other	
Short Term (2007-2009)	33.1	11.5	13.8	20.0	383.4
Medium Term (2010-2013)	1180.4	409.5	434.3	3.5	2027.8
Long Term (2014-2020)	6057.3	289.8	1050.7		7397.8
				<b>Total</b>	<b>N 9808.9</b>

## Assessment of Current and Future Trends

Gwary, (2008) has noted that every Nigerian is vulnerable to disasters, natural or man-made. Every rainy season, wind gusts arising from tropical storms claim lives and damage property worth millions of naira across the country. Also, dam bursts are common following such storms as a result of flooding. As a specific example, in August 1988, 142 people died, 18,000 houses were destroyed and 14,000 farms were swept away when Bagauda dam collapsed following a flash flood. This observation thus suggests the need for dam experts to incorporate climate change into dam design to minimize the impacts noted above.

In 2007, when several localities experienced damage from flash floods, the capital of Ogun State, Abeokuta, experienced 2000 people displaced, 500 homes and 200 vehicles damaged. Similar levels of damage and some deaths were reported in Sokoto, Zamfara, Yobe, and Taraba States in the northeast and northwest of Nigeria. Similar reports came out of Calabar, the capital of Cross River State, and many communities in the Niger Delta especially Delta State (Olorok, 2008). Interestingly, energy infrastructure damage and destruction are rarely mentioned in these flash flood reports likely due to the significance of the tragedies associated with the loss of lives, homes and livelihood, yet they are surely experienced. Floods will increase the flow in the inland waterways supplying the hydro plants but may cause dam siltation and clogging of turbine inlets by debris washed up with the flow. Adaptation measures for energy infrastructure against flash floods include: timely maintenance and strengthening of transmission and distribution lines and sub-stations; de-silting and dredging of dams and reservoirs to improve their capacities and reduce the impact of evaporation in the dry season (Olorok, 2008). Climate change is expected to result in further reduction of the already limited electrical power supply. Service interruption is expected to result from damage to fragile transmission lines and substation equipment impacted by sea level rise, flash floods, high winds and other extreme weather events.

Predicted higher temperatures in Nigeria will also affect power transmission lines which will sag from thermal expansion and will lead to increased growth rates of trees in swamp forest and tropical rainforest zones. This will result in interference from foliage causing unanticipated power disruption which could be time-consuming to trace and repair. Power transmission and distribution lines are at great risk of falling down in flood-prone and coastal ecological zones due to the inherently weak infrastructure of installations. For example, a story entitled *"The Agony Caused by Fallen High Tension Cable in Ogba"* was reported in a national daily and described a situation where two young men were killed when a high tension cable suddenly snapped and fell on them (Daily Independent, Monday May 3, 2010, page 11). It was suggested that the cable that snapped was half the size it should be, 75mm instead of 150 mm diameter. This would have increased the electrical resistance considerably, heating up the cable which combined with climate relate temperature increases could possibly have caused the cable to draw out under tension and eventually snap. The Power Sector Reform Committee indicates that the Power Holding Company of Nigeria (PHCN) has just one 30-year old helicopter for transmission power lines surveillance and emergencies which was slated for replacement at about N1.25 billion.

High temperatures and humidity expected throughout the country, especially in the northern ecological zones, will increase demand for electrical energy for space cooling (air conditioning), ventilation fans and food refrigeration, further straining the few power plant units currently in operation. At the same time, high temperatures will reduce the efficiency of thermal power plants which constitute about 75% of the total installed generating power and 70% of the energy generation. As this efficiency is defined as output power divided by input fuel energy, a loss in efficiency implies consumption of more fuel to maintain a given

output power, i.e. more expenditure on fuel at the power plants. An effective adaptation measure would be the vigorous development of decentralized energy systems, especially renewable energy based systems such as small hydro and wind farms which do not have the above drawbacks (Fagbenle & Karayiannis, 1994; Fagbenle *et al.*, 2010; Harahap, F. 2009; Lahmeyer Int., 2005). Another adaptation measure would be the development of other less energy intensive cooling technologies such as desiccant cooling, absorption and adsorption cooling which may even be solar operated.

The predicted increased frequency of droughts combined with higher temperatures and the associated evaporation may diminish water levels at the three largest hydro power plants in the country – Kainji (760 MW), Jebba (578 MW) and Shiroro (600 MW). Currently, hydro generation constitutes about 25% of the total generating power. Hydro plants are intrinsically more stable than the thermal power plants and they are quite robust and reliable for base-load generation. Further reduction in their contribution would be acutely felt by energy consumers, especially as this is likely to coincide with the high temperature forecasts. Thus, negative effects on the electricity supply and distribution will be felt as a result of extreme weather events (i.e. floods, heat waves) with consequences which imply negative effects on economic activity across Nigeria (DFID, 2009).

### **Fossil Fuel-based Non-Electrical Energy**

Nigeria's fossil-based energy is entirely from oil and gas, with coal expected to stage a comeback in the medium to long term. The major impacts of climate change include sea level rise, floods and storms that may result in disruption and possible reduction in hydrocarbon extraction activities in the Niger Delta, (DFID, 2009). This in turn could result in disruption of gas supply to the nation's gas turbine power plants which comprise over 80% of the nation's thermal power plants, further compounding the serious power sector crisis that already exists.

The main climate change effect on the Nigerian coastline, ports and harbours is flooding from sea-level rise, storm surges and changes in the coastal wave action especially during the months of April to October coinciding with the period of high spring tides (Afiesimama, 2008). For example, with the predicted one metre rise in relative sea level, 18,400 km<sup>2</sup> of Nigeria's coastal land area will be submerged (DFID, 2009), resulting in impacts to the majority of power plants and other power sector infrastructure in the Swamp Forest and Tropical Forest ecozones. Adaptation strategies could include provision of increased insurance coverage for coastal oil and gas infrastructure and power sector infrastructure. Adaptation could also include improvements to infrastructure by incorporating climate change related impacts into the design of future plants and infrastructure repairs and upgrades. In the northern ecozones where sea level rise is not a threat, storms and floods are still a distinct possibility, and oil and gas infrastructure in these zones will need climate change considerations in future infrastructure designs.

### **Biomass Energy**

Predicted increased frequency and severity of droughts in the northern ecological zones of Nigeria could have a disastrous effect on the existing short supply of available biomass for energy. Adaptation measures could include large scale intervention through deployment of efficient improved cookstoves (Obioh & Fagbenle, 2009), the planting of eco-specific fuel-wood species in woodlots and the development of strategic fuel-wood reserves in each State and possibly each Local Council. A policy on the use of planted trees, instead of natural forest wood, for both domestic and industrial purposes has been suggested (Olokor, 2008). It has been noted that adaptation programmes in Nigeria are evident in the government's policy goal of ensuring sustainable use of the forests and control of desert encroachment. For example, Adeoti and Ajibade (2008) noted the extensive reforestation programmes in the southern part of the country and afforestation programmes in the northern part; tightening control of fuel-wood extraction from reserves and development of more efficient woodstoves can contribute to climate change adaptation. Further, Adeoti and Ajibade (2008) also highlighted the dominant role of the Federal Government and the near absence of government at the other levels in adaptation strategies, particularly local governments which is where the emphasis on climate change adaptation should be. Adaptation strategies recommended by Heinrich Boll Stiftung (HBS) (2008) include large scale adoption and dissemination of efficient wood stoves; activation of the SHP facilities designed into many River Basin Development Authority schemes, such as the Oyan Dam of the Ogun-Osun River Basin Development Authority and Challawa Gorge Dam.

## Assessment of Economic Impacts

Nigeria's foreign exchange earnings predominantly come from petroleum resource exports of crude oil and LNG which are exclusively located in the southern Coastal Swamp, Mangrove Forest ecological zones and in offshore marine areas. The economic value of oil and gas investment in these areas is in the order of trillions of US dollars, all of which is at risk from the negative impacts of climate change such as rising sea levels, heavy storms, floods, high winds and gusts and shoreline erosion. These impacts also threaten ocean-going vessels and their crew, and may have negative effects on scheduled production schedules. Oil and gas infrastructure also includes thousands of kilometers of oil and gas pipelines with numerous pumping stations between the oil wells and gas gathering fields to the storage points, refineries and for distribution to consumers within Nigeria and for export. In addition, there are potential economic impacts to infrastructure that face risks associated with increasing yearly maximum wind gusts which have been recorded at up to 50 m/s (180 kph) with the possibility of much higher gusts in future (DFID, 2009; Obioh & Fagbenle, 2009).

Loss and or disruption of onshore or offshore energy infrastructure from climate change related events has serious economic implications for Nigeria. Three of the four refineries in Nigeria are located in the south with two refineries in Port Harcourt and one in Warri, with the fourth refinery located in the north in Kaduna. These refineries, particularly those in the south, represent multibillion dollar investments subject to climate change impacts as described above. Such impacts will negatively affect energy consumers with resulting economic losses and the likelihood of energy shortages leading to national concern.

The 11 thermal power stations in Nigeria are located in the Swamp Forest, Tropical Forest and Guinea Savanna ecozones. They represent multibillion dollar investments, possibly approaching trillion-dollar scale investments by the time the National Integrated Power Project (NIPP) is completed. These investments are also subject to impacts associated with climate change. As each power station represents multi-million dollar investment, the risks associated with climate change impacts are very high indeed.

Two of the three large hydroelectric power stations in Nigeria, Kainji and Jebba, are in the Guinea Savanna zone while the third, Shiroro, is in between the Guinea Savanna and Sahel Savanna zones. All three have dams that are fed by rivers which are subject to floods as has been recently experienced in Sokoto (September 2010) where heavy rains resulted in the failure of smaller upstream irrigation dams.

Climate change impacts resulting in increased fuel-wood scarcity will increase pressure on the remaining forest resources resulting in further degradation of the environment. This can, in turn, exacerbate climate change impacts related to flooding, erosion and wind, etc. Fuel-wood scarcity will drive up the cost of fuel-wood creating economic hardship for those who must purchase wood as their only source of fuel. Adaptation strategies include:

- wider dissemination of improved fuel-wood and charcoal stoves to stretch the scarce fuel-wood resources further;
- switching to alternate fuels such as gas or kerosene (also known as DPK or "dual-purpose kerosene", or paraffin) for those that can afford the cost;
- introduction of manufacturing processes that pelletize of biomass wastes (e.g. stalks, husks, cobs, leaves, logging wastes, etc.) for fuel purposes;
- alternate processing of planted fuel-wood species into wood chips for more effective and efficient utilization (i.e. higher surface area per unit weight) and ease of transportation and storage;
- establishment of strategic fuel-wood storage centres in all States and Local Councils to ease seasonal fuel-wood scarcity; and
- deployment of suitable renewable energy technologies such as small hydro power, wind energy, solar photovoltaic (PV) and solar thermal technologies, etc.

## Assessment of Gender Impacts

Given their primary role in food preparation, women, in particular rural women, are most vulnerable to energy disruptions resulting from climate change due to predicted decreasing availability of fuel-wood. Rural communities have little or no fuel alternatives for cooking, heating and lighting and even if there were alternatives available, these would likely not be affordable for rural families. The plight of the urban women is slightly better in that there are alternatives available although these may not be readily affordable

to a significant segment of the urban population, especially during periods of scarcity. Pregnant women and children, as well as elderly people and senior citizens, are more likely to be at risk from health-related impacts associated with predicated increases in extreme events such as heat waves and drought. Complicating heat-related impacts is the fact that climate change is likely to cause electricity shortages that will in turn reduce the available cooling from electrical appliances such as fans and air-conditioning, again affecting the health risks of pregnant women, the elderly and children.

**Table 2 Hazard-Impact-Vulnerability-Adaptation Matrix for Infrastructure: Energy Sub-sector**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: SAHEL AND SAVANNA</b>			
Variable Rainfall	<ul style="list-style-type: none"> <li>■ reduced and more variable rainfall leads to reduced tree growth and availability of biomass-derived fuels</li> <li>■ reduced water levels in hydro dams negatively affectively electricity generation</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on forests for fuel wood</li> </ul>	<ul style="list-style-type: none"> <li>■ intensify deployment of solar PV, solar thermal energy systems and small hydro plants especially in the rural areas</li> <li>■ ensure the fossil fuelled power plants are fully operational to provide spare capacity as needed for envisaged reduced generation from hydro power plants</li> </ul>
Increased Temperature	<ul style="list-style-type: none"> <li>■ increased availability and use of solar energy</li> <li>■ high temperatures lead to increased incidence of bush fires causing reduced availability of biomass-derived fuel</li> <li>■ high temperatures increase energy demand</li> </ul>	<ul style="list-style-type: none"> <li>■ depleted forests due to over-exploitation</li> </ul>	<ul style="list-style-type: none"> <li>■ introduce climate-conscious architecture and building design and technology to reduce heat stress and energy demand in high temperature seasons</li> </ul>
Extreme Weather Events	<ul style="list-style-type: none"> <li>■ increased incidence of bush fires leading to reduced availability of biomass-derived fuels</li> <li>■ high water evaporation from hydro dams negatively affecting electricity generation</li> <li>■ extreme rainfall events resulting in flooding</li> <li>■ extreme wind events resulting in damage to infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>■ infrastructure has not been built to withstand extreme events predicted to occur with climate change</li> </ul>	<ul style="list-style-type: none"> <li>■ strengthen electrical transmission and distribution lines and all oil and gas transmission pipeline systems against extreme weather events</li> <li>■ establish National/State/Local Government fuel wood coppice farms and strategic fuel wood storage for fast-growing fuel wood species</li> <li>■ propagate energy efficiency nationally in all sectors, especially improved woodstoves, biomass wastes derived fuels, etc.</li> <li>■ revise building standards for infrastructure to ensure it can withstand predicted extreme events, such as flooding and high winds</li> </ul>
<b>Ecozone: COASTAL/RAINFOREST</b>			
Increased intensity of rainfall	<ul style="list-style-type: none"> <li>■ improvement of tree and vegetation growth and enhanced availability of biomass-derived fuels</li> <li>■ improved water levels in hydro dams for electricity generation</li> <li>■ flooding and associated damage of infrastructure</li> </ul>		<ul style="list-style-type: none"> <li>■ see above for Sahel and Savanna ecological zones</li> </ul>
Sea level rise	<ul style="list-style-type: none"> <li>■ risk of ocean surge, tidal waves and erosion will adversely affect oil and gas installations and power generating infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>■ inadequate infrastructure to withstand sea surges</li> </ul>	<ul style="list-style-type: none"> <li>■ all oil and gas and power generating facilities in these ecological zones especially must be strengthened against abnormal seal level rise and other extreme events</li> <li>■ strategic growing, storage and distribution of fuel-wood should be fully utilized where permitted by increased rainfall</li> </ul>

# Review of Existing Governance, Policies and Programs

There are a number of institutions and national policies that either directly or indirectly address climate change issues as relating to the energy sector. Among the policies are the:

- National Energy Policy;
- National Renewable Energy Master Plan;
- Draft National Energy Master Plan;
- Gas Flare-Out Policy;
- Nigerian Vision 20:2020;
- Draft Renewable Electricity Policy and Regulatory Guidelines; and the
- Renewable Electricity Action program.

**The National Energy Policy of August, 2002:** A Draft National Energy Policy (NEP) was developed by the Energy Commission of Nigeria in 1993 based on a review of the then existing 1984 Draft Energy Policy Guidelines of the Ministry of Science and Technology. In 1996, the Head of State requested a review of the 1993 NEP by an Inter-ministerial Committee under the Chairmanship of the Ministry of Science and Technology. While a revised NEP was produced in 2002 with a foreword written by the Presidential Adviser on Petroleum and Energy, it is unclear if the document received the assent of the Head of State and the Council of States.

Policies, objectives, and strategies are outlined in the 2002 NEP for each energy resource of the country, including oil, natural gas, tar sands, coal, nuclear, hydropower, fuel wood, solar, biomass, wind, hydrogen and other renewables. Similar considerations are given to energy utilization in various sectors of the economy such as industry, agriculture and transport. Also considered are energy issues relating to the environment, energy efficiency and conservation, research, development and training and bilateral, regional and international cooperation. Financing issues are considered with particular consideration for indigenous participation in energy planning and policy implementation. Finally short, medium and long term strategies are prioritized for each energy source.

Unfortunately, at the time this policy was developed, climate change impacts were not considered, although energy conservation, management and efficiency were well accepted objectives as was the need to engage renewable energy for energy security, given the earlier experience with the Arab Gulf war and the birth of OPEC. There are a total 64 policies nested within the 2002 NEP that have far reaching implications as can be seen below.

**Energy Sources (35):** 5 for Oil; 4 for Natural Gas; 2 for Tar Sands; 4 for Coal; 5 for Nuclear; 4 for Hydropower; 4 for Fuel-wood; 2 for Solar; 2 for Biomass; 2 for Wind; and 1 for Hydrogen.

**Energy Utilization (13):** 3 for Electricity; 4 for Industry; 3 for Agriculture; and 3 for Transport.

**Energy Issues (6):** 1 for Environment; 2 for Energy Efficiency and Conservation; 1 for Research, Development and Training; and 2 for Bilateral, Regional and International Cooperation.

**Energy Financing (5):** 3 for Financing; and 2 for Indigenous Participation.

## **Planning and Policy**

**Implementation (5):** 3 for Energy planning; 2 for Policy Implementation.

Interestingly, quite a number of these policies have actually been, or are being implemented. Climate change-related issues feature in the various policies under fuel wood, solar, biomass, wind, hydrogen, transport, environment, energy efficiency and conservation. Nevertheless, there is need for a review of this document in order to include climate change issues after which government should produce its own White Paper on the situation.

## **National Renewable Energy Master Plan**

The Renewable Energy Master Plan (REMP) of 2005 was developed by the Energy Commission of Nigeria with financial assistance from UNDP. The REMP includes a national vision, targets and a road map for addressing key development challenges

facing Nigeria through the accelerated development and exploitation of renewable energy. Technologies for the following energy sources are considered:

- small hydropower;
- solar energy - thermal and photovoltaic;
- biomass;
- improved wood stoves and biomass briquettes;
- biogas;
- wind energy;
- hydrogen energy;
- tidal energy;
- wave energy;
- ocean thermal energy conversion; and
- geo-thermal energy.

Targets for both electrical and non-electrical (thermal renewable energy production were produced for short (up to 2007), medium (up to 2015) and long (up to 2025) term timeframes. Strategies and implementation issues as well as financial implications associated with the set targets and the various framework programmes for renewable energy promotion are outlined in the master plan together with analysis of the associated risks.

Similar to the NEP (2002) climate change does not feature in language or terminology used, yet all the issues discussed in the document pertain to climate change mitigation and adaptation. Unfortunately, there has been no discernible follow-up on this document by the government and the National Assembly, especially as regards the various suggested programmes and projects outlined therein. Several Acts of the National Assembly ought to have emanated from the REMP by now, including mandates, incentives such as feed-in tariffs, time-bound subsidies, portfolio standards, loans and tax breaks, however the latter have not been forthcoming. Government similarly needs to review the 2005 REMP and develop its own White paper on it.

### **The Draft National Energy Master Plan**

The Draft National Energy Master Plan (NEMP), which is yet to be approved by the government, was developed in 2007 by a 130-person team referred to as the National Committee on Energy Master Plan (NCEM) set up by the Energy Commission of Nigeria (ECN). It was inaugurated by the Honourable Minister of Science and Technology on the 4th May 2006. The NEMP provides an implementation roadmap for the realization of the energy policy objectives based on the strategies in the 2002 NEP. Technology development and technology transfer are highlighted throughout the NEMP. It is hoped the NEMP will soon be tabled before the National Executive Council for approval as the short-term timeline (2006 - 2009) as the document expires in a few months from the time of writing. As with the 2002 NEP and 2005 REMP, there is no direct reference to climate change in the document. As such, there is a need for this document to be reviewed to include considerations related to climate change.

### **Gas Flare-Out Policy**

The primary aims of the Nigerian Government's Gas Flare-Out policy are:

- cessation of gas flares in Nigeria by December 2008 (a dateline which has been extended several times and currently remains unmet);
- expand natural gas utilization as industrial feedstock, industrial and domestic fuel, and for central electricity generation;
- use natural gas to diversify foreign exchange earnings; and
- encourage indigenous entrepreneurs to participate in the end use devices for natural gas utilization.

The deadline for ending gas flaring has been postponed more than once and it is unknown when or if this policy will be effectively implemented. Again, there is a need to focus the document explicitly on climate change issues since the gas flares make up a sizeable fraction of total energy-related greenhouse gas emissions of Nigeria.

## National Policy on Biofuels

According to the Nigerian National Petroleum Corporation (NNPC), in 2007 Nigeria approved a National Biofuels Policy along with incentives providing an enabling environment for investors. The policy promotes the blending gasoline with 10% ethanol (referred to as E10) and the blending of diesel with 20% biodiesel oils. A National Biofuels Strategic Programme which includes alternative sources of biofuels has been formulated according to the NNPC and the Standards Organization of Nigeria has approved the fuel specifications for fuel ethanol and E10. It is clear that the consideration of issues of sustainability, avoidance of conflict related to land ownership, the availability of land for the production of sufficient food crops and the use of crop residues for biomass that are currently used as fertilizer inputs for food production will be vital to the success of the biofuels programme.

## Vision 20:2020 - the New Technologies Working Group on Energy Report

The Vision 20:2020 Report has a chapter devoted to renewable energy sources, considering the key challenges facing the development of renewable energy in Nigeria. Like the earlier documents reviewed, it too does not specifically consider climate change issues in relation to energy supply and use. The broad vision of the energy sector in Vision 2020 is stated as "by 2020, the energy sector will be the major engine of the nation's sustainable social, economic and industrial growth, delivering affordable and constant energy supply efficiently to other sectors of the economy". Climate change needs to be considered in relation to this vision of the efficient provision of energy.

## The Petroleum Industry Bill 2009 (PIB)

The major preoccupation of the PIB is to open the petroleum sector to broader indigenous participation through private sector entities and companies. Again, there is no specific discussion of climate change.

## National Economic Empowerment And Development Strategy 2004 (NEEDS) and NEEDS-2, 2007

A section of Chapter 5 of the NEEDS document (NPC, 2004) is devoted to infrastructure development, under which the power sector is considered in some detail. The opening statement captures the dream of the nation:

*"NEEDS envisions reforms that will transform the power sector into one led by the private sector, with the role of government primarily in policy formulation and establishment of an appropriate legal and regulatory framework. Full implementation of NEEDS reforms would eliminate generation deficits; rehabilitate, reinforce, and expand transmission and distribution networks; impose payment and collection discipline; and increase rural access to electricity, using grid and off-grid approaches."(NPC, 2004)*

One of the President's six mandates includes "explore alternative energy sources, such as coal, solar power, wind power, and hydropower; and deregulate the power sector to allow increased private sector participation.

Seven of the ten policy thrusts and targets that NEEDS intended to meet by 2007 are:

- (i) increase generation capacity from 4,200 MW to 10,000 MW (an increase of 138%);
- (ii) increase transmission capacity from 85,838 MVA to 9,340 MVA (a 60% increase);
- (iii) increase distribution capacity from 8,425 MVA to 15,165 MVA (an 80% increase);
- (iv) reduce transmission and distribution losses from 45% to 15%;
- (v) create 11 autonomous business units from the distribution division;
- (vi) make the transmission company a semiautonomous unit by April 2004;
- (vii) unbundle generation by the fourth quarter of 2004.

NEEDS 2004 also highlighted the World Bank-assisted transmission development plan project in which multilaterals will provide up to \$500 million for:

- enhancement of the transmission system;
- 4 new generating power stations with a total capacity of 1,400 MW with anticipated private sector ownership;
- proposed coal 500 - 1,000 MW coal power plant; and

- project development studies for the Mambilla (2600 MW) and Zungeru (950 MW) hydroelectric power stations.

NEEDS-2 2007 is a precursor to Vision 20:2020 and is designed to support the vision of establishing Nigeria as one of the world's largest twenty economies by 2020. Issues related to climate change are conspicuously absent from the NEEDS document.

### **Electric Power Sector Reform (EPSR) Act 2005**

The EPSR Act 2005 emphasizes the role of renewable electricity in the overall energy mix, especially for expanding access to rural and remote areas. In Part 9 under Rural Electrification, Section 88 (9) stipulates that information shall be presented to the President by the Minister of Power and Steel on, among others:

- expansion of the main grid;
- development of isolated and mini-grid systems; and
- renewable energy power generation.

The mandated Rural Electrification Agency (REA) is to provide a plan for expanding access to electricity, including use of renewable energy. Again, as in policies reviewed, there is no mention of climate change in the document.

### **Draft Renewable Electricity Policy and Regulatory Guidelines (2006) and Draft Renewable Electricity Action Program (REAP) 2006**

Both documents were prepared for the Federal Ministry of Power and Steel by the private sector entity, the International Centre for Energy, Environment and Development (ICEED) (Ewah & Fagbenle, 2006). The Policy and Regulatory Guidelines include renewable electricity promotion policies and regulatory guidelines, financing of renewable electricity, and international cooperation. The REAP contains 10-year targets as shown in Table 3.

**Table 3** Renewable Electricity Action Program targets to 2016 in MW (Ewah & Fagbenle, 2006).

<b>REAP Targets</b>	<b>2007</b>	<b>2010</b>	<b>2016</b>
Total electricity supply projections	7,000	10,000	15,000
<b>Renewable Electricity Supply</b>			
■ Small hydro	40	100	400
■ Solar PV	10	20	130
■ Wind	0	20	100
■ Biogas Cogeneration	0	15	105
<b>Total Renewable Energy Supply</b>	<b>50</b>	<b>155</b>	<b>735</b>
<b>Percent Renewable Energy</b>	<b>1%</b>	<b>2%</b>	<b>5%</b>

## **Recommended Climate Change Adaptation Actions**

Table 4 below provides an outline of recommended policies and actions, including how recommendations address the proposed climate change adaptation options, the recommended implementing agency, and the estimated cost of recommended adaptation actions. Evaluation of the proposed policies and programs are presented below.

**Table 4** Policies, Programs, Adaptation Options Addressed, Implementing Agency and Costs for Infrastructure Sector: **Energy Sub-sector**

Recommended/Suggested Policy Actions	Proposed Climate Change Adaptation (CCA) Programs	Ecological Zone Addressed	CCA options addressed by proposed policy actions & programs	Implementing Agency(cies)	Cost Implications
<b>Immediate Needs</b>					
1. Government issuance of a White Paper on the 2002 National Energy Policy (NEP) which takes climate change into account	Incorporation of CCA programs into relevant areas of the NEP	All ecozones	All relevant CCA options impacting on national economic & social development	National Assembly & Federal Government of Nigeria (FGN)	Low
2. Government issuance of a White Paper on Clean Energy and the intended Low Carbon Development Path for Nigeria	Enunciation of Relevant CCA the White Paper	All ecozones	All relevant CCA options impacting on national economic & social development	National Assembly & FGN	Low
3. Government enactment of the National Energy Act	Enactment of relevant CCA programs in the Act	All ecozones	All relevant CCA impacting on national economic & social development	National Assembly & FGN	Low
4. Government embarking on immediate implementation of the Renewable Energy Master Plan (REMP) of November 2005	Implementation of CCA programs on all aspects of Renewable Energy are in the REMP	All ecozones	All relevant CCA options impacting on national economic & social development	FGN	N50 billion to start
5. Government immediate adoption & implementation of the Draft NEMP (2007) developed by the ECN	Implementation of CCA programs on all aspects of Energy are in the NEMP	All ecozones	All relevant CCA options impacting on national economic & social development	National Assembly & FGN	N50 billion to start
6. Govt. review of the JICA National Solar PV Master Plan of 2006 & start implementation	Engagement of solar energy in the national energy mix	All ecozones	Substitution of solar PV for kerosene or oil lamps; provision of PV electricity where there is no grid power	FGN	N50 billion to start
7. Incorporation of Climate Change in infrastructural & equipment design standards, Codes & Specifications in Nigeria	CCA programs in buildings, roads, oil & gas facilities, boreholes, dams, bridges, equipment, etc	All ecozones	CCA in design of key infrastructure	FGN, Relevant Professional bodies, Standards Organisation of Nigeria (SON)	Low
8. Implement REMP biomass recommendations	Improved cookstoves; national program & pelletization of biomass wastes for fuel	Sahel & Savanna	Combating deforestation & desertification resulting from inefficient use of fuel-wood	FGN, Organized Private Sector (OPS), ECN, State Govts.	N1 billion to start
9. Strengthen & improve overhead transmission & distribution infrastructure; begin smart grids for feed-in of renewable energy electricity, especially solar & wind electricity	CCA programs to reduce impact of CC on national grid integrity	All ecozones	Infrastructure integrity	FGN, PHCN &/or its successor companies	N1 billion to start
10. Undertake Energy Efficiency & Energy Management in all sectors, particularly in the domestic & industrial sectors	CCA adaptation programmes include efficient lighting (CFLs & LEDs); efficient electric motor drives (VSD); power factor improvement; equipment energy labeling; DSM & SSM in the power sector	All ecozones, but starting with largest load centres first	Optimal use of generated electricity while also reducing generation, transmission & distribution losses.	FGN, PHCN &/or its successor companies; OPS; industry	N1 billion to start
11. Implement Energy Management - efficient energy utilization programmes in air-conditioning in the commercial & institutional sectors	Mandate switch from compression-type refrigeration to low energy consuming absorption refrigeration for air-conditioning systems in large commercial buildings, public buildings.	Nationwide but starting with large load centres such as Lagos, Port Harcourt, etc.	Optimal use of generated electricity while also making more of the generated energy available for more productive uses.	FGN, PHCN &/or its successor companies, OPS, Development Partners	N1 billion to start
12. Implement the renewable energy programmes in the Concept Notes of REMP	Renewable Energy CCA programs described in the Annex: Project Concept Notes on pages 172 to 201	All ecozones	CCA options in biomass, hydropower, solar PV, solar thermal, wind, hydrogen, ocean & geothermal energy	FGN, PHCN &/or its successor companies, OPS, Development Partners	N10 billion to start
<b>Long Term Needs</b>					
13. Implement the Biodiesel & bio-ethanol renewable energy programmes in the REMP	Biodiesel & bio-ethanol from crops & cellulosic plants that do not compete with food chain crops	All ecozones	Energy security through diversification of sources that are CC indifferent, e.g. <i>Jatropha</i> plants, lingo-cellulosic plants, algae & water hyacinth	FGN, NNPC, OPS, Development Partners	N50 billion
14. Uptake of large-scale Solar & Wind Power Generation in the nation's power mix	Renewable energy CCA programs on concentrated solar power, grid solar PV and wind farms	All zones, starting in zones with the most resource & likelihood to succeed	Energy security through diversification of energy resources, especially renewable energy sources with possibility for decentralized generation	FGN, OPS, Development Partners	N50 billion to start
15. Utilization of clean fossil fuels	Combined Cycle Gas Turbine (CCGT), Integrated Gasification Combined Cycle (IGCC) & clean coal technologies in power generation and Combined Heat & Power (CHP) in industry	All highly industrialized ecozones	Engagement of Clean Fossil Fuels in power expansion plans and CHP in industry utilizing both heat & power for optimum efficiency and minimal specific fuel consumption	FGN, OPS, PHCN &/or its successor companies, Development Partners	N50 billion to start

**Table 5** Evaluation of Proposed Policies Infrastructure Sector: **Energy Sub-Sector**

Proposed CCA Action	Criteria to evaluate effectiveness of CCA Action implementation	Implications if CCA Action IS implemented (individuals, communities, private sector)		Implications if CCA Action IS NOT implemented (individuals, communities, private sector)	
		Positive Impact	Negative Impact	Positive Impact	Negative Impact
<b>Immediate Needs</b>					
1. Government's issuance of a White Paper on the NEP (2002) must take climate change into account	White Paper Issued within reasonable timeframe (6 months at most)	Improved governance in the energy sector	None	None	Lack of direction in climate change related energy programmes & projects
2. Government's issuance of a White Paper on Clean Energy and intended Low Carbon Development Path for Nigeria	White Paper Issued within reasonable timeframe (12 months at most)	Improved governance in the energy sector	None	None	Government's lack of accountability continues as there are no parameters for assessing its performance
3. Government's enactment of the National Energy Act	The Act enacted within a reasonable timeframe (12 months at most)	Directed & improved governance in the energy sector	Entrenched interests will attempt to derail government effort	Entrenched interests will benefit	Government cannot be held accountable for poor governance in the sector
4. Government embarking on immediate Implementation of the REMP (2005)	Alignment of ongoing and future renewable energy projects with the REMP	Directed & improved governance in the energy sector	Entrenched interests will attempt to derail government effort	Entrenched interests will benefit	Continuation of spurious, undirected renewable energy projects from one govt. to another
5. Government immediate adoption & Implementation of the Draft NEMP (2007) developed by the ECN	Adoption, alignment with REMP & the National Energy Act; beginning of implementation within a reasonable timeframe (12 months at most)	Highly improved, directed & accountable governance likely to be the resulting impact	Entrenched interests will attempt to derail government effort	Entrenched interests will benefit	Execution of energy projects in haphazard manner will continue
6. Government review of the JICA National Solar PV Master Plan of 2006 & implementation	Review completed & start of implementation within 6 months	Improved, transparent & accountable governance likely to be the outcome	None	None	Business as usual with uncoordinated solar PV projects dotting the landscape
7. Incorporation of climate change in infrastructural & equipment design standards, Codes & Specifications in Nigeria	SON to be mandated by government to complete the process within 12 months	Improved adaptive capacity & preparedness for climate change variability	Increased cost of design & construction	Short-term positive economic impact as the business as usual persists	High likelihood that damaged infrastructure from climate change effects will continue
8. Implement REMP biomass aspects; possible clean development mechanism (CDM) projects could emerge	Completion of 20% of the program annually on cookstoves & pelletization of wood & biomass wastes	Amelioration of the stress on women in sourcing fuel wood; Lower deforestation rate Positive gain to the nation through CDM	Loggers and fuel wood merchants will be impacted but could be helped to key into the program in sourcing biomass wastes for pelletization	Loggers and fuel wood merchants will continue their livelihoods at the expense of overall good of the society and environment	Deforestation and desertification rates unlikely to subside
9. Strengthen & improve overhead transmission & distribution infrastructure. Begin smart grids for feed-in of renewable energy electricity, especially solar & wind electricity	Completion of 25% of the transmission & distribution infrastructure quarterly Significantly reduced outages attributable to transmission & distribution lines	Reduced transmission and distribution losses which currently is about 30-35%	Entrenched interests will attempt to derail government effort	Entrenched interests will benefit	Uneconomic levels of transmission & distribution will continue
10. Undertake Energy Efficiency & Energy Management in all sectors, particularly in the domestic & industrial sectors Possible CDM projects	Certifiable reduced electricity bills in the domestic and industrial sectors attributable to energy efficiency & energy management programs	Reduction of energy wastage while directing gains to productive uses, positively affecting the climate and the economy through delayed investment in generation plants expansion; CDM gain	Entrenched interests will attempt to derail government effort	Entrenched interests will benefit	Energy wastages will continue in business as usual scenario, with attendant economic losses to the consumers & the society at large, while also negatively affecting climate
11. Implement Energy Management - efficient energy utilization programmes in air-conditioning in the commercial and institutional sectors; possible CDM project	Certifiable reduced electricity bills in the commercial & institutional sectors attributable to A/C energy efficiency & energy management programs	Reduction of energy consumption for space cooling equipment & releasing the save energy for more productive uses; positive gain through CDM	Entrenched interests will attempt to derail government effort	Entrenched interests will benefit	Energy wastages will continue in business as usual scenario, with attendant economic losses to the consumers and the society at large, while also negatively affecting climate
12. Implement the renewable energy programmes in the Project Concept Notes of REMP; all of which could be CDM projects	Implementation of at least 4 projects per year out of the 17 projects in total	Progress towards improved renewable energy fraction in the energy mix	Entrenched interests will attempt to derail government effort	Entrenched interests will benefit	Business as usual wherein projects are not streamlined & coordinated to a national objective open for all to see and judge; another opportunity for CDM projects lost

Proposed CCA Action	Criteria to evaluate effectiveness of CCA Action implementation	Implications if CCA Action IS implemented (Individuals, communities, private sector)		Implications if CCA Action IS NOT implemented (Individuals, communities, private sector)	
		Positive Impact	Negative Impact	Positive Impact	Negative Impact
<b>Long Term Needs</b>					
13. Implement the biodiesel & bio-ethanol renewable energy programmes in the REMP. Possibility of CDM projects	Coordination with NNPC biofuels programme for one focused national objective	Diversification of energy sources and increased energy security	Perceived competition with food crops and food farming land & input	Perceived relief from competition between energy and food crops in farming communities	Lost opportunities for engaging in the worldwide movement towards next generation biofuels; Opportunity for CDM projects lost
14. Uptake of large-scale solar and wind power generation in the nation's power mix - all could be CDM projects	Follow-up on the FMST Lahmeyer Wind Energy Resource Mapping Project of November 2005 with at least one installation each in 4 years	Diversification of energy sources & increased energy security	Both solar PV and wind farms pose competition and potential conflict with other land uses which need resolution with judicious & prudent land planning permitting	Land could then be used for other non-energy purposes such as agriculture, or even for energy crops cultivation	Continued loss of utilization of free natural resource for the benefit of the nation; Opportunity for CDM projects lost
15. Uptake of clean fossil fuels & new energy sources & technology	Upgrade one gas turbine plant every 2 years to CCGT; Ensure Clean Coal Technology is used in newly approved coal plants, e.g. IGCC; BIG-STIG; Intensify R&D in carbon sequestration technologies Carbon Capture & Storage (CCS) technology especially for coal power plants; Fuel cells & hydrogen technology; Many could be Clean Development Mechanism (CDM) projects	Clean fossil technologies will open up the nation's large coal resources for power production with low emissions, increasing the energy security & diversification of energy sources  CCS will open up the coal energy sources of the nation to both energy & synthetic fuels/chemicals production with relatively little or no carbon emission; fuel cells & hydrogen technology will be readily applicable in the "Decentralized Energy Systems" model of sustainable energy development	Competition will ensue between natural gas & coal for power production as clean coal could become much cheaper. Hydrogen technology will give natural gas & oil stiff competition which may affect Nigeria's economy negatively in the short term	Coal could then be used for production of synthetic fuels and chemicals using the Fischer-Tropsch synthesis process among others  Could leave room for more studies & familiarity with case studies in other lands	The power sector will continue to rely on natural and coal exclusively among the fossil fuels The environment will be impacted by CCS technology and the switch over to Hydrogen; Another opportunity for CDM projects lost

# Sub-sector 2: Transportation, Communication and Housing

## Introduction

### Transportation

Land, sea and air transportation in Nigeria is plagued with numerous problems and suffers from inadequate data and information management for decision-making. The impact on the environment especially with regards to contribution to GHGs is largely unknown. Technological constraints, poor management, corruption, conflicting decisions, and inadequately researched information are just some of the challenges to improving transportation in Nigeria. A typical example is the controversial dredging proposed to open up inland waterways of the Niger Delta, a decision made with little information on need, cost and environmental impacts.

In Nigeria, existing modes of transportation include both motorized (utilizing CO<sup>2</sup> emitting fuel) and non-motorized (environmentally friendly) modes and consist of the following:

- Road, highway networks and associated structures (e.g. bridges, tunnels, culverts, retaining walls), sign age and markings, electrical systems (street lighting and traffic lights) and edge treatments (curbs, sidewalks, landscaping);
- Railways and associated structures, terminal facilities (rail yards, train stations), level crossings, signaling and communications systems;
- Canals and navigable waterways requiring continuous maintenance (dredging, etc.)
- Seaports;
- Airport runways, terminal buildings and associated air navigation systems;
- Mass transit systems (e.g. commuter rail systems and bus transportation);
- Bicycle paths and pedestrian walkways; and
- Boats, canoes and ferries.

Land transportation includes a network of roads of various qualities of approximately 193,000 kms (comprising 34,123 km Federal roads, 30,500 km State roads, and 129,577 km Local Government roads) that carry over 90% of passenger and freight traffic. There is also a rail network of approximately 3,500km of track that is currently being refurbished, but at present contributes very little to passenger and freight traffic. Given the geographic size of the country, land transportation infrastructure in Nigeria is grossly inadequate to meet the passenger and freight transportation needs of a population of more than 140 million people and for a country that plans to be amongst the top 20 developed economies in the world. In addition, the economic cost of road accidents that may result from inadequate and poorly maintained road infrastructure has been estimated at 2% of national GDP.

Nigeria has 21 international and domestic airports and 62 private airstrips across the country. The airports are owned by the Federal Government and they are managed by the Federal Airports Authority of Nigeria (FAAN). Commercial air transport is often criticized for its use of mostly old, second-hand or refurbished aircrafts that require frequent maintenance, lack fuel efficiency and are a major contributor to carbon emissions in the atmosphere. Nigeria has had several high profile air crashes in recent times, often associated with bad weather conditions. Airport facilities are generally in need of repair, with poor air conditioning being one of the more obvious deficiencies making life uncomfortable for both workers and passengers using overcrowded airports every day.

Prior to the 1960s, the railway system carried over 60% of all freight tonnage compared to its current share of less than 5%. The network of 3,505 km runs from north to south and utilizes an older narrow gauge (1.067 m) standard that is largely single track. Railway transportation in Nigeria has been fading into oblivion, with the highest number of

passengers carried being 15.5 million in 1984 and the highest volume of freight carried being 2.4 million metric tonnes in 1977. In 200, passenger traffic had fallen to 2 million persons with less than 300,000 metric tonnes of freight constituting for about 1% of land transport. The failure of this mode of transport is due to a number of factors, the leading problem being a lack of maintenance resulting in only 45% of the wagons and carriages being useable in 2004 and locomotives being in poor condition resulting in unreliable services due to locomotive failures.

During the 1970s the country's port facilities at Lagos, Port Harcourt, Warri and Calabar became severely overstretched as a result of the oil boom and as a result of a sharp increase in imports, resulting in delays in ship handling and high demurrage charges. Between 1975 and 1980, the Government embarked upon a massive investment programme that increased port capacity by 300%. At present, the port system administered by the Nigerian Ports Authority (NPA) has 13 major ports under eight port managements, 11 oil terminals and 128 private jetties. There are 102 hard quay berths, 62 buoys and over 650 different types of cargo handling plants and equipment. These port facilities have a total cargo handling capacity of over 35 million tonnes annually. The ports mainly handle imports, ranging from between 31.6% and 6.7% for general cargo, 53.5% and 44.5% for bulk cargo, and 23.6% and 22.6% for containerized traffic (Vision 2020, 2009). Overall cargo throughput increased from 20 million tonnes in 1998 to 30 million tonnes in 2000. These ports are located along the erosion prone extensive coastline of about 852 km and are at grave risk of gradual and steady sea level rise or abrupt storm surge.

The country's inland navigable waterways that transverses 20 states is approximately 3,000 km long and has great potential for the movement of goods and passengers from the coast to the interior. Inland waterways traverse 20 out of the 36 states of the country. In order to make these transport systems more resilient against future impacts, climate change considerations should be integrated into the general transport system design, new transport developments, as well as maintenance activities of existing transport networks. The impact of climate change on transport can be classified into three key areas: impacts on transport infrastructure; impacts on vehicles; and impacts on mobility behaviour.

## Communication

Nigeria's communication infrastructure comprises the following:

- postal service and sorting facilities;
- telephone networks (land lines) including switching systems;
- mobile phone networks;
- television and radio transmission stations, including the regulations and standards governing broadcasting;
- cable television physical networks including receiving stations and cable distribution networks;
- internet backbone, including high-speed data cables, routers and servers as well as the protocols and other basic software required for the system to function;
- communication satellite (e.g. NIGCOMSAT);
- undersea cables; and
- server farms computing infrastructure

(Source: [www.en.wikipedia.org/wiki/Infrastructure](http://www.en.wikipedia.org/wiki/Infrastructure): accessed 20/09/2010).

The Report on Global Information Technology (WEF, 2010) ranked 133 countries in terms of readiness to embrace the use of Information Communication Technologies (ICTs). In Nigeria, individual readiness (ranked 116) was lower than government (ranked 101) and business (ranked 51), while in terms of usage government (ranked 113) lower than individuals (ranked 105) and business (ranked 83). For ICT to thrive in any country, the market, infrastructure as well as political and regulatory environment must be conducive for growth. Out of the 133 economies, Nigeria has been ranked in the following way: market environment (70), political and regulatory environment (85) and infrastructure environment (127). However, the impact of climate change on physical infrastructure is very critical due to the fact infrastructure contributes to the effective delivery of services

and provides connectivity to the outside world. The low ranking (127 out of 133 economies) of Nigeria in regard to infrastructure highlights one of the major issues affecting the technology deployment required for growth and development in Nigeria (Vision 20:2020, 2009).

In 1992, the Nigerian Communications Commission (NCC) was established as a regulatory and licensing body for private telecommunication companies. This led to liberalization of ICTs in Nigeria such that in recent times internet availability and service has improved markedly from a previous situation where only a few dial-up Internet service Providers (ISPs) existed. Similarly telephone service provided by Nigerian Telecommunications Limited (NITEL) was deregulated leading to the introduction of major international Global Systems of Mobile Communication (GSM) providers such as MTN Nigeria, Airtel, Globacom, Starcoms and Etisalat, etc. that in turn provided much enhanced communication infrastructure and related services overcoming geographic and financial barriers in providing access to knowledge, information, and in developing skills. Internet and telephone services are key ingredients for participation in a knowledge-based economy.

When it comes to climate change adaptation, ICTs are often referred to as a tool for reducing risk and vulnerability while increasing coping and adaptation strategies at the local level. By strategically integrating enabling tools for ICTs (e.g. community radios, mobile phones, knowledge centres and interactive media) this will help to reduce climate change vulnerability and risks, while including the voices of those most affected for political advocacy. In addition, ICTs contribute tangibly to climate change adaptation and mitigation strategies through access to relevant information, raising awareness at the grassroots level, and facilitating learning and practical knowledge sharing at the community level, while empowering the poor and marginalized to raise their voice for political accountability and concrete action.

ICT provides the tools for disaster prevention, preparedness and risk management as well as information communication and empowerment that facilitate adaptation to climate change. For example, weather prediction used as early warning as well as spatial vulnerability and risk assessment that identifies low risk zones for transportation and housing infrastructure etc utilize ICT (e.g. satellite images). Weigel and Waldburger (2004) categorize the use of ICTs for climate change adaptation into three areas: access, voice and networking. At the same time it is important to bear in mind that climate change is expected to negatively impact ICT infrastructure.

## **Housing**

Nigeria has experienced rapid urbanization with nearly 50% of the 150 million population now living in urban areas compared with just 10% in 1952 and 38% in 1993. Uncontrolled urban development has led in many cases to unplanned and informal housing development giving rise to slums and shanty towns. Generally the condition of housing and provision of essential infrastructure are poor in both urban and rural areas (Vision 20:2020, 2009). Studies have shown that Nigeria has one of the world's largest slum populations and there is an estimated shortage of 16 million housing units.

Land use regulations and property registration is regulated by the existing Land Use Act of 1978, an Act where the Governor of a State has the sole authority over land allocation. This creates a serious impediment to urban land development and reduces opportunities to obtain financing (mortgages) necessary to increase the available housing. As a result, rental housing is inadequate and expensive and private home ownership is only attainable by those with substantial personal financial resources.

The deficit of housing in the country especially in urban environments, results in overcrowding in private dwellings. Furthermore, important housing infrastructure such as water supply and sewage disposal are lacking, with Nigeria ranking among the bottom 40 countries in the world. Only 61% of homes in Nigeria have adequate and improved water supply and sanitation facilities. In Nigeria's Vision 2020 report of 2009, the target for the housing sector is to make it "one of the top 3 contributors to the nation's economy by adding 10 million decent and affordable homes to the national housing stock by the year 2020".

Mainstreaming climate change adaptation into new housing development is essential to minimize the increasing risks of flooding, increasing need for cooling and reduction of

thermal discomfort in buildings, water shortages and droughts. New construction projects and refurbishments are likely to take place over the next few decades driven by a combination of necessary retirement of capital stock, energy costs, demographic trends, and projected and potential resource development. These trends will likely generate a critical need for constructing a range of buildings, including homes, schools, community centres, airport terminals, and hospitals, etc. Climate change and accelerating urbanization demand urgent formulation and implementation of rational adaptation strategies supported by good governance, urban planning and management, including the application of new building codes and other appropriate laws designed to ensure minimal greenhouse gas emissions

## Assessment of Current and Future Trends

Climate change hazards are outlined for the five ecological zones of Nigeria in terms of their associated impacts, the vulnerability of communities and recommended adaptation options for transportation (Table 6), housing (Table 7) and communications (Table 8).

## Assessment of Economic Impacts

DFID (2009) has estimated that for the transportation, communication and housing sub-sectors, 5% to 27% of Nigeria's GDP will be lost due to climate change impacts. The worst hit area will be the southwest including areas of derived savanna, lowland rainforests and mangrove/swamp. The Ministry of Environment estimates that Nigeria will lose almost \$20 billion as a result of a 0.5 metre sea-level rise and US\$ 43 billion from a 1.0 metre sea level rise assuming development and economic growth of 5% over 30 years (MOEFRN, 2003). As such, economic losses through climate change will be far reaching, particularly for a country whose relative poverty ranges between 20 to 95 % (NBS, 2005), with the most affected population (60 to 90 %) located in the Sahel and Guinea ecozones of northern Nigeria. Climate change will affect Gross Domestic Product (GDP), the level of indebtedness of Nigeria, the state of public finances, and much needed future investment in infrastructure development.

### Transportation

The Transport Working Group report of Vision 20:2020 (2009) states that at 2005 prices, the road network is estimated to have a replacement value of N4.567 trillion, of which Federal roads total N2,213 trillion (48.5% of the total investment in national road infrastructure). Without factoring in the impact of climate change it has been estimated that over the next 10 years, N300 billion will be required to bring the existing national roads into a satisfactory condition. Climate change hazards can be expected to further increase both the current annual network value loss of N80 billion and additional operating costs of N35 billion resulting from a lack of road maintenance. Climate change impacts to transport infrastructure along the coast of Nigeria are of particular concern as well as the associated direct and indirect financial implication.

With regards to other forms of transportation, the government has earmarked N10 billion for the rehabilitation of railways, the nation's international airports are undergoing rehabilitation, while the 8,600 km of inland waterways remains underused.

In the last ten years, the nation's 21 airports have generated about N16 billion annually with Lagos, Abuja and Kano airports accounting for 77% to 90% of passenger movements and 64% to 89% of aircraft movements. Predicted increases in climate hazards such as heavy rainfall events, violent thunder storms, severe winds and harmattan dust storms will directly impact airport operations and will reduce the potential revenue generated without development of appropriate climate change adaptation strategies.

Nigerian ports are an important part of the transportation sector moving 30 million tonnes of cargo in the year 2000 with several billion naira in earnings annually. Clearly, mainstreaming climate change adaptation into this particularly vulnerable subsector of infrastructure will, in the long term, contribute to economic growth, poverty reduction and improved standard of living for all Nigerians.

### Communication

One of the most rapidly growing sectors of the Nigerian economy is telecommunications, particularly the mobile phone sector. While at the same time Nigeria is ranked one of the lowest countries in Africa in terms of the number of local, national and international calls.

Massive private investments in telecommunications rose from approximately US\$50 million in 1999 to US\$12 billion in 2008 with a consequent increase in national GDP of 0.62% in 2001 to 2.9% in 2008. The huge investment in this sector is reported in the NCC report of 2005 and includes:

- Private investment into the Nigerian telecoms sector is now the largest generator of Foreign Direct Investment (FDI) after the Oil and Gas Industry (NCC, 2005);
- Equity investments into the Information and Communications (ICT) sector constitute about 56% of total investments made by Nigerian banks under the Small and Medium Enterprises Investment Scheme (SMIEIES). The scheme provides for a setting aside of 10% of annual profit by the banks, for equity investment in small and medium businesses;
- Investment by international agencies and multilateral institutions (e.g. International Finance Corporation (IFC), the private sector arm of the World Bank Group), played a significant role in the US\$395M syndicated loan to MTN Nigeria with a contribution of about US\$100M. This transaction comprised one of the largest ever investments in the telecommunications sector and the IFC's contribution was the corporation's second largest investment in Africa; and
- Other international agencies investing locally include the Export - Import Bank of the US (US Exim Bank), African Export – Import Bank (Afrexim), African Development Bank (ADB), Development Bank of South Africa (DBSA), and DMO Germany.

With the advent of GSM, the number of telecom subscribers has risen from approximately 509,000 in 1999 to 74,000,000 million in 2009 and approximately, with 87% of these subscribers using GSM. The tele-density of telecommunications, a measure of the number of telecom users, has increased from 0.45% to approximately 46% over the same time period. This trend has been facilitated by massive infrastructure deployment of microwave radio, fibre-optics and base stations. There is a spill-over effect from the telecom industry terms of job creation, improved business performance and timely information exchange.

Telecommunications investment is vulnerable to the impact of changing climate hazards resulting from windstorms, coastal inundation and erosion. Increased use of mobile phones also provides an opportunity for early warning systems for urban and rural communities impacted by climate related hazards associated with flooding and storm surges, etc.

## Housing

Housing is a high investment endeavour, which in most cases appreciates over time. Real estate contribution to the GDP rose from N219 billion to N444.68 billion between 2001 and 2004 while building construction increased from about N30.6 billion to N80.1 billion over the same time period.

Given the substantial investment in housing, the economic impact of climate change can be large, particularly in the coastal cities like Lagos, where erosion and coastal inundation is already affecting high cost properties in Victoria Island and Ikoyi. Climate change will have an economic impact on housing throughout the country due to the wide range and distribution of hazards including mean sea level rise, increased frequency and severity of storm surges increased flooding associated with high rainfall events, and high winds. Unfortunately, no reliable figures have been given for the extent of this damage in Nigeria. It is speculated, however, that it will run into billions of naira. As climate change impacts will decrease the national GDP this will in turn result in decreased available funding available for the construction and renovation of housing. To what degree this will occur, it is not yet certain.

## Assessment of Gender Considerations and Interactions

Climate change can be expected to impact most severely on men and women in societal groups that are the poorest and most vulnerable, given that they are most at risk from the elements, most reliant on natural resources for their living, and least able to adapt. In Nigeria, as in numerous countries around the world, the poorest sections of society are often disproportionately represented by women, young children and the elderly, and these groups will accordingly be most vulnerable to climate change (UNICEF, 2007). Women's role in bearing children and as the primary care givers of children tend to make them more susceptible to disasters, particularly those related to housing, that may be caused by climate change. It is therefore very important to highlight gender-focused assessments and adaptation provisions in climate change policies. Below is an assessment of gender and climate change for each infrastructure sub-sector.

### Transportation

Travel behaviour and patterns are one of the most gendered aspects of life (Wachs, 1996) and statistics have shown that men are the greatest contributors to climate change through emission through ownership and use of vehicles. Generally, women's travel purpose reflects the care-giver role played, generally women are more likely to have multiple purposes and destinations per trip. For men, vehicle use is more likely to be employment /work-related purposes. Low income men and women utilize poor quality transportation systems that have higher incidence of accidents and which are more susceptible to climate change hazards.

There are very few women that own vehicles in Nigeria and as such improvements in mass transit system will be very beneficial to women exposing them to less personal risk and danger. For a gender-sensitive transportation sector to be feasible gender analyses are needed to assess gender friendly designs that incorporate road safety, personal security, gender friendly infrastructure etc.

### Communication

The gender digital divide cuts across all social and income groups and is one of the inequalities to be amplified by the digital revolution (UNESCO, 2003). Constraints limit ICT opportunities for women, make access of ICT services difficult and in some cases women have limited access to community tele-centres, where available. Yet there is a need to enhance the ability of women and their families to benefit from ICT to obtain information about climate change, particularly when ICT is used for risk reduction.

If more women have access to ICT they may participate and become empowered by new income-generating activities adapted to their flexible schedules and home locations. Also, women can benefit from initiatives such as, voter registration, rural microfinance and license applications, etc.

### Housing

In the provision of suitable housing, consideration of women and girls is paramount given their role as caregivers who spend more time at home. One of the challenges is the fact that women often do not have access to land, owning less than two percent of the world's private land. Climate change policies for housing that include considerations of the UN Habitat Strategy of 2010 will consider gender in regard to:

- gender responsive urban planning;
- governance and management (e.g. resource allocation, personal safety and security, and post-conflict and disaster reconstruction);
- addressing inequalities in land and housing (e.g. improving policy, legal and regulatory frameworks that also respond to women's land and housing);
- developing environmentally sound urban services (e.g. provision of infrastructure such as clean drinking water, sanitation and waste management, transportation and power); and
- improving finance systems for affordable housing.

**Table 6 Hazard-Impact-Vulnerability-Adaptation Matrix for Infrastructure Sector: Transportation Sub-sector**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: SAHEL AND SAVANNA</b>			
Variable rainfall and increased aridity	<ul style="list-style-type: none"> <li>road surfaces may be destroyed</li> </ul>	<ul style="list-style-type: none"> <li>destruction of roads (heated, melted) with increased rutting of asphalt</li> <li>vehicle engines will be subjected to heat stress, requiring higher maintenance due to degradation of various engine parts</li> </ul>	<ul style="list-style-type: none"> <li>the construction of longer runways for aircrafts plying various airports will be necessary</li> </ul>
Increased temperature	<ul style="list-style-type: none"> <li>loss of efficiency in diesel engines used in transportation and as generators used in communication masts resulting in higher diesel fuel consumption</li> <li>melting of road &amp; tarmac tarred surfaces from extremely high temperatures pose high risks to vehicles and planes respectively</li> </ul>	<ul style="list-style-type: none"> <li>thermal expansion of joints in steel and concrete bridges will cause collapse</li> <li>old narrow gauge single tracking system that was constructed on steel gradients with poor track alignments and sharp curves will degrade faster with increased likelihood of rail buckling and engine expansion</li> <li>increased energy demands for cooling for air conditioning and refrigerators for freight facilities</li> <li>materials used for storage facilities may degrade faster thereby requiring frequent maintenance</li> <li>vehicle interiors may become hotter leading heat exhaustion in passengers and drivers causing more distractions and accidents, use of coolant in cars, wearing of tires</li> <li>increased growth of aquatic plants that clog the waterways</li> </ul>	<ul style="list-style-type: none"> <li>the use of a more climate friendly materials for roads and asphalt pavements (with higher polymer content)</li> <li>greening the road ways with vegetation to provide cooling and shading</li> <li>road re-construction to accommodate increased thermal expansion</li> <li>invest in technological innovations such as use of aircrafts with powerful engines, low fuel consumption and lighter airframes- better navigation equipment</li> <li>energy efficiency can be facilitated by the use of renewable energy such as solar energy</li> <li>windows should be sufficiently large and tinted to provide shading and circulate air- improve thermal insulation and cooling systems</li> </ul>
Extreme weather events	<ul style="list-style-type: none"> <li>sandstorms adversely affect transportation &amp; communication</li> <li>intense harmattan reduces visibility disrupting air &amp; ground transportation</li> </ul>	<ul style="list-style-type: none"> <li>less friction on roads due to sand and dust</li> <li>degraded road foundation; more landslides if rain is intense on dry soil</li> <li>low use of inland water ways, rivers, lakes due to lower water volume- low electricity generation disrupts human consumption, industrial processes, water transport and agricultural activities</li> <li>difficult driving conditions have implications for safety, operations and performance</li> <li>disruptions (e.g. in flights and greater risks of air crashes)</li> <li>washing away of roads</li> <li>soil conditions may change leading to structural instability or massive landslides etc</li> </ul>	<ul style="list-style-type: none"> <li>new design standards for vehicles</li> <li>intensify maintenance of waterways</li> <li>better training for drivers</li> <li>early warning and emergency evacuations- managing of speed limits to reduce over-speeding on wet roads;</li> <li>greening of roadsides to reduce flooding and washing away of roads</li> <li>flood insurance provisions</li> <li>construction of large culverts to accommodate huge flow of runoff</li> <li>improved weather forecasting</li> </ul>
<b>Ecozone: COASTAL/RAINFOREST</b>			
Increased intensity of rainfall	<ul style="list-style-type: none"> <li>will adversely affect telecom infrastructure</li> <li>destruction of road surfacing</li> <li>airport infrastructure will be adversely affected</li> <li>waterways will flow better to improve water transportation</li> </ul>	<ul style="list-style-type: none"> <li>debris washed onto the roads and constitutes a hazard to vehicles - possible submergence of terminals located within the coastal area of Lagos and Port Harcourt</li> <li>sea level rise may affect the functionality and protection of lock and dam structures that may be put in place to control inland water way systems, as well as dockyards- damage to terminals and facilities and decrease in structural integrity</li> </ul>	<ul style="list-style-type: none"> <li>construction of environmentally sound embankments and levees to curtail the outpour of debris and flood waters.</li> <li>flood risk mapping and assessment- restriction of development in high risk zones</li> <li>improved flood and coastal management</li> <li>early warning systems and coordinated evacuation planning</li> </ul>
Sea level rise	<ul style="list-style-type: none"> <li>risk of flooding is high which will affect communication and transportation infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>challenge to service delivery as disruptions occur</li> </ul>	<ul style="list-style-type: none"> <li>use of durable materials</li> </ul>

**Table 7** Hazard-Impact-Vulnerability-Adaptation Matrix for Infrastructure Sector: **Housing Sub-sector**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: SAHEL AND SAVANNA</b>			
Rainfall variability	<ul style="list-style-type: none"> <li>low rains reduce availability of water for household use but tends to improve general sanitation</li> </ul>	<ul style="list-style-type: none"> <li>lowering of water table and scarcity of water and poor water quality</li> <li>higher water table that could exacerbate incidences of floods</li> </ul>	<ul style="list-style-type: none"> <li>design and construct new buildings for natural cooling or the use of air conditioners</li> <li>use solar shading, reducing power density and output of electricity</li> </ul>
Increased temperature	<ul style="list-style-type: none"> <li>overheating of homes</li> </ul>	<ul style="list-style-type: none"> <li>house construction, particularly in urban areas, that retains heat</li> <li>lack of trees to provide shading to reduce heat load</li> </ul>	<ul style="list-style-type: none"> <li>design and construct more attached and multi-unit houses</li> <li>explore and invest in green building designs</li> <li>increase use of rain water harvesting techniques to store excess rain water</li> <li>more boreholes (after EIA is done)</li> <li>flood resilient design techniques</li> <li>raising level of dykes (or building on higher ground on stilts)</li> <li>phased out relocation of houses from risk zones</li> <li>design features to speed up or enhance drying process (e.g. weep holes at the bottom of cavity walls)</li> <li>use of construction materials that are anti-corrosive and durable (masonry, stone and concrete etc.)</li> </ul>
<b>Ecozone: COASTAL/RAINFOREST</b>			
Increased rainfall intensity	<ul style="list-style-type: none"> <li>improved availability of potable water for household use</li> <li>flooding</li> </ul>	<ul style="list-style-type: none"> <li>housing has been built in areas vulnerable to flooding</li> </ul>	<ul style="list-style-type: none"> <li>include consideration of flood risks in future urban planning and development</li> <li>improve existing flood management</li> <li>move habitation from areas of greatest flood risk</li> <li>increase/retrofit existing infrastructure to protect housing from flooding</li> </ul>
Sea level rise and ocean surge	<ul style="list-style-type: none"> <li>ocean surge, tidal waves will adversely affect municipal housing infrastructure located in low-lying areas and riverbanks and ocean fronts</li> </ul>	<ul style="list-style-type: none"> <li>urban planning has not included management of storm water resulting from rainstorms</li> </ul>	

**Table 8 Hazard-Impact-Vulnerability-Adaptation Matrix for Infrastructure Sector: Communications Sub-sector**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: SAHEL AND SAVANNA</b>			
Temperature increase Extreme weather events	<ul style="list-style-type: none"> <li>■ degradation of heat sensitive infrastructure</li> <li>■ increased damage and disruptions to telephone network</li> <li>■ poor GSM, radio and TV signals and delay in the delivery of mails during storm events</li> </ul>	<ul style="list-style-type: none"> <li>■ communications infrastructure has not constructed to withstand climate change impacts.</li> </ul>	<ul style="list-style-type: none"> <li>■ use of durable anti corrosion materials that are heat resistant: underground cabling for telephone lines</li> <li>■ use of optical fibre as cables</li> <li>■ use of durable materials (anti-corrosion or moisture effect)</li> <li>■ shelters built to protect infrastructure using durable materials such as steel, aluminium, fibre, glass and concrete</li> </ul>
<b>Ecozone: COASTAL/RAINFOREST</b>			
Extreme weather events Sea level rise and storm surge Increase in temperature and more heat waves Increased rainfall intensity	<ul style="list-style-type: none"> <li>■ increased damage and disruptions to telephone networks</li> <li>■ poor GSM, radio and TV signals and delay in the delivery of mails during storm events</li> <li>■ increased droughts</li> <li>■ increased energy use e.g. for air conditioning, refrigeration</li> <li>■ lowering of water table and scarcity of water</li> <li>■ higher water table that could exacerbate incidences of floods</li> </ul>	<ul style="list-style-type: none"> <li>■ communications infrastructure located within areas vulnerable to climate change impacts</li> </ul>	<ul style="list-style-type: none"> <li>■ underground cabling for telephone lines· use of optical fibre as cables</li> <li>■ use of durable materials that are resistant to soil moisture</li> <li>■ shelters built to protect infrastructure should use durable materials such as steel, aluminium, fibreglass and concrete</li> <li>■ design and construct new buildings for natural cooling</li> <li>■ the use of air conditioners</li> <li>■ use of solar shading, reducing power density and output of electricity</li> <li>■ design and construct more attached and multi-unit houses</li> <li>■ explore and invest green building design</li> <li>■ increased use of rain water harvesting techniques to store excess rain water</li> <li>■ drill boreholes (after EIA)</li> <li>■ flood resilient design techniques</li> <li>■ raising level of dykes (or building on higher ground on stilts)</li> <li>■ phase out relocation of houses from risk zones</li> <li>■ design features to speed up or enhance drying process</li> <li>■ use of construction materials that are anti-corrosive and durable (masonry, stone and concrete)</li> </ul>

## Review of Existing Governance, Policies and Programs

For climate change adaptation to be successful, all levels of government from Federal, State and Local Governments should be involved. Currently, the roles for each level of government on environmental and climate change issues are poorly articulated, making positive policy development challenging. For example, issues such as intergovernmental lines of responsibility, accountability, representation, and financial and human capacity are not clearly delineated. Climate change adaptation can be effectively tackled if climate risks are incorporated into existing planning and decision-making processes. It is imperative, therefore for processes to be firmly in place with clearly defined roles, and responsibilities. In addition, all stakeholders including NGOs, CBOs, educational institutions, etc. should be involved to various degrees.

For the infrastructure sub-sectors, current policies do not contain climate risk information and there is no reference made to risk assessment prior to any of the initiatives that are recommended for implementation. Therefore, there is the need to mainstream climate change adaptation information in all the sub-sector policies.

Some of the existing policies do contain some indirect references that could be regarded as foundations to mainstream climate change adaptation. For example, in the National Housing Policy, it was stated that the usage of certified locally-produced building

materials should be promoted. These materials could further be produced to reduce energy consumption in homes before being certified.

## Existing Governance Structure

The Federal Government represents the national level where:

- Legislature and regulations are set and these may enhance or constrain the ability of other stakeholders to adapt to the impact of climate change;
- The national policy framework within which other levels of government operate are established, designed and implemented through budgetary allocations;
- Co-ordination of State and Local government and sectoral policies takes place at this level;
- International relations are managed especially where shared resources are involved as well as implementation and management of cross border treaties; and
- Development partners interface with governments at this level to support national development processes; for example massive funds being invested into the telecom industry by the World Bank and other international bodies.

The role of the state government is to carry out responsibilities according to the federal government guidelines. The local governments are closer to the grassroots and are important because climate change impacts are manifested locally, vulnerability and adaptive capacity are realized locally and adaptation is best observed and understood at the local level. However, the most critical and pertinent issue is the need for massive re-orientation of the mindset of these levels of government and focal ministries and their parastatals to mainstream climate change adaptation into their development plans as a critical strategy.

## Transportation

Existing federal government institutions in the transportation sub-sector are numerous. A reorganization, as well as more effective coordination and supervision would help to effectively mainstream climate change adaptation into activities and policies. At the state level, there also are state ministries that focus on transportation issues and most states sponsor Mass Transit Systems for motorized road transportation.

There are two key transport related ministries, they are Transport and Aviation with each having associated parastatals. For example, the Federal Ministry of Transport has seven parastatals and each of the modes of transport has a coordinating body: Nigeria Railway Corporation (NRC), Nigerian Ports Authority (NPA), Nigerian Shippers Council (NSC), Maritime Academy of Nigeria (MAN), Nigerian Institute of Transport Technology (NITT), Nigerian Inland Waterways Authority (NIWA) and Nigerian Maritime Administration and Safety Agency (NIMASA). Other relevant bodies are Federal Highways Authority and Federal Roads Maintenance Agency (FERMA). Furthermore, the Federal Ministry of Aviation as the supervising ministry for air transportation in Nigeria and has the following parastatals: Federal Airports Authority of Nigeria (FAAN), Nigerian Airspace Management Agency (NAMA), Nigerian Civil Aviation Authority (NCAA), Nigerian College of Aviation Technology (NCAT), Nigerian Meteorological Agency (NIMET) and Skypower Aviation Handling Company Limited (SAHCOL).

In terms of governance, therefore, the country has adequate institutions to oversee and implement the mainstreaming of climate change adaptation into the needs of the transportation subsector.

## Communication

This sub-sector is currently within the Federal Ministry of Information and Communication which is the supervisory ministry in charge of all the services of the subsector with the exclusion of managing the Nigerian Communication Satellite (NIGCOMSAT), which sits under the National Space Research and Development Agency (NASRDA). The parastatals that focus on specific aspects are:

- Telecommunication: Nigerian Communication Commission (NCC), Nigerian Postal Services (NIPOST); and
- Information Technology (Print and Electronic Media): News Agency of Nigeria (NAN), Nigerian Television Authority (NTA), Federal Radio Corporation of Nigeria

(FRCN), Voice of Nigeria (VON), National Broadcasting Commission (NBC), National Film and Video Censors Board (NFVCB) and Nigerian Press Council (NPC).

The Information Technology Department of the Ministry of Information and Communication is in charge of ICT, although there seems to be some duplication of functions and activities with the telecommunication and postal services department regarding internet communications. While the telecommunication infrastructure is the focus of this sub-sector, the IT section deserves mention because it promotes dissemination of information that is key to broadcasting disaster related information as previously discussed. Awareness is required of the critical need to mainstream climate change adaptation in this sub-sector and one of the driving forces of this awareness creation is the print and electronic media. However, it is important that the infrastructure relating to this awareness creation be 'climate proofed' so that it is not at risk in a changing climate.

It is noteworthy that the Information and Communications Technology Department in the Federal Ministry of Science and Technology deals with the internet connectivity component of telecommunication encompassing the "major concepts, developments, specifications, standards, and managerial implications involved in computer hardware, software, systems networks, telecommunications and technologies used in computer-based information system" ([http://www.fmst.gov.ng/ict\\_department.php](http://www.fmst.gov.ng/ict_department.php)). In order to avoid duplication of efforts, there needs to be harmonization of the functions of IT and Telecommunications/Postal Service Department of the Federal Ministry of Environment and the ITC Department of the Federal Ministry of Science and Technology. An example of duplication is the fact that both Ministries are involved in the implementation of rural telecommunication programmes. However, a very important function of the latter is the implementation of the national ICT policy as well as coordination of relevant ICT programmes like National Space Research and Development Agency (NASRDA), National Information Communication Education Programme (NICEP), Computer for All Nigerian Initiatives (CANI), National Information Technology Development Agency (NITDA) and Nigerian Communication Satellite (NIGCOMSAT) etc.

## Housing

This sub-sector is supervised by the Federal Ministry of Lands, Housing and Urban Development. The most prominent institution here is the Federal Housing Authority (FHA), Federal Mortgage Bank of Nigeria (FMBN), Federal Mortgage Finance Limited (FMF) and Urban Development Bank Limited (UDB). The 'Public Private Participation' is a growing initiative encompassing private sector participation in housing projects. These institutions will need to take into account climate risk in the housing designs, plans and programmes of the country. The new National Housing Policy's proposal, that provides an annual target of 1000 housing units to be built by state governments, should incorporate climate risk information.

## The Private Sector and Non-Governmental Organisations

At the local level, the private sector and NGOs could support adaptation by internalizing and institutionalizing climate change adaptation in the implementation of projects as well as in their daily operations. This could be achieved through adjusting strategic planning processes, business planning processes, insurance, private finance institution and project cycles. Projects could be specifically designed to target high risk communities. The private sector can contribute towards building the resilience of a community through their operations, in partnership with the communities and in collaboration with global markets (OECD, 2009).

## Recommended Climate Change Actions

### Transportation

In a changing climate, the impacts will become more frequent and extreme and if no adaptive measures are taken, will lead to more frequent disruptions and increasing cost of services. In the worst case, frequent and severe climate change impacts may result in transport systems inability to recover between such events. Hence, building climate-resilient urban transport systems is vital to safeguard existing and future transport infrastructure and its embedded value, ensure reliable mobility and economic vitality and development, as well as guarantee the health and well being of Nigerians.

Success in adaptation goes beyond merely adjusting existing transport networks to the impacts of climate change (especially when the infrastructure currently does not exist or is inadequate) to the actual building resilient infrastructure. This will require the use of the three basic approaches which involve retreating (or avoiding) from high risk zones, protecting facilities and infrastructure from negative impacts or accommodating the infrastructure or transport system itself. For transportation systems, adaptation cannot be viewed in isolation nor be reduced to technical infrastructure. Therefore, the overarching strategy for achieving climate change resilience encompasses:

- Spatial planning that combines risk mapping (avoiding high risk areas) and regulatory planning (e.g. zoning such as creating green and blue zones to avoid heat island effects);
- Improvement in design standards (e.g. improvement of urban drainage and building codes);
- Transport infrastructure insurance for cushioning the risk climate impacts the governments; and
- Adaptation auditing involving the identification of vulnerabilities, monitoring progress and suitability of adaptation measures including the identification of future adaptation needs.

The highlights on policies and programmes presented in 0 draw heavily on these strategies.

## **Communication**

Typically, ICT policy making encompasses three dimensions of information:

1. Infrastructural (i.e. issues related to national communication infrastructure);
2. Vertical (i.e. the variety of sectoral issues); and
3. Horizontal (i.e. impacts on broader social concerns like freedom of information, tariffs, pricing and security).

To emphasize the important role of ICT in Nigeria there is a need to link the social goals of information policies with developmental goals for the country (Vision 20:2020, NPC, 2004). In regard to climate change, it is of utmost importance that the ICT sector is supported by policies that promote improvement in infrastructure, create greater access, including relevant and gender-sensitive content.

**Table 9** Policies, Programmes, Adaptation Options Addressed, Implementation Agency and Cost for Infrastructure Sector: **Transportation Sub-sector**

Recommended/Suggested CCA Policy Actions	Proposed CCA Programmes	Ecozone Addressed	CCA Options Addressed by Proposed Policies and Programmes	Implementation Agency (s)	Estimated Costs
<b>Immediate Needs</b>					
1. Evaluate the existing transportation system to identify problems	1. Collect & analyse transportation data	All Ecological zones	All options that adopt the "avoid, protect & accommodate" approach to adaption	Federal Ministry of Transport in collaboration with Federal Ministries Finance, Aviation, Works, National Planning & all relevant Agencies such as NIMASA	1. N500 million in the first instance on research
2. Conduct regular transport infrastructure safety audits	2. Assessment of current design standards under different climate change scenarios & establish procedures for regular audit and update of standards				2. N50 million annually
3. Conduct risk assessment of both existing & existing transport infrastructure	3. Establish a procedure for regular climate change vulnerability/risk assessment				3. N2 billion every 5 years
4. Provide incentives to cushion the risk of infrastructural damage by climate change	4. Provide insurance to minimize government involvement in risk management to facilitate regular maintenance of infrastructure				4. N5 billion annually
5. Improve infrastructure (including vehicles, aircrafts, ships/boats/ferries/trains) & fuel technologies	5. Procure durable, efficient & resilient vehicles for public transportation				5. N10 billion in the first instance
6. Enforce regulatory standards for fuel consumption to encourage using non-motorized forms of transport	6. Conduct registration of vehicles with the provision of all necessary data to enforce standards & issue modified certificates of road worthiness				6. N5 billion in the first instance
<b>Long term Needs</b>					
1. Develop non-motorized transport alternatives (walking, cycling etc)	1. Construct sidewalks wherever possible	All Ecological zones	All options that adopt the "avoid, protect and accommodate" approach to adaption		1. N50 billion in the first instance for all existing roads
2. Integrate ICT, land use & transport planning in densely populated areas	2. Map risk zones & apply regulatory policies e.g. green zones				2. N20 billion during the first Phase
3. Reorganize and revitalize public transport systems (e.g. mass transit, railways, ferries etc) by making them reliable, fashionable & affordable	3. Reroute road to lighten traffic				3. N10 billion
4. Improve infrastructure including cooling, fuel technologies	4. Promote the use of ICT for telecommuting, improved traffic management & route designs				4. N10 billion to promote research
	5. Develop and produce durable infrastructure including efficient & resilient vehicles that use clean fuels & CO <sub>2</sub> for cooling for public transport system				

**Table 10** Policies, Programmes, Adaptation Options Addressed, Implementation Agency and Cost for Infrastructure Sector: **Communications Sub-sector**

Proposed CCA Policies	Proposed CCA Programmes	Ecozone Addressed	CCA Options Addressed by Proposed Policies and Programmes	Implementation Agency (s)	Estimated Costs
<b>Immediate Needs</b>					
1. Evaluate existing & proposed telecommunication infrastructure	1. Collect and analyse telecommunications infrastructure data	All Ecological zones	All options that emphasize improvement in telecommunication infrastructure	Federal Ministries of Science & Technology; Communications; and National Planning Commission; Private Sector ICT practitioners (e.g. GSM operators, cyber cafes, etc)	1. N1 billion at the first instance; & an annual release of N50 million
2. Conduct regular telecommunication infrastructure safety audit	2. Asses current design standards under different climate change scenarios & establish a procedure for regular audit & update of standards				2. N1 billion at the first instance & subsequently, an annual release of N50 million
3. Conduct risk assessment of both existing & proposed infrastructure	3. Establish & implement a procedure for regular climate change vulnerability/risk assessment				3. N10 billion at the first instance & subsequently, an annual release of N100 billion
4. Provide incentives to cushion the risk of infrastructural damage by climate change	4. Provide insurance to minimize government involvement in risk management to facilitate regular maintenance of infrastructure				4. N5 billion to be contributed by both the Private & Public Sector annually
<b>Long term Needs</b>					
1. Using incentives (tax relief) to enhance deregulation of the ICT sector to promote investment in qualitative rural telecommunication infrastructure & connections with specific targets being the marginalized groups (i.e. women)	1. Intensify the provision of infrastructure at subsidized costs to ensure access especially during disaster periods	All Ecological zones	All options	Federal Ministries of Science and Technology; Communications; & National Planning Commission; Private Sector ICT practitioners (e.g. GSM operators, cyber cafes, etc)	1. N5 billion annually
2. Improve infrastructure (e.g. materials, equipment) technologies through research & development	2. Development and production of durable (use of anti-corrosion materials) infrastructure including efficient & resilient vehicles that use clean fuels & CO <sub>2</sub> for cooling for public transport system				2. N10 billion annually

**Table 11** Policies, Programmes, Adaptation Options Addressed, Implementation Agency and Cost for Infrastructure Sector: **Housing Sub-sector**

Proposed CCA Policies	Proposed CCA Programmes	Ecozone Addressed	CCA Options Addressed by Proposed Policies and Programmes	Implementation Agency (s)	Estimated Costs
<b>Immediate Needs</b>					
<ol style="list-style-type: none"> <li>1. Review building codes and design standards and develop new one</li> <li>2. Establish risk zones mapping through enhanced land use planning</li> <li>3. Establish appropriate PPP guidelines with climate change adaptation embedded</li> </ol>	<ol style="list-style-type: none"> <li>1. Organize a stakeholders' workshop</li> <li>2. Conduct risk mapping</li> </ol>	All ecozones	All options that are related to the construction of resilient buildings	Federal Ministry of Housing and Urban Development; all related agencies in this sector (FHA, FMB)	<ol style="list-style-type: none"> <li>1. N50 million</li> <li>2. N20 billion across country</li> <li>3. N20 million</li> </ol>
<b>Long term Needs</b>					
<ol style="list-style-type: none"> <li>1. Promote the investment in construction of low cost green buildings and space</li> <li>2. Provision of incentives for utilization of energy efficient infrastructure and materials</li> <li>3. Invest in research and development for localised construction materials</li> </ol>		All ecozones	All options that are related to the construction of resilient buildings	Federal Ministry of Housing and Urban Development; all related agencies in this sector (FHA, FMB)	<ol style="list-style-type: none"> <li>1. N20 million</li> <li>2. N10 million</li> <li>3. N50 million</li> </ol>

## Sub-sector 3: Industry and Commerce

### Introduction

Climatic change impacts industry and commerce, which in turn shapes socio-economic conditions in Nigeria. The challenge for government is to provide appropriate policy interventions to cushion the effect of climate change by helping private industry and communities develop adaptive measures that are sustainable and which contribute to the existing national development policy framework.

The impact of climate change across different ecological zones of the country is varied and has its greatest impacts on the most vulnerable groups. The multifaceted nature of climate change will result in significant impact to infrastructure. This is of particular concern due to the fact that infrastructure provides the foundation for activities critical to the Nigerian economy; most especially, the commerce and industry subsectors. Adaptation to climate change will be required for energy consumption, modes of transportation, new industrial developments, and even housing needs; maintaining well-developed and resilient infrastructure is critical to achieving the best adaptive outcomes. As an example, in the Sahel region, where drought is the main impact of climate change, ecosystem degradation will result in a shortage of traditional energy sources (e.g., fuel wood, dung). At the same time, it will create an increase in demand for contemporary energy sources (e.g., electricity, fuel) needed to pump water to alleviate water stress, and needed for air-conditioning to alleviate heat stress (DFID, 2009).

### Assessment of Current and Future Trends

A report prepared by the Nigerian Environmental Study/Action Team (NEST, 2004) has reinforced the view that many industries in Nigeria are vulnerable to a myriad of climate change-induced problems. Construction, transportation operations, road infrastructure, energy production and transmission, off-shore oil and gas operations, thermal power generation, as well as tourism and recreation, are some of the industrial sectors that are exposed to the vagaries of changing climate conditions. NEST (2004) also noted that industries dependent on climate-sensitive resources will suffer the most, as they derive their raw materials from sectors most affected by climate change, such as agriculture. The consequences of negative impacts to industry and commerce will be greater poverty among people who depend on these for their livelihoods.

In the Savanna ecozone, where climatic change impacts are contributing to the degradation of natural resources that support livelihood opportunities, improved infrastructure for industry and commerce can provide alternative livelihood opportunities for vulnerable communities.

Nigeria has considerable industry and commerce within its coastal regions that are at risk of flooding and sea-level rise and that have the potential to disrupt economic activities. This is a particular consideration in Lagos and the Niger Delta, where substantial amount of infrastructure investment is in place. These areas are made more vulnerable by the large population present and the existing poor quality of infrastructure, including buildings and flood control structures. The infrastructure needed to protect industry commerce in coastal regions includes detached breakwaters, floodgates, and tidal barriers, as well as salt water intrusion barriers, periodic beach nourishment, seawall revetments, and bulkheads, among others (Klein et. al, 2001). Well-built infrastructure in coastal regions will mitigate the impact of climate change and promote manufacturing activities, leading to wealth creation.

The climate change challenges facing Nigeria's industrial and commercial sectors are exacerbated by the current poor state of manufacturing in the country (Adeyemi, 2007): 30% of industries have closed down, 60% are ailing, and only about 10% are operating at a sustainable level (Table 12).

**Table 12** State of Manufacturing Industries in Nigeria\*

Industries that have Closed	Ailing Industries	Industries Operating at a Sustainable Level
<ul style="list-style-type: none"> <li>■ Chalk manufacturers</li> <li>■ Candle manufacturers</li> <li>■ Dry cell and auto batteries</li> <li>■ Shoe polish</li> <li>■ Matches</li> </ul>	<ul style="list-style-type: none"> <li>■ Textiles</li> <li>■ Vehicle assemblers</li> <li>■ Cable manufacturers</li> <li>■ Paint manufacturers</li> <li>■ Still firms</li> <li>■ Petrochemicals</li> </ul>	<ul style="list-style-type: none"> <li>■ Food, beverages &amp; tobacco sector</li> <li>■ Leather sub-sector</li> <li>■ Household products</li> </ul>

\*(Adeyemi, 2007)

## Assessment of Economic Impacts

The impact of climate change on industry and commerce will constitute one of the greatest challenges the government of Nigeria will have to tackle in its efforts to achieve the Vision 20:2020 goal of positioning the country as one of the top twenty global economies by the year 2020. Industrial and commercial investment requires reasonable stability in the country – socially, economically, and environmentally. Without clear direction from government on adaptation to climate change, the stability of industry and commerce will be vulnerable to climate impacts. The UK Department for International Development (DFID) has reported that global climate change is one of the largest threats to Nigeria's development and economy. There is therefore a strong need for policy to address climate change at the federal and state levels, and to ensure that the private sector adequately factors into risk assessment, investment planning, and project execution the risks posed by climate change.

The largest export earning industry in Nigeria is oil and gas production, industries strongly associated with coastal areas that are vulnerable to climate change impacts such as rising sea-level and ocean storm surges. It has also been documented (NEST, 2004) that some of Nigeria's most important industrial areas are located in Lagos, Port Harcourt, and Onitsha – areas that are vulnerable to climate change-related flooding. Some industrial products (e.g., agricultural and fisheries products) are highly weather-dependent and their production is therefore more vulnerable to climate change impacts.

## Assessment of Gender Impacts

The impact of climate change is already being experienced on a human level, and the impact is affecting men and women differently. It is recognized that those in society who are already the most vulnerable and marginalized are those who experience the greatest impacts arising from climate change (IPCC, 2007) and who therefore are in greatest need of adaptation strategies. At the same time, vulnerable and marginalized people have the least capacity and opportunity to adapt to the impacts of a changing climate. And finally, as women constitute the largest percentage of the world's poorest people, they are most affected by climate change (Brody, Demetriades & Esplen, 2008).

Even where there is a lack of hard evidence, it is commonly recognized that climate change exacerbates existing inequalities in the key dimensions that are not only the building blocks of livelihoods, but are also crucial for coping with change - building blocks that include wealth, access to and understanding of technologies, education, access to information, and access to resources (Masika, 2002). The unusual droughts, heat waves, flash floods, severe wind storms, sea-level rise, flooding, and coastal erosion would certainly impede efforts in bridging the inequality gaps between men and women, and weaken efforts in gaining access to these livelihood building blocks.

The informal economy comprises all forms of employment (small scale businesses, marketing, local processing of products, etc.), with a greater percentage of women than men captured in this group. Women often have less access to land because of inheritance laws; less access to education and skills training; less access to inputs, information, technology and capital. These are all factors that limit the ability of women to secure an increasing share of benefits in business and investment, which in turn prevent them from creating a strong and resilient female workforce that is able to withstand the impact of climate change.

In 2006, the Nigerian National Bureau of Statistics reported the following (NBS, 2006):

- Manufacturing and processing employment is 89 % male and 11 % female;
- Construction employment is 94 % male and 6 % female;

- Hotel and tourism employment is 64 % male and 36 % female; and
- The national average in seven sectors of employment is 82 % male and 18 %.

These statistics show the exclusion of women from industry and commerce, with the benefits employment provides, and emphasizes the fact that women are part of a marginalized group most susceptible to climate change impacts.

The following are the recommended strategies to provide more equitable participation of women in industry and commerce:

- Promote the effective integration and participation of women at all levels of development, especially at the decision-making levels;
- Eliminate regulations and customs that are discriminatory against women; specifically, regulations and customs which prevent women from owning land and other assets that will increase their access in participating in business activities;
- Create or adopt technologies which will ensure the stability of employment and professional progress for female workers;
- Encourage and strengthen institutions which are engaged in the promotion and development of labour-saving devices aimed at improving the productive capacity of women.
- Strengthen the role of women in business, with special emphasis on easing access to inputs, technology, and information that will promote women's participation in business as it relates to agriculture, industry, and trade and increase the awareness of women-in-business issues at the policy level;
- Create an enabling environment for the effective participation of women in regional market trade and development activities;
- Promote special programmes for women in small- and medium-size enterprises, and eliminate laws and regulations that hinder women's access to credit;
- Initiate changes in educational and training strategies to enable women to improve their technical capacities through the acquisition of transferable skills offered by various forms of vocational and on-the-job training schemes;
- Recognize and support the Nigerian Association of Women Entrepreneurs established to promote the effective participation of women in business and investment activities;
- Facilitate the transformation of female entrepreneurship from small- to large-scale businesses in order to benefit from economies of scale;
- Facilitate the access of women to adequate and timely credit and finance;
- Integrate gender perspectives in the private sector development programmes; and
- Build the capacities of all officials involved in private sector development in Nigeria to integrate gender in all of their work.

## **Review of Existing Governance, Policies, and Programs**

Over the years, the federal government of Nigeria has made a concerted effort to address the challenges faced by the industrial and commerce sectors. These past efforts, as documented in the First National Communication (UNFCC, 2003), included development of legal and institutional frameworks, capacity building and institutional strengthening, encouragement of private initiatives, and collaboration with international agencies, as well as promotion of community partnerships in wealth creation and empowerment. Efforts have also been made to address environmental challenges posed by variations in climatic conditions, which have direct impact on the commercial and industrial activities in Nigeria. These efforts have been encapsulated in various government of Nigeria policy instruments.

Non-governmental organizations (NGOs) and community-based organizations (CBOs) are also supported by government in addressing the challenges faced by industries, business organizations, and households across the country. Government efforts include providing micro credits to small business organizations, sensitizations and mobilization of local knowledge and skills to support households to find alternative means of livelihood, and strengthening the institutions that support the organized private sector to enhance their capacity to engage the government on policy issues.

## **Recommended Climate Change Adaptation Actions**

The income base of communities has been expanded through small-scale, income-generating projects organized at the community levels. In addition, Cooperative Societies have sprung up to play a key role in funding various skills acquisition centres in communities. There have also been community-led programmes aimed at increasing livelihood opportunities.

The legislative and regulatory policy instruments recommended for climate change will reinforce the proposed adaptation options. This will be a major step in setting limits and regulations, as well as establishing bylaws, standards, constitutional guarantees, and national agreements based on international conventions. It is equally necessary that financial and market instruments be used in strengthening climate change adaptation in Nigeria. The policy instruments used may also include concessions, licenses, permits, taxes, user-fee charges, tax credits, payments for amenities, and other market-based measures that include procurement policies, product standardization and certification, and intellectual property rights, among others. The establishment of economic zones as a catalyst in building the required synergies for industrial and commercial development is also a policy issue that should be used, as it provides a holistic and integrative approach for industry and commerce.

It is also proposed that income stabilization initiatives be established to support the most vulnerable groups. Issues of access to credit and economic diversification - which has been a major government policy over the years - should be reinvigorated. Policy initiatives aimed at diversifying technological acquisition to cleaner and green-friendly technologies is a global initiative that Nigeria should also latch onto. As well, Nigeria should pursue public enlightenment campaigns; these can be very powerful instruments that deepen people's understanding of government programmes. Following this will be a vigorous pursuit of professional development programmes on environmental-related issues. Communities should be encouraged to collectively articulate their problems and learn to find solutions to them as climate change issues are most often community- or ecozone-specific. A participatory approach in development will be crucial in engaging communities toward the process of technology receptivity.

Table 13 outlines climate change hazards, impacts, and various adaptation options that may be implemented. Table 14 provides information on recommended policies and actions, including how recommendations address the proposed climate change adaptation options, the recommended implementing agency, and the estimated cost of recommended adaptation actions. Evaluation of the proposed policies and programs are presented in Table 15 below.

**Table 13** Hazard-Impact-Vulnerability-Adaptation Matrix for Infrastructure: **Industry and Commerce Sub-sector**

Climate Change Hazard	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: SAHEL AND SAVANNA</b>			
High temperatures	<ul style="list-style-type: none"> <li>■ More frequent and intense heat waves</li> <li>■ Depletion of natural resources needed for economic livelihoods</li> <li>■ Destruction and relocation of investments</li> <li>■ Fewer available jobs</li> <li>■ Reduced income earning opportunities</li> <li>■ Higher prices for food</li> </ul>		<ul style="list-style-type: none"> <li>■ Strengthening of markets for locally made products through deliberate government intervention to encourage consumption of local goods and services</li> <li>■ Insurance initiative to support industry</li> <li>■ Capacity building to diversify local production and through value addition to products</li> <li>■ Incentives to industries to adopt more efficient technologies</li> </ul>
Lower rainfall	<ul style="list-style-type: none"> <li>■ More frequent and intense droughts</li> <li>■ Negative impacts to agro-based industries through lower productivity and investment returns</li> <li>■ Industry and commerce impacted through reduced hydro power energy supply</li> <li>■ Increased cost for water reliant processes</li> <li>■ Potential migration of labour force</li> <li>■ scorched crops as a result of excessive heat</li> </ul>		<ul style="list-style-type: none"> <li>■ Acquisition, promotion, and development of local skills</li> <li>■ Introduction of technology to support economic diversification</li> <li>■ Development of special economic/ industrial zones or clusters</li> </ul>
<b>Ecozone: COASTAL/RAINFOREST</b>			
Extreme rainfall events	<ul style="list-style-type: none"> <li>■ Disruption to industry and commerce activities</li> <li>■ Negative impacts to infrastructure such as transportation and energy, upon which industry and commerce depend</li> <li>■ Flooding of agricultural land that provides products for industry</li> </ul>		<ul style="list-style-type: none"> <li>■ Designing new industrial technologies with increased resilience and flexibility to build in climate change adaptation technologies</li> </ul>
Sea-level rise and storm surge	<ul style="list-style-type: none"> <li>■ Flooding of industry and commerce infrastructure</li> <li>■ Loss of coastal agricultural land that provides products for industry</li> <li>■ Damage to oil and gas infrastructure</li> </ul>		<ul style="list-style-type: none"> <li>■ Industry and commerce business premises built to withstand predicted impacts of climate change in coastal areas</li> <li>■ Introduction of risk-sharing programmes</li> <li>■ Provision of credit to assist in climate-proofing industry and commerce facilities</li> <li>■ Industry and commerce business premises built to withstand predicted impacts of climate change in coastal areas</li> </ul>

**Table 14** Policies, Programs, Adaptation Options Addressed, Implementing Agency and Costs for Infrastructure Sector: **Industry and Commerce Sub-sector**

Recommended/ Suggested Policy Actions	Proposed CCA Programs	Ecozone Addressed	CCA Options Addressed By Proposed Policy Actions & Programs	Implementing Agency(s)	Cost Implication
<b>Immediate Needs</b>					
<ul style="list-style-type: none"> <li>■ Access to medium-/long-term credits</li> <li>■ Special economic zones</li> <li>■ Income stabilization initiative</li> <li>■ Economic diversification</li> <li>■ Provision of physical and social infrastructure (e.g., roads, electricity, water, schools; well-equipped skills acquisition centres, etc.)</li> </ul>	<ul style="list-style-type: none"> <li>■ Credit facilities</li> <li>■ Insurance initiatives supporting commercial and industrial activities at informal level</li> <li>■ Commercial activities- Insurance facility fund- Improved access to resources</li> <li>■ Promotion of social networks</li> <li>■ Infrastructure development programmes</li> <li>■ Skills acquisition programmes</li> <li>■ Tax relief</li> </ul>	All ecozones	<ul style="list-style-type: none"> <li>■ Mobilization of investment fund</li> <li>■ Improved access to resources and markets, appropriate economies of scale</li> <li>■ Lowering of inequities</li> <li>■ Capacity building</li> <li>■ Flooding &amp; wind storm in the markets and other industrial centres in the coastal regions</li> <li>■ Capacity building on how to manage locally processed industries</li> </ul>	<ul style="list-style-type: none"> <li>■ SMIEIES</li> <li>■ CBN</li> <li>■ NAPEP</li> <li>■ Federal Ministry of Commerce and Industry</li> <li>■ State and Local Government</li> <li>■ Multinational Companies</li> <li>■ NGOs</li> <li>■ CBOs</li> </ul>	
<b>Long Term Needs</b>					
<ul style="list-style-type: none"> <li>■ Incentives to industries and establishments adopting environmentally-sensitive/cleaner technologies</li> <li>■ Shifting of major proportion of portfolio credit to real sector activities</li> <li>■ Acquisition, promotion, and development of local skills/ technology</li> <li>■ Income stabilization initiative</li> <li>■ Promotion of economies of scale through the development of special economic zones to strengthen local markets</li> <li>■ Development of local markets through price control</li> <li>■ Designing new industrial technologies/activities with increased resilience and flexibility, with climate change already built in</li> </ul>	<ul style="list-style-type: none"> <li>■ Micro credit facilities</li> <li>■ Promotion of locally generated technologies</li> <li>■ Commercialization of R &amp; D results</li> <li>■ Promotion of new innovation technology</li> <li>■ Improved education &amp; access to information &amp; institutional capacity building</li> <li>■ Establishment of credit management associations</li> <li>■ Skills learning/technology incubation centres</li> </ul>		<ul style="list-style-type: none"> <li>■ CO<sub>2</sub> emissions reduction</li> <li>■ Credit mobilization for commercial activities</li> <li>■ Better equipments for processing local products</li> <li>■ Increased efficiency &amp; effectiveness of production of locally made goods</li> <li>■ Capacity building</li> <li>■ Enhanced standards of products</li> <li>■ Lowering of inequities in resource allocation</li> </ul>	<ul style="list-style-type: none"> <li>■ Federal Ministry of Finance</li> <li>■ Micro finance regulatory agencies</li> <li>■ NOTAP</li> <li>■ NAPEP</li> <li>■ Federal Ministry of Commerce and Industry</li> <li>■ SMEDAN</li> <li>■ Federal Ministry of Science and Technology</li> </ul>	

CCA = climate change adaptation; CBN = Central Bank of Nigeria; CBO = community-based organization; CCA = climate change adaptation; CO<sub>2</sub> = carbon dioxide; NAPEP = National Poverty Eradication Programme; NGO = non-governmental organizations; NOTAP = National Office for Technology Acquisition and Promotion; R&D = research and development; SMEDAN = Small and Medium Enterprises Development Agency of Nigeria.

**Table 15** Evaluation of Proposed Policies Infrastructure Sector: **Industry and Commerce Sub-Sector**

Proposed CCA Action	Criteria to Evaluate Effectiveness of CCA Action Implementation	Implications if CCA Action IS Implemented (individuals, communities, private sector)		Implications if CCA Action IS NOT Implemented (individuals, communities, private sector)	
		Positive Impact	Negative Impact	Positive Impact	Negative Impact
<b>Immediate Needs</b>					
<ul style="list-style-type: none"> <li>■ Access to medium-/long-term credits</li> <li>■ Cluster formation</li> <li>■ Income stabilization initiative</li> <li>■ Economic diversification</li> </ul>	<ul style="list-style-type: none"> <li>■ Based on meeting immediate needs of citizens</li> <li>■ Creates large-scale opportunity for industry &amp; market</li> <li>■ Creates alternative employment opportunities</li> </ul>	<ul style="list-style-type: none"> <li>■ Reduces inequality</li> <li>■ Makes resources available for investment</li> <li>■ Opportunity to galvanize the informal economy &amp; make it useful, as an engine of growth &amp; development</li> </ul>	<ul style="list-style-type: none"> <li>■ May breed corruption on implementation</li> <li>■ Cluster could raise environmental challenges facing industry &amp; commercial activities</li> </ul>	<ul style="list-style-type: none"> <li>■ May increase the competition across communities, leaving the most vulnerable further marginalized</li> </ul>	<ul style="list-style-type: none"> <li>■ No opportunity to explore available opportunities</li> <li>■ Unemployment &amp; poverty increased</li> </ul>
<b>Long Term Needs</b>					
<ul style="list-style-type: none"> <li>■ Incentives to industries &amp; establishments adopting environmentally-sensitive cleaner technologies</li> <li>■ Shifting of major proportion of portfolio credit to real sector activities</li> <li>■ Acquisition, promotion, &amp; development of local skills &amp; technology</li> <li>■ Development of local markets through price control mechanism</li> </ul>	<ul style="list-style-type: none"> <li>■ Cost-effective</li> <li>■ Strategy to attract global funding</li> <li>■ More environmentally friendly technologies</li> <li>■ Maximize capacity utilization</li> <li>■ Integration of Nigerian economy into the global market</li> <li>■ Ease of adaptation &amp; most useful to the local industries</li> <li>■ Reduce losses from local businessmen &amp; women</li> </ul>	<ul style="list-style-type: none"> <li>■ Increases the production base</li> <li>■ More investment funding</li> <li>■ Increases raw material utilization thereby creating market for local people</li> <li>■ Maximizes opportunities</li> <li>■ Increases the income</li> </ul>	<ul style="list-style-type: none"> <li>■ Capacity constraints to use the new technologies</li> <li>■ May breed corruption on implementation</li> <li>■ May run contrary to government policy initiatives on a market-based economy</li> </ul>		<ul style="list-style-type: none"> <li>■ Skewed in favour of some industries</li> <li>■ No motivation to adopt cleaner technologies</li> <li>■ Loss of businesses</li> </ul>

CCA = climate change adaptation.

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# Climate Change Adaptation Strategy Technical Report

## **Agriculture Sector**

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## Introduction to Agriculture Sector

The state of the agricultural sector in Nigeria now and in the future is critical to Nigeria's economic and social well-being. Agriculture is the most important sector of the Nigerian economy in terms of its contribution to Gross Domestic Product (GDP) and employment, contributing approximately 42 % of GDP in 2009 (National Bureau of Statistics, 2009). Despite a growing urban population, the majority (>56 %) of Nigerians still reside in rural areas (Earth Trends, 2003) where the main economic activity is agriculture. According to FAO (2010) 60% to 70% of the population is engaged in agriculture. This puts the agricultural sector ahead of other sectors in terms of the potential consequences of climate change impacts for the majority of Nigerians, eclipsing even the petroleum sector despite it being the most important foreign exchange earner and source of public finance.

In recent years, Nigeria's domestic food production has consistently lagged behind national food demand. Generally, agricultural production is not meeting the demand of Nigerians. For example, the average intake of 9 grams of protein per day falls far below the recommended rate of 65 grams (Okolo, 2004). The increasing gap between production and demand can be seen in the rising food import costs from N3.5 billion in 1990 to N195.8 in 2001 (Okolo, 2004). The pattern of increasing annual shortfalls suggests food security is an important issue, and one that will be exacerbated by the impact of climate change.

The Nigerian agricultural sector is characterized by dominance of small producers on small land holdings, low technology use, and reliance on human labour. Women's labour is very important with women being major producers of staple food crops, estimated at between 60 to 80% of the food in Nigeria. In addition, women are engaged in most of the post-harvest activities especially food processing (Akinyele *et al.*, 1991). However there are distinct and diverse roles for men, women and children in various parts of the country. The major areas where women's labour is most predominant is in the rainforest of the southeast and the middle belt, followed by the southwest and less so in northern areas. The factors determining the geographical differences in women's contribution to agricultural labour on the farm are both cultural and religious.

In terms of diversity, the pattern and structure of the agricultural sector follows the ecological diversity of the country, ranging from the mangroves on the coast, rainforest in the south, savanna in the middle belt and the Sahel in the north. These ecological zones are related to the nature of agricultural production with a south to north pattern that roughly follows fisheries, tubers, cereals and livestock respectively as the dominant products. Various vegetables, fruits and tree crops are produced in all the ecological areas but are predominantly associated with the rainforest and savanna ecological zones. These patterns of production are influenced mostly by the length of rainy season and the amount of annual rainfall (Amanza, *et al.*, 2007).

There are some common features in Nigeria's agricultural sector irrespective of the agro-ecological area. For example, across the country, agriculture is relatively under-developed, with a generally low productivity and a low adoption of new technologies and a lack of sophisticated management. As a result, Nigeria's agricultural sector growth has been unable to keep up with population growth and food demand. Hence Nigeria has become a significant food importer over time and has become a large importer of rice. Over the years, Nigeria's government has initiated some policies, programmes and projects to develop the agricultural sector. However, these have met with limited success. One of the major reasons for the poor performance of the agricultural sector is the fact that most farming is directly dependent on climate. For example, less than two percent of farming in Nigeria uses irrigation, hence most agricultural production is rain-fed. As a result, changes in climate factors have significant consequences for the agricultural sector.

The adverse impacts of climate change are expected to lead to production losses in the agricultural sector and compromise the attainment of the Millennium Development Goals (MDGs), especially Goal 1 "*Eradicate Extreme Poverty and Hunger*" and Goal 7 "*Ensure Environmental Sustainability*" (Ikpi, 2010). The range of possible climate change hazards

and relevant adaptation measures are diverse and must be considered in the context of the local agro-ecological, production and socio-cultural conditions present for any particular area in Nigeria. Climate change adaptation measures have also been considered in the context of the related policy environment. Therefore, there is scope for new policy initiatives to address issues concerned with agriculture and climate change.

## Assessment of Current and Future Trends

### Sub-sector 1: Crops

Agricultural production in Nigeria is carried out primarily by small scale farmers working on rural farms that are generally small in size, varying from 0.1 to 6.0 hectare, farming mostly under rain-fed conditions (Olowu *et al.*, 2008). While some larger farms have been established by organizations and individuals, small scale farmers account for approximately 95% of total agricultural output (Federal Ministry of Agriculture, 2005) with crop yields that are in the range of 0.6 to 1.5 tonnes per hectare (NAERLS, 2004).

Crop production in Nigeria follows patterns that relate to local conditions with climate being one of the most important determining factors. The location, size, and characteristics of geographic position and relief in Nigeria give rise to a variety of climates ranging from a tropical rainforest climate along the coast to a Sahelian climate in the northern part of the country (Adejuwon, 2004). The climate of the country ranges from very wet coastal areas with annual rainfall greater than 3,500mm, to the drier Sahel region in the north-western and north-eastern parts of the country with annual rainfall less than 600mm (Ojo, 1987 cited in Adejuwon, 2004). The inter-annual variability of rainfall, particularly in the northern regions, is large and often results in climate hazards such as floods, wind storms and droughts which can have devastating effects on food production and human well-being.

In the southern Coastal and Rainforest ecological zones where the rainy season is longer and annual rainfall greater, the staple foods are based on root crops. The middle belt Savanna ecological zone is characterized by a drier and more seasonal (wet/dry) climate and the staple crops include root crops and cereals. In the northern Savanna and Sahel ecological zones, characterized by low rainfall and a short and variable wet season with low annual rainfall, the staple foods are based on cereal crops and legumes (see Table 1). Ecological regions of the country associated with higher elevations and cooler temperatures, such as the plateau areas, favour specialized root crops such as carrots, Irish potato and sweet potato.

**Table 1** Major crops grown within various regions of Nigeria

Crop Type	Southern coastal & Rainforest	Middle-belt Savanna	Northern Savanna & Sahel
Root crops	<ul style="list-style-type: none"> <li>■ Cassava</li> <li>■ Yam,</li> <li>■ Cocoyams</li> <li>■ Sweet potatoes</li> </ul>	<ul style="list-style-type: none"> <li>■ Yam</li> <li>■ Cassava</li> </ul>	<ul style="list-style-type: none"> <li>■ Carrot</li> <li>■ Irish potato</li> <li>■ Sweet potato</li> </ul>
Cereals	<ul style="list-style-type: none"> <li>■ Maize</li> <li>■ Rice</li> </ul>	<ul style="list-style-type: none"> <li>■ Maize</li> <li>■ Rice</li> </ul>	<ul style="list-style-type: none"> <li>■ Sorghum</li> <li>■ Millet</li> <li>■ Maize</li> <li>■ Rice</li> </ul>
Legumes			<ul style="list-style-type: none"> <li>■ Groundnut</li> <li>■ Cowpeas</li> </ul>
Tree crops	<ul style="list-style-type: none"> <li>■ Cocoa</li> <li>■ Palm oil</li> <li>■ Rubber</li> </ul>	<ul style="list-style-type: none"> <li>■ Citrus</li> <li>■ Mangoes</li> </ul>	

Crop production in Nigeria has experienced and is experiencing many hazards related to climate change. Climate change impacts are associated with a range of climatic variables such as temperature, rainfall, and extreme events. Also important are the country's social, cultural, geographical and economic backgrounds which determine the resilience of communities dealing with climate change impacts.

While climate change is driving aridity and desertification in northern Nigeria, it is increasing flooding and erosion (gully, sheet and coastal/beach) in the middle belt and

southern regions especially in the coastal and rainforest ecological zone (Uyique and Agho, 2007). Flooding and erosion has increasingly been reported as a major climate change hazard in almost all communities in these zones.

Flooding and erosion lead to crop failure by removing topsoil, making soil more acidic and washing away or submerging crops. Flooding is a climate change hazard related to a more irregular rainfall pattern which can give rise to a single or series of rain events of high intensity and duration leading to very high total rainfall amounts over a short period of time (Adelekan, 2009). Other climate change hazards include landslides, severe windstorms, excessive heat, drought and late and variable onset of the rainy season.

Another climate change hazard relates to the trend of rising temperatures, reported to be increasing in Nigeria since 1901 (Odjugo, 2010). Temperature increase was gradual until the late 1960s, with more rapid increases occurring since the 1970s' a trend which has continued to the present.

Sea-level rise, resulting from climate change, is affecting crop production in coastal areas. The Nigerian Environmental Study/Action Team (NEST, 2004), reported that sea-level rise and repeated ocean surges is leading to increased coastal erosion and associated intrusion of sea-water into surface water and groundwater resources. Exacerbating the problem is the fact that many coastal ecosystems are degraded due to a loss of mangrove forests which, when present, provide a protective function reducing the impact of salt water on inland areas of crop production.

Farmers in the Coastal and Rainforest ecological zones face a range of impacts from climate change hazards, contributing to a loss of livelihoods. Climate change impacts can include:

- decline in crop yields resulting in reduced marketable surpluses;
- irregular fruiting of cocoa;
- total failure of some crops;
- increase in pests and disease;
- soil degradation and loss of farm land due to flooding and erosion;
- reduction in bush foods such as bush mango (*Irvingia gabonensis*) and *Getup africana* also known as Okazi, Afang or eru; and
- post-harvest losses of farm products due to bad/extreme weather events

As the BNRCC pilot projects results and research demonstrates, farmers are affected by the decline in yields and reduced income they receive from the sale of crops thus reducing their ability to purchase other needed foods and goods.

A serious hazard of climate change that directly impacts agriculture in the Savanna and Sahel ecological regions is increased variation in the amount, geographic distribution and timing of rainfall. Traditionally, planning and timing of farming operations are tied to the onset and duration of rainfall, particularly the first rainfall events of the wet season. In the past, farmers in these ecological regions have indicated that the period of initial rainfall onset usually occurred during the month of March with rainfall continuing until November. Recent observations report a delayed onset of rainfall until May or June and a cessation of rainfall in October. The impacts can include a loss of planting materials, reduction in grain yield, reduction in animal feed/fodder, and at times complete crop failure due to cessation of rain (BNARDA, 1992; NAERLS, 2004).

Due to extreme levels of poverty, poor levels of infrastructure and heavy dependence on rain-fed agriculture, communities in the Sahel and Savanna ecological regions are extremely vulnerable to climate change impacts and have limited ability to adapt. In the Savannah and Sahel the impacts of climate change include:

- decreased rainfall, increased temperature and evaporation;
- more frequent drought spells leading to source water shortage;
- changes in the onset of the rainy season changing planting dates and the length of the growing season of annual crops;
- increased fungal outbreaks and insect inter-relation due to changes in temperature and humidity;
- decrease in the available areas that can be cultivated and decline in yields;

- increased risk of food shortage and famine;
- increased potential of malaria transmission and the related reduction in available labour to work on farms;
- increased movement of pastoralists to more humid southern areas in search of fodder and water;
- lower quality and quantity of grazing lands;
- increased desertification of arable lands;
- increased rural to urban migration leading to a reduction of available farm labour; and
- loss of soil fertility.

Crop farmers in all of the agro-ecological areas of Nigeria are vulnerable to climate change impacts because of their low adaptive capacity (Onyeneke, 2010). BNRCC pilot and research project results have identified the following vulnerabilities of small-holder farmers in the agricultural sector:

- lack of knowledge of alternative cropping options;
- dependence on rain fed agriculture;
- lack of access to alternative crops, fertilizers and other agricultural inputs leading to low crop yields;
- rising populations;
- lack of access to information about climate change trends and weather forecasting;
- lack of knowledge and use of soil management techniques;
- poor market outlets;
- lack of knowledge on how to protect crops from extreme weather;
- lack of viable alternative livelihood options;
- high dependence on crops for food security and income; and
- overall declining productivity of agriculture.

The low adaptive capacity of crop farmers in Nigeria can be attributed to a variety of factors, including poverty, lack of access to resources, and poor infrastructure, etc. However, despite these changes, small-holder farmers are developing strategies to cope with and adapt to the impacts of climate change. It is important to recognize that in the past many communities have faced harsh changes in environmental conditions and over time have been trying, testing and adopting different types of coping and adaptation strategies for crop and animal production. Important adaptation strategies that have been adopted by some crop farmers include (Onyeneke & Madukwe, 2010 and results from the BNRCC research and pilot projects):

- changing planting dates, including early planting and early harvest of improved varieties;
- changing tillage operations (full tillage, digging ridges across their farms, minimum tillage);
- planting trees to serve as shade and act as a wind break;
- portfolio diversification (planting improved crop varieties, intercropping, crop rotation);
- adoption of soil conservation techniques (cover cropping, mulching, application of fertilizers);
- irrigation (informal type);
- bush fallowing;
- indigenous and improved agroforestry;
- domestication of forest products;
- diversification of crops produced;
- use of early maturing crops;
- trading in new cash crops from other markets;
- expanding their skill sets;
- building storage facilities for various farm products;

- attending field schools to improve cultivation methods, e.g. cocoa cultivation;
- construction of culverts to enhance water passage to/from farmlands;
- shore protection to prevent erosion and inundation of arable land;
- improved transportation to points of sale to prevent spoilage of produce; and
- introducing and expanding the production of hydrophytes (like water lettuce) and halophytic crops (groundnut -Ex-Dakar cultivar).

Climate change undermines food security in Nigeria on several levels. In extreme cases, individual farm production is no longer sufficient for household consumption and intense rain and flooding disrupts accessibility to markets. Climate change results in malnutrition, especially of women and children, it leads to out-migration from rural farms by men and youth (i.e. farm labour), and loss of food crops due to impacts resulting from climate change.

Women are more vulnerable than men to climate change impacts in all parts of Nigeria. In addition, women tend to have lower adaptive capacity than men performing similar activities. For example, men were found to have greater adaptive capacity in the use of wetlands for irrigation, use of weather forecasts and early warning systems, of resistant varieties, expansion of cultivated farmland and change from livestock to crop production. Women's adaptive capacity may be lower due to their limited access to resources, such as land, as in many cultures women cannot hold title to land and rarely obtain land through inheritance which is the major means of transfer of land ownership in these communities (RULIN, 2011).

**Table 2 Hazard-Impact-Vulnerability-Adaptation Matrix for Agriculture: Crop Sub-sector**

Climate Change Hazard	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: COASTAL/RAINFOREST</b>			
Increased rainfall intensity	Gully and sheet erosion which leads to: <ul style="list-style-type: none"> <li>■ loss of farm lands</li> <li>■ leaching and loss of soil fertility</li> <li>■ low crop yield</li> <li>■ low productivity</li> <li>■ loss of deep rooted crops due to soil water logging</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on crop production for livelihoods</li> <li>■ poverty</li> <li>■ dominant crops in the farming systems are susceptible to soil erosion; crops not able to protect the soil from rain impact</li> <li>■ lack of weather forecasting/information</li> </ul>	<ul style="list-style-type: none"> <li>■ planting of cover crops to protect against erosion</li> <li>■ construction of culverts for drainage</li> <li>■ digging ridges along farm boundary</li> <li>■ making higher mounds (i.e. for yam) which requires more labour</li> <li>■ outmigration of men and youth to cities (coping strategy)</li> <li>■ use of water tolerant varieties (e.g. water lettuce)</li> <li>■ farmlands/river shore protection</li> </ul>
Sea level rise	<ul style="list-style-type: none"> <li>■ loss of farmland</li> <li>■ saltwater intrusion into farm lands</li> <li>■ soil becomes hard to till due to presence of clay</li> <li>■ low yield due to intolerance of saline soils</li> <li>■ low productivity</li> </ul>	<ul style="list-style-type: none"> <li>■ poverty</li> <li>■ farming on low lying plains</li> </ul>	<ul style="list-style-type: none"> <li>■ use of salt tolerant varieties (e.g. Ex-Dakar cultivar of groundnut)</li> <li>■ shore protection using sand bags</li> <li>■ land reclamation</li> </ul>
Rising temperature	<ul style="list-style-type: none"> <li>■ scorched crops as a result of excessive heat</li> <li>■ invasion of pests and diseases</li> <li>■ low crop yield</li> <li>■ reduced germination of seeds</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on crop production for income</li> <li>■ poverty</li> </ul>	<ul style="list-style-type: none"> <li>■ planting of heat tolerant and disease resistant crop varieties</li> <li>■ outmigration (coping strategy)</li> <li>■ planting trees for shade</li> <li>■ less tillage</li> </ul>
Changing rainfall patterns: occasional dryness & drought	<ul style="list-style-type: none"> <li>■ changing cropping calendar/dates</li> <li>■ late harvest</li> <li>■ increased pest incidence</li> <li>■ crop failure</li> <li>■ low yield</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on rain fed agriculture</li> <li>■ poverty</li> <li>■ dependence on crop production for income</li> <li>■ lack of access to resources on climate change trends and weather forecasting</li> </ul>	<ul style="list-style-type: none"> <li>■ outmigration of men and youth to the cities</li> <li>■ planting of drought tolerant varieties of crops, e.g. cassava varieties that are drought tolerant</li> <li>■ provision of irrigation devices which could be either hand or mechanically propelled</li> <li>■ late planting and late harvesting</li> <li>■ planting early maturing varieties</li> </ul>
Severe windstorms	<ul style="list-style-type: none"> <li>■ loss of farm assets</li> <li>■ low productivity</li> <li>■ loss of livelihood</li> </ul>	<ul style="list-style-type: none"> <li>■ lack of access to resources on climate change trends and weather forecasting</li> <li>■ dependence on crop production for income</li> </ul>	<ul style="list-style-type: none"> <li>■ early planting and early harvesting</li> <li>■ planting of trees to serve as windbreak</li> <li>■ out-migration</li> </ul>
<b>Ecozone: SAVANNAH</b>			
Changing rainfall patterns: late onset & early cessation of rain	<ul style="list-style-type: none"> <li>■ late planting of crops</li> <li>■ low germination of seeds</li> <li>■ wilting/scorching of crops</li> <li>■ low crop yield and reduced marketable surplus, reduced income</li> <li>■ late harvesting and prolonged hunger</li> </ul>	<ul style="list-style-type: none"> <li>■ poverty</li> <li>■ dependence on crop production</li> </ul>	<ul style="list-style-type: none"> <li>■ migration</li> <li>■ dependence on the market for food</li> <li>■ growing new varieties that are drought tolerant</li> </ul>
Rising temperature	<ul style="list-style-type: none"> <li>■ scorching/wilting of crops</li> <li>■ low yield</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on crop production</li> <li>■ low vegetative cover</li> </ul>	<ul style="list-style-type: none"> <li>■ planting of tree crops</li> </ul>
Severe windstorms	<ul style="list-style-type: none"> <li>■ loss of farm assets</li> <li>■ low productivity</li> <li>■ movement of sand dunes</li> <li>■ reduced pollination</li> </ul>	<ul style="list-style-type: none"> <li>■ low vegetation cover</li> <li>■ poverty</li> </ul>	<ul style="list-style-type: none"> <li>■ planting of trees as windbreaks</li> <li>■ cultivation of cover crops</li> </ul>
Changing rainfall regime/pattern	<ul style="list-style-type: none"> <li>■ affects cropping calendar</li> <li>■ lowers crop yield</li> <li>■ late harvesting</li> <li>■ drought</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on rain fed agriculture</li> <li>■ poverty</li> <li>■ dependence on crop production for income</li> <li>■ lack of access to resources on climate change trends and weather forecasting</li> </ul>	<ul style="list-style-type: none"> <li>■ use of early maturing varieties</li> <li>■ irrigation</li> <li>■ use of fadama land</li> <li>■ cultivation of residual crops like sweet potato, watermelon, sweet pepper, cucumber</li> </ul>
<b>Ecozone: SAHEL</b>			
Late onset & early cessation of rainfall	<ul style="list-style-type: none"> <li>■ late planting of crops</li> <li>■ low germination of seeds</li> <li>■ wilting/scorching of crops</li> <li>■ low crop yield and reduced marketable surplus, reduced incomes</li> <li>■ late harvesting</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on rain fed crop production</li> <li>■ dependence on crop production</li> <li>■ poverty</li> </ul>	<ul style="list-style-type: none"> <li>■ construction of dams</li> <li>■ out migration</li> <li>■ dependence on markets for food</li> </ul>
Change in rainfall pattern & distribution through the cropping season	<ul style="list-style-type: none"> <li>■ low crop yield</li> <li>■ increased cost of production through use of more inputs</li> <li>■ severe drought</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on rain fed agriculture</li> <li>■ dependence on crop production</li> </ul>	<ul style="list-style-type: none"> <li>■ construction of dams</li> <li>■ construction of waterways</li> <li>■ planting of crop varieties that are tolerant to variable rainfall patterns (soya bean, upland rice)</li> </ul>
Occasional & increased intensity of rainfall	<ul style="list-style-type: none"> <li>■ seasonal flooding</li> <li>■ loss of food crops</li> <li>■ loss of farm assets</li> <li>■ erosion</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on rain fed agriculture</li> <li>■ dependence on crop production</li> </ul>	<ul style="list-style-type: none"> <li>■ resort to irrigation</li> <li>■ use of fadama (irrigable) land</li> </ul>
Rising temperature	<ul style="list-style-type: none"> <li>■ scorching/wilting of crops</li> <li>■ low crop yield</li> <li>■ crop failure</li> <li>■ desertification</li> </ul>	<ul style="list-style-type: none"> <li>■ lack of vegetation cover</li> <li>■ poverty</li> <li>■ dependence of rain fed agriculture</li> <li>■ dependence on crop production</li> </ul>	<ul style="list-style-type: none"> <li>■ irrigation</li> <li>■ planting of trees to serve as shade</li> <li>■ shift to cultivation of heat-tolerant crops like the Ex-Borno millet, short corn variety</li> </ul>

## Review of Existing Governance, Policies & Programs

There have been a number of government policies and programmes in Nigeria intended to raise agricultural production and ensure food security, reduce poverty and supply raw materials to agro-allied industries. Some of these policies and programmes include:

- National Accelerated Food Production Programme 1972;
- Operation Feed The Nation 1976;
- River Basin Development Authorities 1976;
- Agricultural Credit Guarantee Schemes 1977;
- Green Revolution Programmes 1979;
- World Bank Assisted Agricultural Development Project 1986;
- Directorate of Foods, Roads and Rural Infrastructure 1986;
- Better Life Programme 1989;
- National Agricultural Land Development Authority 1991;
- National Fadama Development Programme 1993;
- Family Support Programme 1995;
- Family Economic Advancement Programme 1997;
- Agriculture in Nigeria: FMARD (2000); and
- National Poverty Eradication Programme 2001 (Baba, 2010).

Unfortunately, however, none of these policies and programmes specifically addressed issues related to the impacts of climate change on agriculture. To date there are no climate change adaptation plans at the federal or local government levels and only 2 of 36 states (Lagos State and Delta State) have developed climate change strategies. In addition, the majority of Nigerians have a very low awareness and understanding of the risks associated with climate change impacts.

That said, the government has recently begun to take some positive steps towards understanding and addressing climate change. For example, land degradation mapping and assessment for the prevention of erosion hazards was undertaken by the Federal Government (Nigeria Vision 20: 2020, 2009). The intent of this work is to ensure that the problem of erosion and flooding is adequately monitored using up-to-date data.

Additional activities of the federal government which have the potential to assist farmers in adapting to climate change include (Nigeria Vision, 2020, 2009; Manyong *et al.*, 2003; FMARD, 2000; FEPA, 1998):

- several flood and erosion control projects are being implemented across the nation with support from the National Ecological Fund;
- intensified implementation of the National Policy on Erosion, Flood Control and Coastal Zone Management;
- launching of awareness campaigns to control the amount of erosion in various states;
- promoting farming systems that implement natural adaptation strategies applicable to each ecological zone;
- ensure maintenance of soil quality and capability through sound management;
- developing, through research, sustainable agro-forestry techniques for the prevention and remediation of erosion and desertification;
- discouraging the cultivation of marginal lands and encouraging off farm activities;
- prescribing and regulating appropriate land preparation and agriculture mechanization techniques in collaboration with the Ministry of Agriculture;
- promoting efficient use of crop and livestock waste products;
- minimizing agricultural product losses by promoting efficient processing techniques, improved transportation infrastructure, appropriate storage facilities and efficient marketing strategies;
- encouraging the production of high yield crop varieties requiring minimum agro-chemical inputs;
- monitoring pesticide and agro-chemical residue levels in air, soil, water, sediments, flora, fauna and human, and document the environmental fate of such chemicals;
- promoting farming, using manures and other soil conditioners;

- promoting integrated pest management;
- promoting agro-forestry with multi-purpose tree species to diversify farm produce and improve the soil environment;
- collaboration with State and Local Governments for effective Agricultural Extension delivery;
- establishment of an Agricultural Insurance Scheme; and
- encouraging afforestation.

At the state level, some governments in the Coastal and Rainforest zones of Nigeria are contributing to climate change adaptation. For example, the Edo State government through its Agricultural Development Programme (ADP) has acquired and distributed agro-forestry tree seedlings to farmers in the State. The goal is to enhance agro-forestry and its benefits in the State through propagation of the high yielding improved cassava and plantain seedlings for combating losses of yield, and encouraging dry season farming through construction of micro-earth dams. The Imo State ADP is currently teaching farmers the importance of using vetiver grass to control erosion. Virtually all the State governments through their ADPs are disseminating improved and disease resistant seeds, and water tolerant cassava varieties packages to farmers.

The recommendations for state government, local government and private sector roles in ensuring increased crop production outlined in Agriculture in Nigeria: (FMARD, 2000; Manyong *et al.*, 2003) could, if implemented, make an important contribution to climate change adaptation in the agriculture sector.

For state-level government, the recommended roles include:

- promotion of primary production of all items of crop produce through the provision of a strong and effective extension service;
- promotion of the production of inputs for crops;
- ensuring access to lands by those who wish to engage in farming;
- development and management of irrigation areas associated with large dams;
- management of impounded water and downstream structures of large dams;
- promotion of appropriate farm mechanisation;
- training and manpower development;
- control of plant pests and diseases;
- promotion of appropriate institutions for administering credits to small holders;
- maintenance of buffer stocks of agricultural commodities;
- investments in rural development including rural roads and water supplies; and
- ownership, management and control of forest estates held in trust for the local communities.

Recommended roles for local governments include:

- provision of an effective agricultural extension service;
- provision of rural infrastructures; management of irrigation areas of dams;
- mobilization of farmers for accelerated agricultural and rural development through cooperative organizations, local institutions and the communities;
- provision of land for new entrants into farming in accordance with the provision of the Land Use Act; and
- coordination of data collection at the primary levels.

Recommended roles for private sector include:

- investment in all aspects of crop production;
- crop produce storage, processing and marketing;
- crop input supply and distribution;
- production of commercial seeds and seedlings under government certification and quality control;
- agricultural mechanisation;
- provision of enterprise-specific rural infrastructure; and
- support for research in all aspects of crop production.

## Recommended Climate Change Adaptation Actions

The following is a summary of climate change adaptation actions recommended for the crop sector:

- **Developing improved crop varieties** (high yielding and early maturing varieties): Government should increase support for plant breeders in developing high yielding and early maturing crop varieties to combat the problem of low crop yields posed by climate change. This could be done through training of plant breeders and partnership with foreign breeders.
- **Developing water, heat, salt, drought, and disease resistant crop varieties:** Government should increase funding for research institutes to explore the development of crop varieties resistant to climate change hazards.
- **Greater support for seed banks to ensure the proper preservation of seeds and plant seedlings to enhance viability, diversity and reduction of crop failure:** Government should establish seed banks to maintain biological diversity and provide farmers with opportunities to diversify.
- **Building systems for conveying climate information to farmers:** It is important to build early warning systems to disseminate projected weather patterns in a timely manner. This will help to increase farmers' adaptive capacity to climate change impacts e.g., through changing planting dates, crop varieties, irrigation strategies, etc. to adapt to changing conditions for crop production.
- **Greater support for crop insurance:** Government should increase support for Nigerian Agricultural Insurance Scheme (NAIS) and farmers should register with the scheme. This will help insure farmers against crop failure due to flood, erosion and drought.
- **Building crop storage and marketing facilities:** Government and the private sector should support in building crop storage facilities to reduce losses.
- **Improve rural transportation:** Government should ensure adequate transportation exists to link crop production areas with related supporting infrastructure such as markets, seed, fertilizer and pesticide sources, and extension services, etc. to improve the livelihood opportunities of farmers.
- **Improving agricultural extension services:** Extension agents are change agents in agriculture. They have the capacity to disseminate important climate change adaptation information. Therefore it is paramount to increase the number of well-trained government and NGO extension staff and provide them with the tools needed to reach farmers with training programs.
- **Addressing land degradation:** It is important to implement locally-appropriate land management techniques such as building of soil and stone bunds to control run-off during floods and increase soil moisture and reduce soil erosion and leaching; planting of vetiver grass strips, tree or hedgerow together with contour leveling to reduce runoff velocity and allow water to infiltrate and trap sediments to help control flooding and erosion; and planting cover crops for mechanical stabilization.
- **Shore sand filling, reclamation and protection:** Increasing support for coastal land protection and filling to help prevent coastal zone erosion and subsidence.
- **Irrigation:** Building of dams for irrigation to allow farmers to adopt appropriate climate change adaptation strategies in dry and drought prone areas.

**Table 3** Policies, Programs, Adaptation Options Addressed, Implementing Agency and Cost: **Crop Sub-sector**

Recommended Policy Action	Proposed CCA Program	Ecological Zone	CCA Options Addressed by Proposed Policies & Programs	Implementing Agency(s)	Cost Implication
<b>Immediate Needs</b>					
Review water management & irrigation policies & create legislation for rainwater harvesting	Comprehensive review of the River Basin Development Programme	All  Coastal zone	<ul style="list-style-type: none"> <li>■ addressing climate change induced land degradation such as erosion, flooding, &amp; desertification.</li> <li>■ construction of small dams for drip irrigation, planting cover crops</li> <li>■ shore sand filling, reclamation &amp; protection</li> </ul>	<ul style="list-style-type: none"> <li>■ Ministry of Works</li> <li>■ Ministry of Environment, River Basin Development Authorities, Communities</li> <li>■ Federal Ministry of Agriculture</li> <li>■ NGOs</li> </ul>	N1+ B
Review & revise Agricultural Research Policy, Agricultural Support Policy especially the aspects of processing, storage, agro-allied industry & rural enterprise development	Research & development programme, including biotechnology, Food Reserve Programme launched in all States of Nigeria, mainstream CCA in FADAMA programme	All	<ul style="list-style-type: none"> <li>■ developing improved crop varieties like water, heat, drought tolerant varieties</li> <li>■ developing early maturing varieties; building crop storage &amp; marketing facilities</li> </ul>	<ul style="list-style-type: none"> <li>■ Research Institutes</li> </ul>	N500 M
Create policy to develop agricultural Early Warning Systems	Programmes on needed monitoring & distribution of information supporting early warning systems for agriculture	All	<ul style="list-style-type: none"> <li>■ building on measures to institutionalize Early Warning Systems for onset of rains, drought, floods, &amp; disease outbreaks</li> </ul>	<ul style="list-style-type: none"> <li>■ Nigerian Meteorological Agency (NIMET)</li> <li>■ Ministry of Agriculture</li> </ul>	N500+ M
Comprehensive review of Agricultural Policy on Extension	Mainstream CCA in ADP programmes; encourage full private sector participation in Extension programmes	All	<ul style="list-style-type: none"> <li>■ improve agricultural extension programmes</li> </ul>	<ul style="list-style-type: none"> <li>■ Federal Ministry of Agriculture</li> <li>■ State Ministries of Agriculture</li> <li>■ Local Governments Departments of Agriculture</li> <li>■ Private sector</li> <li>■ NGOs</li> </ul>	N200 M
<b>Long Term Needs</b>					
Review & revise Agricultural	Mainstream CCA in Nigerian Agricultural Insurance Scheme, & unified Agricultural Extension Programme	All	<ul style="list-style-type: none"> <li>■ greater support for insurance companies</li> </ul>	<ul style="list-style-type: none"> <li>■ Nigerian Agricultural Insurance Corporation</li> <li>■ Central Bank of Nigeria</li> </ul>	N250 M

**Table 4** Evaluation of Proposed Policies for **Crop Sub-sector**

CCA Options Addressed by Proposed Policies & Programs	Criteria to Evaluate Effectiveness of Policy Implementation	Implications if Policy IS Implemented (individuals, communities, private sector)		Implications if Policy NOT Implemented (individuals, communities, private sector)	
		Positive Impact	Negative Impact	Positive Impact	Negative Impact
<b>Immediate Needs</b>					
Review water management & Irrigation Policy; develop legislation for rainwater harvesting	Legislation for rainwater harvesting developed & providing successful framework for revised water management & irrigation policy	Increased crop production, reduced climate change induced flood, erosion, desertification	None	None	Decreased crop production, increase risk of climate change induced flood, erosion, desertification
Review & revise Agricultural Research Policy, Agricultural Support Policy especially the aspects of processing, storage, agro-allied industry & rural enterprise development	Provision of successful framework for reviewed Agricultural Research, & Support Policies. Increased number of improved crop varieties developed & planted & number of seed banks established	Increased crop yield and reduced post-harvest losses due to extreme climate events	None	None	Decreased crop yield & increased post-harvest losses due to extreme climate events
Develop policy on Early Warning Systems on floods & disease outbreaks	Policy in place, & a number of Early Warning Systems built	Reduction in animal diseases & increased preparedness for flood and other climatic hazards	None	None	Increase in animal diseases & decreased preparedness for flood & other climatic hazards
Comprehensive review of Agricultural Policy on Extension	Provision of successful framework for revised Agricultural Policy on Extension, increased extension staff strength in the Ministry of Agriculture	Increase awareness of climate change by farmers, increased dissemination of innovations from research institutes to rural farmers, increased farm output, & reduced vulnerability to climate change impacts	None	None	Decrease awareness of climate change to farmers, decreased dissemination of innovations from research institutes to rural farmers, decreased farm output, & increased vulnerability to climate change impacts
<b>Long Term Needs</b>					
Review & revise Agricultural Policy on Insurance	Increased budgetary allocation to NAIS & increased farmers' subscription to NAIS	Reduction in risk of crop production failure	Disincentive to adopting innovations	Incentive to adoption of improved production	Increase in risk of crop production failure

## Assessment of Current and Future Trends

### Sub-sector 2: Livestock

Livestock production accounts for one third of Nigeria's agricultural GDP, providing income, employment, food, farm energy, manure, fuel and transport (Nuru, 1986). Pastoral herding is a major occupation of the people in the Sahel and parts of the savanna regions of Nigeria. Approximately 75% of all the livestock in Nigeria are in the northern region (World Bank, 1992). The livestock species are cattle, goat, sheep, camel, local poultry; other non- livestock animals are donkey, horse, and wildlife. The feeding sources are natural range lands, tree forage, and crop residues. Because of the low annual availability of feed, animals are kept partly under a transhumant system in which animals are moved shortly before the dry season to the more humid southern areas for grazing and watering.

The livestock sub-sector is affected by climate change and other environmental hazards within all ecological regions of Nigeria. The climate change hazards affecting livestock production in Nigeria include late onset of rainy season, higher than normal temperatures, flooding, salt water intrusion and windstorms. Late onset of the rainy season causes a lack of available water for livestock and reduces forage availability. Higher than normal temperatures leads to poor livestock health which reduces the market value of affected livestock thereby reducing farmers' income. Flooding leads to loss of livestock, destruction of livestock enclosures and outbreak of diseases. Windstorms impact fodder crops for livestock. Salt water intrusion leads to decline in livestock production as quality of fodder becomes poor due to salt water (Scholes, 1990,1993).

This sub-sector is vulnerable to climate change hazards because livestock farmers in Nigeria are dependent on water to provide sufficient quantity and quality of fodder from rangeland and to provide drinking water for livestock. The high levels of poverty among livestock farmers and lack of economic alternatives for farmers and their household members combine to enhance the vulnerability of the livestock sub-sector

The main economic impact of climate change on livestock production is the loss of income that sustains pastoral livelihoods. Men are predominantly involved in livestock production therefore they have greater vulnerability to climate change impacts. However women are also affected because of their role in marketing milk products and indirectly through loss of family income from livestock.

Despite the low adaptive capacity of livestock farmers to the impacts of climate change, historically they have developed strategies to cope with and adapt to a region characterized by a variable climate. Communities dependent on livestock have over time faced harsh changes in environmental conditions and are therefore aware of the need to adopt different types of coping and adaptation strategies. These strategies include the use of forage obtained from hedgerows and compound farms, application of herbs to livestock diseases, migration of male and female youth to cities in search of jobs, drilling boreholes and water harvesting (e.g. from zinc roofs).

The livestock sub-sector is particularly susceptible to climate change due to the extent that livestock depend on water for survival. Shortage of rainfall, late onset of rains and rising temperature in the Sahel and Savanna will result in declining livestock production and productivity as well as increased incidence of diseases. In the Rainforest and Coastal zones, flooding and erosion will displace livestock farmers, destroy their assets and increase disease infestation in livestock farms. This trend will ultimately reduce animal protein supply in the country as much of the livestock production in Nigeria comes from these regions.

**Table 5** Hazard- Impact-Vulnerability-Adaptation Matrix for **Livestock Sub-sector**

Climate Change Hazard	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: COASTAL/RAINFOREST</b>			
Late onset & early cessation of rainy season	<ul style="list-style-type: none"> <li>■ lack of availability of water for livestock</li> <li>■ reduced forage availability</li> </ul>	<ul style="list-style-type: none"> <li>■ high dependence on water for livestock production</li> <li>■ poverty</li> </ul>	<ul style="list-style-type: none"> <li>■ rainwater harvesting</li> <li>■ digging of boreholes</li> <li>■ use of forage obtained from hedgerows &amp; compound farms</li> <li>■ intensive livestock management</li> </ul>
Rising temperature	<ul style="list-style-type: none"> <li>■ poor livestock health which reduces the market value of affected livestock</li> <li>■ reduced farmers' income</li> <li>■ reduction in livestock production</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on livestock production</li> <li>■ poverty</li> </ul>	<ul style="list-style-type: none"> <li>■ rainwater harvesting</li> <li>■ digging of boreholes</li> <li>■ use of forage obtained from hedgerows &amp; compound farms</li> <li>■ intensive livestock management</li> </ul>
Increased intensity of rainfall	<ul style="list-style-type: none"> <li>■ loss of livestock</li> <li>■ destruction of livestock houses</li> <li>■ disease outbreaks</li> <li>■ loss of pasture land from flooding &amp; erosion</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on livestock production</li> <li>■ poverty</li> </ul>	<ul style="list-style-type: none"> <li>■ use of traditional medicine in treating livestock diseases</li> <li>■ out-migration</li> <li>■ building of culverts</li> <li>■ quarantine</li> </ul>
Severe windstorm	<ul style="list-style-type: none"> <li>■ fodder crops can be destroyed</li> <li>■ destruction of livestock houses</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on fodder from rangeland</li> <li>■ poverty</li> </ul>	<ul style="list-style-type: none"> <li>■ use of forage obtained from hedgerows &amp; compound farms</li> <li>■ plant trees to serve as windbreaks</li> </ul>
Sea level rise	<ul style="list-style-type: none"> <li>■ decline in livestock fodder &amp; pasture lands</li> </ul>	<ul style="list-style-type: none"> <li>■ same as above</li> </ul>	<ul style="list-style-type: none"> <li>■ out-migration of men &amp; male &amp; female youth to the cities</li> </ul>
<b>Ecozone: SAVANNAH</b>			
Late onset and early cessation of rainy season	<ul style="list-style-type: none"> <li>■ reduced fodder production leads to reduced livestock production</li> <li>■ lack of available water for cattle</li> <li>■ loss of pasture/rangeland for cattle</li> <li>■ heat stress</li> </ul>	<ul style="list-style-type: none"> <li>■ poverty</li> <li>■ dependence on livestock production</li> </ul>	<ul style="list-style-type: none"> <li>■ feed supplementation</li> <li>■ out-migration</li> <li>■ shift to crop production especially to production of drought tolerant crops like millet and maize</li> <li>■ drill boreholes</li> <li>■ water harvesting (zinc roofs)</li> </ul>
Rising temperature	<ul style="list-style-type: none"> <li>■ heat stress</li> <li>■ high incidence of disease</li> <li>■ reduced livestock production</li> <li>■ loss of pasture</li> </ul>	<ul style="list-style-type: none"> <li>■ poverty</li> <li>■ dependence on livestock production</li> </ul>	<ul style="list-style-type: none"> <li>■ intensive livestock management</li> <li>■ migration to Fadama sites where there is moisture</li> <li>■ migration to the forest zone</li> </ul>
Occasional increase in rainfall intensity	<ul style="list-style-type: none"> <li>■ loss of livestock</li> <li>■ destruction of livestock houses from flooding</li> <li>■ outbreak of diseases, i.e. foot rot</li> </ul>	<ul style="list-style-type: none"> <li>■ poverty</li> <li>■ dependence on livestock production</li> </ul>	<ul style="list-style-type: none"> <li>■ use of ethno-veterinary medicine for livestock</li> <li>■ selling off livestock to reduce losses</li> <li>■ diversification into mixed farming</li> </ul>
Severe windstorms	<ul style="list-style-type: none"> <li>■ fodder crops destroyed</li> <li>■ loss of pasture land</li> <li>■ destruction of livestock houses</li> <li>■ outbreak of diseases like livestock catarrh</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on fodder from rangeland</li> <li>■ poverty</li> </ul>	<ul style="list-style-type: none"> <li>■ use of ethno-veterinary medicine for livestock</li> <li>■ quarantine</li> </ul>
<b>Ecozone: SAHEL</b>			
Late onset & early cessation of rainy season	<ul style="list-style-type: none"> <li>■ drought and desertification lead to loss of rangeland/pasture for livestock</li> </ul>	<ul style="list-style-type: none"> <li>■ poverty</li> <li>■ dependence on livestock production</li> <li>■ lack of weather forecasting resources</li> </ul>	<ul style="list-style-type: none"> <li>■ transhumant migration</li> <li>■ use of animal feed</li> </ul>
Rising temperature	<ul style="list-style-type: none"> <li>■ more frequent droughts</li> <li>■ heat stress</li> <li>■ increased incidence of diseases</li> </ul>	<ul style="list-style-type: none"> <li>■ poverty</li> <li>■ dependence on livestock</li> </ul>	<ul style="list-style-type: none"> <li>■ intensive livestock management</li> <li>■ migration to Fadama sites where there is moisture</li> <li>■ migration to the forest zone</li> </ul>
Occasional increase intensity of rainfall	<ul style="list-style-type: none"> <li>■ loss of livestock</li> <li>■ destruction livestock houses</li> <li>■ outbreak of diseases like foot rot disease of cattle</li> </ul>	<ul style="list-style-type: none"> <li>■ poverty</li> <li>■ dependence on livestock production</li> </ul>	<ul style="list-style-type: none"> <li>■ use of ethno-veterinary medicine for livestock</li> <li>■ selling off livestock to reduce losses</li> <li>■ diversification into mixed farming</li> </ul>
Severe windstorms	<ul style="list-style-type: none"> <li>■ fodder crops destroyed</li> <li>■ loss of pasture lands</li> <li>■ destruction of livestock houses</li> <li>■ outbreak of diseases like livestock catarrh</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on fodder from rangeland</li> <li>■ poverty</li> </ul>	<ul style="list-style-type: none"> <li>■ vaccination</li> <li>■ use of ethno-veterinary medicine for livestock</li> <li>■ quarantine</li> <li>■ dam construction</li> </ul>

## Review of Existing Governance, Policies and Programs

The recommendations for federal, state and local government and the private sector for improving livestock production are outlined in Agriculture in Nigeria: FMARD, 2000; Manyong *et al.*, 2003). If implemented, these recommendations could make an important contribution to climate change adaptation in the agriculture sector.

Recommended roles for the federal government include:

- research and development of appropriate technology for agriculture, including biotechnology, to continually increase the yield of agricultural production as well as find markets for the products;
- establishment and maintenance of an effective and robust national animal quarantine service;
- establishment of an agricultural insurance scheme;
- collaboration with state and local governments for a well-trained and effective agricultural extension service delivery to all farmers;
- support to inputs, supply and distribution including improved breeds; and
- playing a larger role in the control of livestock pests and diseases of national and international significance.

Recommended roles for state governments include:

- promotion of all livestock products through the provision of more effective extension service;
- promotion of the production of inputs required to support livestock production;
- promotion of grazing reserve development and access to water for livestock;
- contribute to training and manpower development;
- promote the control of animal pests and diseases;
- promotion of appropriate institutions for administering credit to smallholders;
- maintenance of buffer stocks of agricultural commodities; and
- investments in rural development infrastructure including rural roads and water supplies.

Recommended roles for local governments include:

- provision of an effective agricultural extension service;
- provision of rural infrastructure;
- mobilization of farmers for accelerated agricultural and rural development through cooperative organizations, local institutions and the communities; and
- coordination of data collection at the primary levels.

Recommended roles for the private sector include:

- investment in all aspects of livestock production;
- investment in livestock product storage, processing and marketing;
- investment in livestock input supply and distribution;
- production of commercial breeds under government certification and quality control;
- provision of enterprise-specific rural infrastructure; and
- support for research in all aspects of livestock production.

## Recommended Climate Change Adaptation Actions

The following adaptation actions have been recommended for the livestock sub-sector:

- **Intensive livestock keeping:** Keeping livestock in a confinement instead of free range (extensive) will help farmers adapt to climate change impacts like disease infestation. Government, private sector, and NGOs can help livestock farmers adapt to climate change by providing soft loans needed to initiate intensive livestock production.
- **Planting trees near livestock houses and on pasture land:** This strategy will help farmers adapt to severe windstorms which are responsible for destruction of livestock houses and forage land.
- **Greater support for insurance:** Government should increase support for the Nigerian Agricultural Insurance Scheme (NAIS) and farmers should register with the

scheme. This will help farmers in the event the death of livestock due to flood, diseases and lack of water.

- **Developing improved livestock breeds:** Government should increase support for livestock breeders in developing disease resistant species.
- **Building up measures to institutionalize Early Warning Systems:** This will increase livestock farmers' ability to respond to climate related drought, flooding and disease impacts.
- **Provision of potable water for livestock:** Construction of dams, boreholes and wells are recommended to cater to the water needs of livestock management during the dry spells.
- **Construction of embankment (dikes):** This will help to reduce flooding caused by high rainfall events.
- **Culling animals:** Maintaining manageable herd size and removing diseased animals early will help reduce and control disease infestations.
- **Regular vaccination of livestock and cross border diseases surveillance:** Vaccination can help reduce infections especially for migrating animals.
- **Encourage rainwater harvesting practices:** This will help farmers adapt to shortage of water during dry spells and improve available forage on rangelands.

**Table 6** Policies, Programs, Adaptation Options Addressed, Implementing Agency and Cost for **Livestock Sub-sector**

Recommended/Suggested CCA Policy Actions	Proposed CCA Programmes	Ecozone Addressed	CCA Options Addressed by Proposed Policies and Programmes	Implementation Agency (s)	Estimated Costs
<b>Immediate Needs</b>					
Comprehensive review of national agricultural policies on pest and disease Control; agricultural credit schemes	<ul style="list-style-type: none"> <li>■ Mainstream CCA in Animal Disease Control &amp; Surveillance Programme;</li> <li>■ Comprehensive review of National Agricultural Credit Guarantee Scheme</li> </ul>	All	<ul style="list-style-type: none"> <li>■ regular vaccination of livestock and cross border diseases surveillance;</li> <li>■ culling animals;</li> <li>■ intensive livestock keeping</li> </ul>	<ul style="list-style-type: none"> <li>■ Farmer &amp; Government Agencies</li> </ul>	N200+ M
Maintenance of existing large dams & developing small dams, provision of borehole for livestock farmers' communities as a further effort in implementing National Agricultural Policy on Water Resources; Integrate rainwater harvesting awareness in Agricultural Extension Policy	<ul style="list-style-type: none"> <li>■ Mainstream CCA in River Basin Development Programmes</li> <li>■ Encourage rainwater harvesting by Agricultural Extension agents</li> </ul>	All Rainforest/ Coastal Zone	<ul style="list-style-type: none"> <li>■ provision of potable water for livestock,</li> <li>■ construction of embankments</li> <li>■ encourage rainwater harvesting practices</li> </ul>	<ul style="list-style-type: none"> <li>■ River Basin Development Authorities</li> <li>■ National Fadama Programme</li> <li>■ Communities</li> <li>■ NGOs</li> </ul>	N1+ B
Increase national coordination of Agricultural Research Policy	<ul style="list-style-type: none"> <li>■ Mainstream CCA in livestock development programme of the Federal Ministry of Agriculture</li> </ul>	All	<ul style="list-style-type: none"> <li>■ develop improved hybrids of livestock species</li> </ul>	<ul style="list-style-type: none"> <li>■ Livestock Research Institutes</li> </ul>	N500 M
Develop policy on Early Warning Systems for floods & disease outbreaks	<ul style="list-style-type: none"> <li>■ Programmes on early warning systems for floods and other climate related disasters including disease outbreaks</li> <li>■ Encourage indigenous knowledge on weather forecasting</li> </ul>	All	<ul style="list-style-type: none"> <li>■ building up measures to institutionalize Early Warning Systems for rainfall, drought, floods, &amp; disease outbreaks</li> </ul>	<ul style="list-style-type: none"> <li>■ NIMET &amp; its affiliated agencies</li> <li>■ Communities</li> </ul>	N500+ M
<b>Long term Needs</b>					
Comprehensive Review of Agricultural Policy on Insurance	<ul style="list-style-type: none"> <li>■ Mainstream CCA in Nigerian Agricultural Insurance Scheme</li> </ul>	All	<ul style="list-style-type: none"> <li>■ greater support for Insurance</li> </ul>	<ul style="list-style-type: none"> <li>■ Nigerian Agricultural Insurance Corporation</li> </ul>	N250 M

**Table 7** Evaluation of Proposed Policies for **Livestock Sub-sector**

CCA Options Addressed by Proposed Policies & Programs	Criteria to Evaluate Effectiveness of Policy Implementation	Implications if Policy IS Implemented (individuals, communities, private sector)		Implications if Policy NOT Implemented (individuals, communities, private sector)	
		Positive Impact	Negative Impact	Positive Impact	Negative Impact
<b>Immediate Needs</b>					
Comprehensive review of National Agricultural Policies on Pest and Disease Control; Agricultural Credit Schemes	Successful provision of a framework for revised National Agricultural Policy	Increased livestock production and reduction of diseases	None	None	Decreased livestock production, increased diseases
Maintenance of existing large dams & developing small dams, provision of borehole for livestock farmers' communities as a further effort in implementing National Agricultural Policy on Water Resources; Integrate rainwater harvesting awareness in Agricultural Extension Policy  Increase national coordination of Agricultural Research Policy	Number of small dams constructed  Increased number of improved livestock species	Increased livestock production  Increased livestock production & reduction of animal diseases	None  Increase in production cost	None  Decrease in production cost	Decreased livestock production  Decreased livestock production and increase in animal diseases
Developing measures to institutionalize Early Warning Systems on floods, and disease outbreaks	Number of Early Warning Systems built	Reduction in animal diseases & increased preparedness for flood and other climatic hazards	None	None	Increase in animal diseases & decreased preparedness for flood and other climatic hazards
<b>Long Term Needs</b>					
Greater support for Insurance	Increased budgetary allocation to NAIS and increased farmers' subscription to NAIS	Reduction of financial risk of livestock production	Disincentive to adopting innovations	Incentive to adoption of improved production	Increase in financial risk of livestock production

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# Climate Change Adaptation Strategy Technical Report

## Natural Resources Sector

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## Introduction to Natural Resources Sector

Nigeria's landscape of approximately 923,768 km<sup>2</sup> is made up of diverse ecological systems that include the dry savannah (Sahel), the savannah grass and woodland, the lowland and montane forests and the freshwater and coastal ecosystems. The Nigerian coastal and marine environment is bordered by an approximately 853 km stretch of coastline. This coastline is composed of barrier and lagoon ecosystems and coastal plains with a width of approximately 10 km in the west to 150 km in the eastern Niger delta.

Nigeria enjoys rich genetic and ecosystem diversity. These diverse ecosystems have different climatic systems including rainfall patterns, temperature, relative humidity, etc. which support a high diversity of plant and animal species. The total land area of Nigeria is made up of rainforest (9.6%), mangrove and coastal wetlands (1%), freshwater and inland wetlands (29.2%), savannah (48%), tree plantations (0.3%), and fallow vegetation and farmlands (20.3%) (FEPA, 1993).

Nigeria possesses more than 7,895 plant species (FME, 2008), and 22,000 species of animals including 889 species of birds and 1,489 species of micro-organisms (FEPA, 1993). The high biological diversity in Nigeria is an indication of a potentially healthy environment when properly managed (NBSAP, 2008). The climatic and geographical diversity in Nigeria are largely responsible for the high biodiversity associated with vast fresh water/swamp water forest, humid tropical forests, semi-arid and arid savanna, montane forests, seasonal flooded riparian ecosystems and coastal ecosystems. There are a number of endemic species in Nigeria such as the white throated monkey (*Cercopithecus erythrogaster*) and the Cross River gorilla. The importance of Nigeria's rich biodiversity cannot be overstated.

The country's rich natural heritage provides direct benefit through the supply of food, medicine and energy. The abundant biodiversity is required for recycling of essential elements such as carbon and nitrogen, and it is a source of genetic improvement in the sectors of agriculture and medicine. Also, intact habitats that support biodiversity play a vital role in providing ecosystem services needed for sustainable livelihoods, including moderating the climatic and environmental characteristics of the country. However much of the country's original forest cover and biodiversity have been seriously impacted by human exploitation (i.e. farming and logging), a situation that is now being exacerbated by the impacts of climate change.

In Nigeria, natural resources are seriously under threat because of a high dependence of the majority of the population on food production from rural areas, an ongoing rapid rate of population growth; poor institutional and policy framework for the management of natural resources; and limited expertise for managing natural areas that sustain biodiversity (NBSAP, 2008; USAID, 2007). Much of what once existed as natural heritage in the forest resources, biodiversity and fisheries sectors have been greatly depleted by anthropogenic actions. Uncontrolled clearing and exploitation of these resources have continued over the years as a result of population growth, overgrazing, deforestation, poverty, and competition for land for infrastructural development and settlement.

The link between natural resources and climate are twofold (Locatelli *et al.*, 2008). First, natural resources are vulnerable to the impacts of climate change. Therefore those managing and conserving natural resources will need to adapt their management methods so that forest and natural environments that sustain biodiversity can survive and continue to provide their much needed ecosystem services. Second, healthy natural resources will provide important ecosystem services that will contribute to a reduction of the vulnerability of communities to the predicted impacts of climate hazards such as sea-level rise, drought, changing rainfall patterns, warmer temperatures and extreme weather (NEST, 2003; Oladipo, 2008).

Many species in Nigeria are already at risk of extinction due to pressures arising from increasing population and growing economic wealth leading to greater demand for natural resources. Climate change is expected to add to these pressures for many threatened and vulnerable species (IPCC, 2007; Fischlin *et al.*, 2007). For example, Lake

Chad has been reduced to less than 50% of its former size. The water level in some lakes and reservoirs has been reduced by up to 11 metres. The reduced water volume of the Kainji Lake, and the Jebba and Shiroro dams has far reaching implications for native species and for an economy that depends on the hydro-electric power generated from these natural resources.

Adequate response measures, which include revising national development policies, are needed in order to reduce the vulnerability of the natural resource sector to climate change impacts to ensure these resources continue to support native biodiversity and secure livelihoods.

## Sub-sector 1: Water Resources

The importance of water to humans is summarized by the words of the ancient philosopher Pinder, "Water is life". Given that climate change will have a significant impact on water resources, Nigeria should be concerned and must plan to effectively respond to the predicted impacts.

Current and projected climate changes will impact water resources in diverse ways. An intensification of the global hydrological cycle will be characterized by an increase in the rates of evaporation and evapotranspiration, increased rainfall variability and rainfall extremes and increased variability of runoff. There will also be a rise in sea level as a result of thermal expansion of ocean water and melting of polar ice and glaciers.

All of these climate change related impacts will change the existing nature and characteristics of water resources on which humans and all biodiversity depend. The impacts may exacerbate water problems in three major ways: too much water (floods), too little water (droughts) and reduced water quality (e.g. salt water intrusion of fresh water, pollution, etc.).

### Assessment of Current and Future trends

Currently, less than 50% of the water demand of both urban and rural settlements in Nigeria is met by the available supply. In most Nigerian cities, the per capita consumption of water is less than 50 litres per day in contrast to the estimated required minimum of 115 litres per day for developed societies. Further, the water supply and demand projections for Nigeria up to 2030 by the Federal Ministry of Environment (FME) do not indicate any substantial increase in the available water for consumption in the country (see Table 1 below).

**Table 1** Per Capita Water Consumption to 2030 in Nigeria

Year	Population (million)			Water Supply (mld*)			Water Demand (mld*)		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
1996	50.7	39.6	90.5	2593.5	363	2956.7	4905.6	1596	6501.6
2000	62.8	44.7	107.5	3212.2	407.7	3619.9	6074.1	1792.5	7866.6
2005	82.1	51.6	133.7	4199.4	470.6	4670	7947.3	2069.2	10016.5
2010	107.3	59.5	166.8	5488.4	542.6	6031.1	10386.6	2386	12772.6
2015	140.3	68.5	208.6	7166.1	624.7	7730.8	13561.7	2746.9	16308.6
2020	183.5	78.9	262.4	9386	719.6	10105	17762.8	3163.9	20926.7
2025	240	90.9	330.9	12776	829	13605	23232	3645.1	26877.1
2030	313.6	104.9	418.5	16040.6	956.7	16997	30356.5	4206.5	34563

\*millions of litres per day

According to the information in the table, the per-capita water supply in 2030 will be 40.6 litres per day while the per capita water consumption for the same year will be 86.6 litres per day. In other words, only about a half of water demand will be met and this amount is well below the estimated amount of 115 litres per person per day.

Climate change can be expected to exacerbate the discrepancy between water supply and demand in both the rural and urban areas unless effective measures are put in place to avert a serious water crisis in the future. Climate change will increase the demand for water for human consumption and hygiene. This situation will be further complicated by climate change impacts that are anticipated to increase the demand for water for agriculture, particularly irrigated agriculture, as a result of increased rates of evapotranspiration, increased rainfall variability and increased incidence and severity of droughts.

In the Sahel ecozone the major climate change hazards will be increased frequency, severity and spatial extent of droughts, leading to drying up of wells, streams and water bodies as well as wetlands including *fadama* lands. Windstorms and wind erosion will increase resulting in a reduction of vegetation cover. There will also be an increase in

## Climate Change Impacts, Vulnerability and Adaptation Options

inter-annual rainfall variability leading to a decrease in the length of the growing season. Also predicted is an increase in the occurrence of flash floods from extreme rainfall events causing soil erosion and sedimentation of river channels. Finally, there will be increase in the occurrence of very high temperatures leading to heat waves and increased physiologic discomfort and heat-related ailments. This will be exacerbated by an increase in the frequency and intensity of dust haze.

In the Savanna ecozone of Nigeria the climate change hazards will be largely the same as in the Sahel ecozone but will generally be less in intensity. However, the risk of flooding, soil erosion and river sedimentation will be much higher in this zone than in the Sahel. There will also be a fall in water table as a result of decreased infiltration and over-utilization of groundwater.

In the Coastal/Rainforest ecozone, climate change hazards will include floods arising from extreme rainfall, soil erosion and silting of rivers and increase in the salinity of ground and surface water in coastal areas as a result of global-warming induced rise in sea level. Increased air temperature will cause increased physiologic discomfort as this is likely to be accompanied by increased humidity as a result of the increase in the rates of evaporation and evapotranspiration in the Forest ecozone. Increased rainfall variability will lead to uncertainty in the onset and cessation of the rainy season with consequences for agriculture. There might be the need for supplementary irrigation although not on the scale of what will be required in the Savanna and Sahel ecozones.

The impacts of the above climate change water resource hazards will manifest in various ways in the different eco-zones. In the Sahel, there will be inadequate water supply for human consumption and for livestock and farming, thus affecting many aspects of people's livelihood security. Lack of water can also affect human health, making people more vulnerable to infection by various water-related diseases such as diarrhea and cholera. Women and children who are usually in charge of fetching water for domestic use will have to travel longer distances in search of water most often from doubtful sources. Many hours will be expended on securing water to the detriment of other socio-economic and education (for children) activities and the health of the people concerned.

In the Savanna ecozone, the human impacts of the climate change hazards identified earlier will be similar to those in the Sahel ecozone although they may not be at the same intensity since the Savanna environment will not be as harsh as the Sahel environment. There will be scarcity of water for domestic use especially during the dry season which may become longer. There is also predicted to be an increase in the occurrences of floods from extreme rainfall generated by destructive rainstorms which may increase in frequency because of anticipated increase in rainfall variability.

In the Forest/Coastal ecozone, the human impacts of water-related climate change hazards will include damage to properties and farm lands by floods, loss of fish resources and other marine organisms in coastal areas as a result of sea level rise, storm surge, coastal erosion and the adverse effect on mangrove ecosystems, destruction of roads and bridges by floods, and an increase in the occurrence of water-related diseases such as malaria and diarrhea, the latter being due to lack of access of people to potable water.

Climate change adaptation to impacts on the water resources sector may involve:

- (i) measures to alter or modify the natural hydrological characteristics to suit human demands; and
- (ii) measures to alter or modify human demands to fit conditions of water availability.

Through these measures, people may improve their ability to deal with water resource problems or reduce exposure or vulnerability to the water resource hazards caused by climate change. At the individual or community level, the following adaptation strategies have been employed across the three ecological zones in Nigeria:

- To solve the problem of inadequate water supply or scarcity of water, people have resorted to the digging of *wells and boreholes* to tap the groundwater resources in all ecozones within Nigeria. Many of these wells and boreholes have been provided by governments at various levels and by non-governmental organizations (NGOs) especially in rural areas.

- *Rainwater harvesting* is commonly practiced in many areas, especially in southern Nigeria. During the rainy season, rainwater is collected and stored in underground or surface tanks for use during the succeeding dry season for mostly domestic purposes.
- In the northern parts of Nigeria the *fadama lands* around the major river valleys are used for the cultivation of wheat, potatoes, onions, pepper and other vegetables during the dry season when rain fed agriculture is not feasible. State and federal governments, especially the latter, have established large *irrigation* schemes in mostly the northern parts of Nigeria to deal with the inadequate supply of water for agriculture especially during the long dry season prevailing in these parts of the country.
- Engaging in *alternative livelihoods* that are less dependent on water is another adaptive strategy to inadequate water supply. Farmers may also change to the planting of crops that are less water demanding. Examples include the planting of millet instead of sorghum or maize and the planting of cassava instead of yams.

In many parts of Nigeria, people have adapted to water scarcity by *reducing their usage* of water for domestic purposes. This has been at the expense of their personal and environmental hygiene and is the major reason for the frequent occurrences of water-related diseases such as cholera and diarrhea in the country. Cutting water utilization for domestic purposes beyond a critical threshold results in negative health and economic impacts and is not therefore a viable adaptation strategy. Health is wealth and a sick population cannot be a productive population. Table 2 is a summary of the hazards, impacts, vulnerability and adaptation options for the water resources sector.

**Table 2** Hazard-Impact-Vulnerability-Adaptation Matrix for Natural Resources: **Water Resources Sub-sector**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: SAHEL AND SAVANNA</b>			
Sea level rise Extreme weather events: high intensity rainfall	<ul style="list-style-type: none"> <li>■ salinization of surface and groundwater in coastal areas</li> <li>■ flooding will cause water pollution, siltation of water ways, soil erosion</li> <li>■ warming of surface water</li> <li>■ scarcity of potable water</li> </ul>	<ul style="list-style-type: none"> <li>■ deforestation and intensive agriculture leading to exposed soils vulnerable to erosion</li> <li>■ population growth in rural coastal areas and reliance on agricultural lands for livelihood</li> <li>■ existing infrastructure prone to flood hazards impacts (e.g. Lagos)</li> </ul>	<ul style="list-style-type: none"> <li>■ desalinization</li> <li>■ protection of boreholes from flooding</li> </ul>
<b>Ecozone: COASTAL/RAINFOREST</b>			
Extreme weather events: high intensity rainfall, drought, windstorms, heat waves, flash floods Increased rainfall variability Increased aridity	<ul style="list-style-type: none"> <li>■ Reduction in river flow and fadama land</li> <li>■ decrease in surface and groundwater levels</li> <li>■ increased frequency of drought</li> <li>■ windstorms lead to dust haze and wind erosion</li> <li>■ drying up of water bodies and other wetlands</li> <li>■ flash floods lead to soil erosion</li> </ul>	<ul style="list-style-type: none"> <li>■ water is scarce in these ecozones even before climate change impacts</li> </ul>	<ul style="list-style-type: none"> <li>■ harvesting rainwater</li> <li>■ sink more boreholes</li> </ul>

## Review of Existing Governance, Policies and Programmes

There are existing policies and programmes for water supply and management that involve the engagement of all levels of government from local to federal. This underscores the importance attached to water resources development in the socio-economic development of Nigeria. The federal government is involved in water resources development in the country through the Federal Ministry of Water Resources and the eleven River Basin Development Authorities created by the federal government (see Decree No.35 of 1987).

The Water Resources Decree No.101 (1993) of the federal government has vested rights and control of surface and groundwater throughout the country, while state governments control water within the border of their state. Historically, water resources development in

## Recommended Climate Change Adaptation Actions

Nigeria was initially in the hands of municipal or local government authorities. When these bodies were not able to cope for financial and technical reasons, regional governments of the time took over and established water boards or water corporations as parastatals to handle water resources development mainly for domestic and industrial purposes within their area of jurisdiction. It was only in the late 1960's to early 1970's that the federal government started participating actively in water resources development in the country with the construction of large multipurpose dams for irrigation, water supply and hydro-electric power generation. Most of these dams are located in the drier northern parts of Nigeria where the water situation is most critical.

Because of the critical role of water in human affairs, other stakeholders have over the years been involved in water resources development in the country. These include both local and foreign NGOs, UNICEF, communities and individuals. These stakeholders have constructed thousands of wells and boreholes for water supply in various parts of Nigeria in both urban and rural areas. It is a well-known fact that house developers in major cities of Nigeria now construct wells or boreholes in their premises to meet their water demands. This is because state and municipal authorities can no longer meet the people's demand for water in the face of increasing population. There is an insufficient investment in water supply provision by the state governments through their various water corporations or boards which leads to this static water supply situation.

As indicated earlier, climate change will exacerbate the already poor state of water supply provision in Nigeria. Hence, there is urgent need to put in place workable adaptation strategies to avert a looming water crisis in Nigeria. The adaptation strategies suggested here are broadly categorized into two types namely those to boost or improve water supply (*supply-side adaptation*) and those to manage water demand (*demand-side adaptation*). In Nigeria, given the fact that there already exists a significant supply side deficit, the emphasis must be on supply-side adaptation. The demand-side adaptation measures are designed basically to control demand where people are already using (or misusing) large quantities of water. However, this is not the case in Nigeria where the per capita consumption of water is less than 50 litres a day, well below the estimated level of 115 litres per head per day in other societies.

The supply-side adaptation measures in the water resources sector in Nigeria should include the following options:

- Prospecting and *extraction of ground water* a comprehensive geophysical survey of the country is needed to determine the quantity, distribution and quality of Nigeria's ground water resources which have been estimated to be around 52B m<sup>3</sup>.
- *Building more dams* to increase the country's water storage capacity in the face of highly variable river flow due to climate change.
- Greater investment in *rainwater harvesting* using proven and modern methods is needed, especially in the Savanna and Coastal/Rainforest ecozones. Currently, rainwater harvesting is done by individuals on a small scale. There is need to expand rain-water storage and engage in it on a large scale. This can only be done successfully by government at local or state level that can provide adequate needed resources.
- A programme to rid our water courses of *pollution* needs to be mounted. Pollution limits the quantity of water available for our utilization. Eradication of water pollution will not only clean up the environment but will make more water available for our use.
- As a long term plan to boost the amount of water supply available to Nigeria, consideration may be given to the desalination of sea water and saline groundwater in the coastal areas of Nigeria. While *desalination of salty water* is a highly technical and expensive venture, it is currently being done in many countries of the world.
- Another long term plan that involves the modification of the hydrological cycle is *inter-basin transfer* of water. Water can be transferred through pipes from river basins in humid areas such as the south to river basins in the dry north. This is not as expensive as desalination and it would be a good way of controlling the amount of water that runs unused into the Atlantic Ocean every year. It may also assist in controlling floods in the river basins in the southern parts of the country.

The demand-side adaptation measures in the water resources sector in Nigeria will become more significant in the event of increasing scarcity of water due to climate change. Currently, there is little wastage of water in Nigeria because supply is not enough to meet the demand. The main source of current waste is in the course of distribution as a result of burst pipes that are not quickly repaired. The burst pipes usually occur due to careless road-building construction workers or because the pipes are too old and rusty and should have been replaced much earlier.

The following are some of the demand-side adaptation measures in the water resources sector in Nigeria that should be considered in addition to supply-side measures to tackle water resource problems that climate change may cause:

- Water demand for irrigation may be reduced by adopting *irrigation methods* that are water-use efficient. It is also necessary to determine, through agro-climatological studies, the most efficient timing and amount for using irrigation water.
- *Water recycling* may also be considered. In some African countries such as Botswana, Namibia and Zimbabwe, treated waste water is currently being used for domestic and irrigation purposes.
- Water demand may be controlled by *reducing water pressure* in pipes and by *instituting appropriate water rates* to discourage excessive or unnecessary use of water e.g. for watering lawns. Water rates must however take into account the income of the people to avoid the water being priced out of the reach of poor households. Willingness and ability to pay should be the critical factors in fixing water rates. The rates may be graduated, taking into account the volume of water consumed such that after a given threshold (i.e. the more the water consumed by a household), the higher the rates.
- *Water use restrictions* may be imposed during periods or in areas of water crisis. This is to ensure that water is used for the most basic human needs such as drinking cooking, washing and maintenance of basic hygiene. Water use may be restricted for gardening, swimming pools and watering of lawns during periods of water shortages.
- Finally there is need for *public engagement and education* on the need for and various methods of water conservation. Indigenous water practices that favour sustainable water use should be identified and promoted.

In all the various adaptation measures outlined above, the governments at all levels should play the leading role. Governments should also put in place the enabling environment for the participation of individuals, communities, the private sector and non-governmental organizations (NGO's). The Federal Ministry of Water Resources should be the coordinating authority. All the state ministries of water resources, the state water boards and corporations should be focal points at the state level. The federal and state governments should provide the bulk of the financial resources and technical expertise to implement feasible adaptation measures that will be selected by a competent team of experts in consultation with all stakeholders, especially the populace.

Table 3 provides an overview of the policies, programmes and adaptation options as well as the recommended Implementing Agency and associated cost.

**Table 3** Policies, Programmes, Adaptation Options Addressed, Implementing Agency and Cost:  
**Water Resources Sub-sector**

Proposed CCA Policies	Proposed CCA Programmes	Ecozone Addressed by Proposed Policies and Programmes	CCA Options Addressed by Proposed Policies and Programmes	Implementation Agency (s)	Estimated Costs
<b>Immediate Needs</b>					
<ul style="list-style-type: none"> <li>■ Prospecting and development of groundwater resources</li> </ul>	<ul style="list-style-type: none"> <li>■ Geophysical surveys to determine the quantity, quality and distribution of groundwater resources</li> </ul>	<ul style="list-style-type: none"> <li>■ All ecozones</li> </ul>	<ul style="list-style-type: none"> <li>■ Improvement of water supply</li> </ul>	<ul style="list-style-type: none"> <li>■ Federal &amp; state governments working together</li> </ul>	<ul style="list-style-type: none"> <li>■ billions of Naira</li> </ul>
<ul style="list-style-type: none"> <li>■ Expansion of water storage dams</li> </ul>	<ul style="list-style-type: none"> <li>■ Building of more water storage dams on suitable rivers</li> </ul>	<ul style="list-style-type: none"> <li>■ Sahel &amp; savanna</li> </ul>	<ul style="list-style-type: none"> <li>■ Improvement of water supply</li> </ul>	<ul style="list-style-type: none"> <li>■ Federal &amp; state governments working together</li> </ul>	<ul style="list-style-type: none"> <li>■ billions of Naira</li> </ul>
<ul style="list-style-type: none"> <li>■ Rainwater harvesting</li> </ul>	<ul style="list-style-type: none"> <li>■ Building of rainwater harvesting structures</li> </ul>	<ul style="list-style-type: none"> <li>■ Savanna &amp; rainfall/coastal zones</li> </ul>	<ul style="list-style-type: none"> <li>■ Improvement of water supply</li> </ul>	<ul style="list-style-type: none"> <li>■ State &amp; local governments</li> </ul>	<ul style="list-style-type: none"> <li>■ millions of Naira</li> </ul>
<b>Long term Needs</b>					
<ul style="list-style-type: none"> <li>■ Inter-basin water transfer</li> </ul>	<ul style="list-style-type: none"> <li>■ Transfer of water by pipes from humid river basins in the south to dry river basins in the north.</li> </ul>	<ul style="list-style-type: none"> <li>■ Water resources</li> <li>■ Sahel &amp; savanna ecozones</li> </ul>	<ul style="list-style-type: none"> <li>■ Improvement of water supply</li> </ul>	<ul style="list-style-type: none"> <li>■ Federal &amp; state governments</li> </ul>	<ul style="list-style-type: none"> <li>■ billions of naira</li> </ul>
<ul style="list-style-type: none"> <li>■ Desalination of saline water</li> </ul>	<ul style="list-style-type: none"> <li>■ Desalination of saline groundwater.</li> </ul>	<ul style="list-style-type: none"> <li>■ Water resources</li> <li>■ Coastal zone</li> </ul>	<ul style="list-style-type: none"> <li>■ Improvement of water supply</li> </ul>	<ul style="list-style-type: none"> <li>■ Federal &amp; state governments</li> </ul>	<ul style="list-style-type: none"> <li>■ billions of naira</li> </ul>
<ul style="list-style-type: none"> <li>■ Water recycling</li> </ul>	<ul style="list-style-type: none"> <li>■ Treatment of wastewater for re-use.</li> </ul>	<ul style="list-style-type: none"> <li>■ Water resources</li> <li>■ All ecozones</li> </ul>	<ul style="list-style-type: none"> <li>■ Augmentation of water supply</li> </ul>	<ul style="list-style-type: none"> <li>■ Federal &amp; state governments</li> </ul>	<ul style="list-style-type: none"> <li>■ billions of naira</li> </ul>

## Assessment of Current and Future Trends

## Sub-sector 2: Coastal Resources

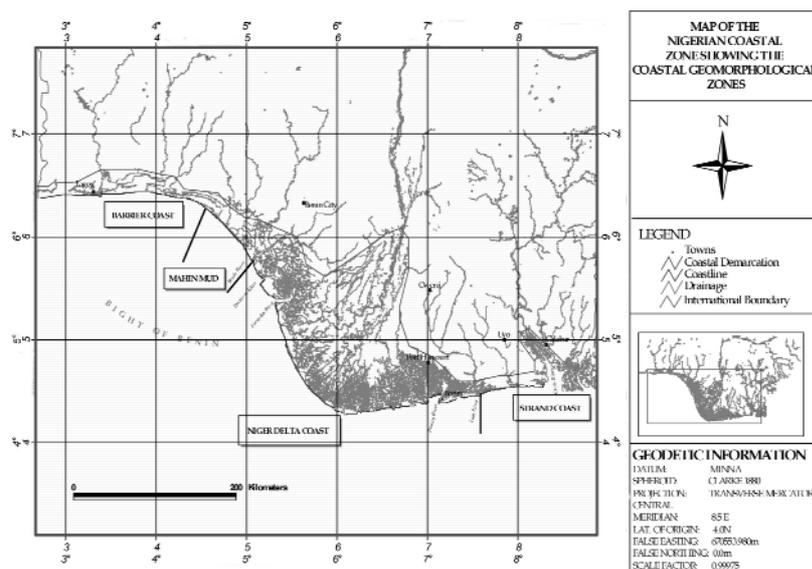
The Nigerian coastal and marine environment bordered by approximately 853 kms of coastline composed of:

- Barrier/lagoon systems and coastal plains that widen from about 10 km in the west to 150 km in the Niger delta;
- Coastal lagoons confined largely to the western part of Nigeria at Lagos, Lekki, Ologe and Mahin; and
- Estuaries, mangroves especially those of the Niger delta and coastal plains.

Geo-morphologically, the entire Nigerian coastal area is divided into four main physiographic zones, (Figure1):

1. Barrier Lagoon Coast lying between Badagry and Ajumo east of Lekki town;
2. Mahin Mud Coast lying between Ajumo and the Benin river-estuary in the north-western flank of the Niger delta;
3. Niger Delta lying between Benin river in the west and Imo river in the east; and
4. Strand Coastline lying between Imo river and the Nigerian/Cameroon border in the east with the Cross river inclusive.

**Figure 1.** Map showing the four geomorphic zones along the Nigerian coastal belt. (Awosika *et al.*, 2000)



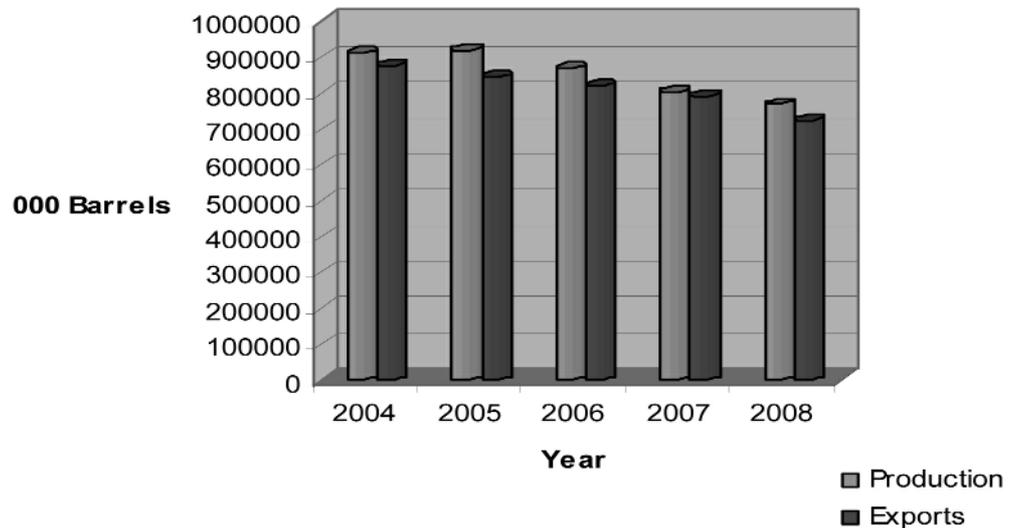
The Nigerian coastal zone harbours approximately 30 million people, about 25% of the total national population which is estimated at 120 million. Lagos, once the capital of Nigeria, remains the economic nerve centre of Nigeria with a population estimated at well over 15 million. Other coastal cities with large populations and substantial residential and commercial infrastructure include, Warri, Port Harcourt, Eket and Calabar, which are also important oil and port cities. There are also numerous rural communities that dot the entire Niger delta, some of which constitute large settlements that specialize in fishing, trading and other small-scale industries.

### Oil and Gas

Nigeria is Africa's leading oil producer and ranks in the top ten oil producers in the world. Oil and gas form the economic backbone of Nigeria generating over 90% of Nigeria's

foreign exchange earnings. Between 1967 and 1970, Nigeria's oil production rose to over 2 million barrels per day. In 1997, the Nigerian production rose to over 2.3 million barrels per day, by 2004 production and exports was about 10 million barrels per day. Coming to the present day, in 2008 production dropped to 8 million barrels per day. Offshore oil revenues represented nearly 40% of the Gross National Product (GNP) in 1974-75, and this increased to about 85% in 1979-80.

**Figure 2.** Crude oil production and export 2004 to 2008 (National Bureau of Statistics, 2009)



### Fish and Shellfish

The inshore fish resources of the Nigerian waters (0-50 metres) depth include demersal (bottom dwelling), pelagic (free swimming) and shellfish resources. The total surface area where coastal fish resources are located is estimated at 26,700 km<sup>2</sup> with a potential yield of 201,000 metric tonnes per annum for the inshore waters. Small-scale fisheries contribute between 50 and 70% of total domestic production. Shrimp resources are abundant around river mouths and lagoon entrances. Important shrimp species occurring in Nigerian waters include the pink shrimp (*Penaeus notialis*) dominant in 10 to 50 metres of water, the tiger shrimp (*Penaeus kerathurus*) and the near shore shallow coastal shrimp (*Parapenaeopsis atlantica*).

### Sand

Sand is one of the most important non-fuel resources in the Nigerian coastal zone. Sand is mined along major estuaries, lagoons, near-shore areas and along the beach. Much of the sand mined from lagoons and near-shore areas is used for nourishment of eroding beaches, for example the Bar Beach in Lagos, sand filling swamps for development, for example in the Lekki area of Lagos, and for construction of buildings and roads.

### Mangroves

Most of the nation's fragile mangrove ecosystems are to be found in the Niger delta area especially between the Benin and Cross-River estuaries. The mangrove vegetation in this zone occupies an area of about 7,500 km<sup>2</sup> in a belt 30 to 40 km wide.

The red mangroves (*Rhizophora racemosa*) make up about 90% of the vegetation of the mangrove ecosystem. Other species present are *R. harrisonii*, *R. mangle* and the white mangrove (*Avicennia nitida*).

Climate change and concomitant sea level rise have been shown to have adverse effects on coastal areas especially low lying areas. Even a small amount of rise in sea level can have the following profound effects:

- Coastal flooding and storm damage;
- Eroding shorelines;
- Salt water contamination of fresh water supplies ; and
- Flooding of coastal wetlands, barrier islands and agricultural lands.

## Climate Change Hazards and Impacts

Approximately one metre of land could be lost with every centimetre rise in sea level. The consequences will be:

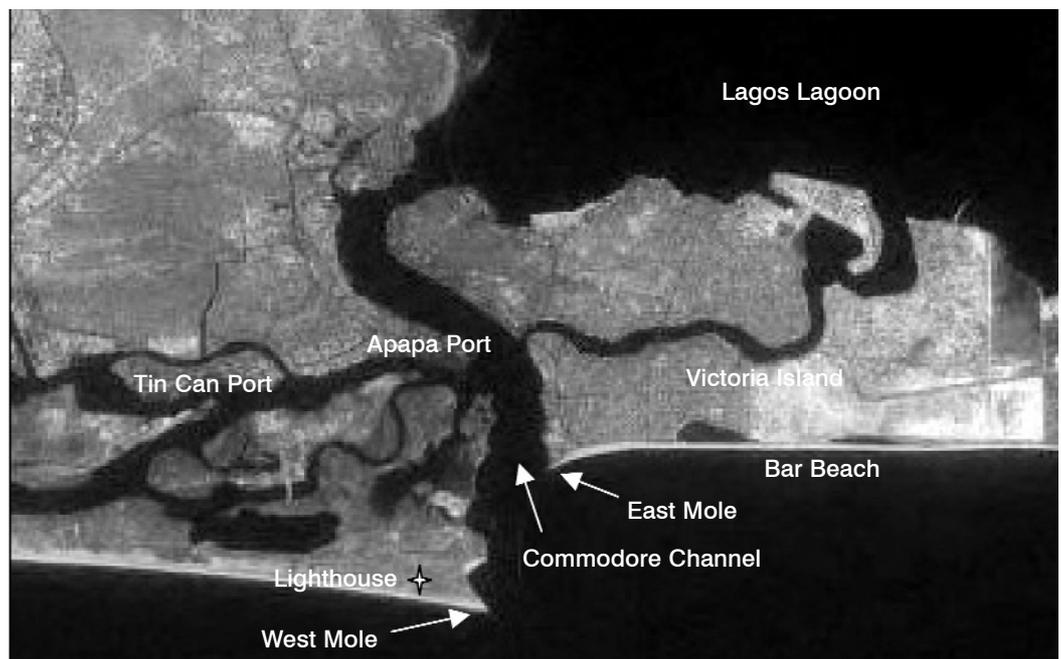
- Death and spread of diseases due to extensive floods and challenges faced in evacuating huge numbers of people;
- Reduced availability of fresh water which will further affect human health;
- Changes in salinity are likely to cause the loss of important biological communities;
- Thousands of species of fish and wildlife which thrive in the coastal areas will be threatened. These species are crucial for the regional economy, culture and quality of life;
- Healthy coastal habitats, which protect coastal settlements from the effects of hurricanes and flooding, are in danger because of potential sea level rise; and
- Salt marshes and mangroves, being closest to the sea level, are particularly in danger. Sea rise will erode the outer boundaries of these wetlands, and with the flooding of dry areas by higher water levels, new wetlands will form inland.

The Nigerian coastal and marine area constitutes an important socio-economic nerve center for Nigeria. Sea level rise could cause large-scale inundation and exacerbate coastal erosion and salt water intrusion into coastal aquifer in the Nigerian coastal zone. Other adverse effects of sea level rise on the Nigerian coastal zone (Awosika *et al.*, 1992 and 1993) indicate increased salinisation of both ground and surface water leading to death of flora and fauna that cannot tolerate high salinity. This will adversely affect coastal agriculture, water supply as well as coastal industries and energy supply (Awosika, 1995).

### Ports and Harbours

The Nigerian coastal zone has six large ports: Apapa, Tin Can, Koko, Warri, Port Harcourt and Calabar ports. These ports are located in very fragile coastal ecosystems which experience flooding and erosion. All these ports have protecting structural facilities that were built to protect them from silting up or from the action of waves. In particular, the east and west moles (see Figure 3) were built between 1908 and 1912 to protect the ports from waves and silt. The moles also serve to trap sediments on the up-drift beach (the Lighthouse beach) and thereby stop the silting up of the Commodore channel entrance. This has resulted in accretion of the up-drift Lighthouse beach and erosion on the down-drift Bar beach. Erosion rates at Bar Beach are very serious, averaging 25 to 30 metres per year (Ibe, 1988). Sea level rise will exacerbate erosion and flooding, destabilize the moles, flood port facilities and coastal infrastructures and disrupt socio economic activities.

**Figure 3.** Satellite imagery of Lagos showing the ports and the Bar Beach (Victoria Island) which is eroding due to the construction of moles



## Flooding and Inundation

The low-lying topography of the coastal areas of Nigeria makes the coastline highly susceptible to flooding by the waves and storm surges especially during astronomical high tides (i.e. "perigean" spring tides when both the Sun and the Moon are closest to the Earth). Results from a study on drainage systems and sea level rise in Victoria and Ikoyi Islands Lagos (Awosika *et al.*, 2000) revealed that many huge drainage channels and smaller channels built several decades ago serve as receptacles for surface runoff into the Lagos lagoon or the Kuramo waters. However, because of siltation, many of these drainage channels are no longer as effective in draining water away into the lagoons. Rising sea levels, increased rainstorm intensity and duration, and ocean storm surges associated with astronomical high tides are now making these drainage channels completely ineffective. Currently during extreme events, this results in the backup of runoff in the drainage channels and eventual flooding of the islands. Such occurrences are most apparent and disastrous during the rainy season, when heavy rain events, storm surges and astronomical high tides coincide.

The assessment also found out that over 18,000 km<sup>2</sup> or 2 of the Nigerian coastal zone and about 3.68 million people are at risk of a predicted one metre sea level rise (Awosika *et al.*, 1992, Nicholls *et al.*, 1993) (see Table 4). Even with no climate change induced acceleration in sea level rise (i.e. only 0.2 m rise) Nigeria could lose over 3,000 km<sup>2</sup> of coastal land by the end of the next century.

## Coastal Erosion

Using earlier Intergovernmental Panel on Climate Change (IPCC) scenarios of 0.2, 0.5, 1.0 and 2.0 metre sea level rises by the year 2100, the impacts of sea level rise were assessed in a study conducted in 1993 (Awosika *et al.*, 1993). This assessment showed that the barrier lagoon coastline in the western extremity with the associated high value real estate on Victoria Island and in Lekki could lose over 600 km<sup>2</sup> of land due to erosion while inundation could completely submerge the Lekki barrier system (Table 4).

**Table 4** Total land loss (km<sup>2</sup> by shoreline type) due to erosion and inundation by different IPCC scenarios. (Awosika *et al.*, 1993).

Coastline Type	Low estimates of land loss due to sea level rise				High estimates of land loss due to sea level			
	0.2m	0.5m	1.0m	2.0m	0.2m	0.5.m	1.0m	2.0m
Barrier	177	284	584	1,167	118	289	602	1,204
Mud	403	1,008	2,016	3,456	403	1,008	2,016	3,456
Delta	2,846	7,453	15,125	18,398	2,865	7,500	15,332	18,803
Strand	79	197	395	575	85	212	446	677
<b>Totals</b>	<b>3,445</b>	<b>8,942</b>	<b>18,120</b>	<b>23,596</b>	<b>3,471</b>	<b>9,009</b>	<b>18,396</b>	<b>24,140</b>

Such adverse impacts will affect the residential, commercial and tourist facilities on the Nigerian coastal zone especially those of the Victoria, Ikoyi and Lagos islands as well as the port facilities valued at well over US \$12 billion.

## Salinisation

Other adverse effects of sea level rise on the Nigerian coastal zone as earlier assessed by Awosika *et al.*, (1992 and 1993) indicate increased salinisation of both ground and surface water leading to death of flora and fauna that cannot tolerate high salinity. This will also adversely affect coastal agriculture, water supply as well as coastal industries that rely on freshwater (Awosika, 1995). The intrusion of saline water into groundwater supplies is likely to adversely affect water quality which could impose enormous costs on water treatment infrastructure.

## Health-related Risks

Climate variability and change can affect health directly and indirectly. Climate change impacts resulting in flooding can lead to a contamination of potable water that in turn leads to an increase in water and food-borne diseases. Indirect impacts of climate change in the coastal zone include environmental health problems due to changes in geographic ranges and incidence of vector-borne and infectious diseases, allergic and respiratory disorders, nutritional disorders as a result of climate-related food shortages, as well as the physical damages and institutional strains imposed on the health care system.

An increased frequency and severity of heat waves is expected, leading to more illness and death, particularly among the young, elderly, frail, and poor. In many cases, the urban heat island effect will exacerbate heat waves leading to higher urban heat-related mortality. High temperatures, high air pollution, high population, lack of infrastructure (electricity, air conditioning, housing, water, etc.) can interact to result in additional health impacts.

### Impacts on the Petroleum Industry

Oil and gas constitute Nigeria's main source of foreign exchange earnings. The related sectors of the oil industry also form a major part of the economy. Almost all of these industries are located within the coastal zone. With sea level rise, most petrochemical industrial installations concentrated along the coastal zones as offshore and onshore installations in Nigeria are seriously threatened by sea level rise. According to Mr. Mohammed Barkindo, former acting secretary general of the Organisation of Petroleum Exporting Countries (OPEC) accelerated sea level rise associated with climate change poses a significant threat to all these installations and should extreme climate change scenarios occur the resulting hazards associated with sea level rise will include loss of human life and irreparable damage to all Nigeria's oil installations. In addition to the human calamities, this will also affect the country's foreign earnings which will in turn affect the country's economic performance both in the short- and the long-term.

### Impacts on Agriculture

Although coastal areas are not part of the major agricultural zone in Nigeria, there are local subsistence farming communities with upland farms and paddy rice plantations. Sea level rise and concomitant inundation of these agricultural areas will lead to an increase in salinity of the soil, thus having a negative effect on agriculture. Plants that cannot tolerate high salinity will die, some which may be subsistence crops which serve as food for local communities, thereby raising food insecurity and poverty level.

### Impacts Fisheries

The coastal zone supplies almost 90% of Nigeria's fish supply. Artisanal fishermen (i.e. small scale, low technology) live very close to shore for easy access to the sea. With rising sea levels, many fishing communities will be flooded thereby affecting the livelihoods of local fishermen. As a result, these fishermen may be forced to move inland which will be costly and therefore will raise the poverty levels of fishermen.

## Mitigation and Adaptation Options

The responses required to protect human life and property from climate change and sea level rise fall broadly into three categories as follows:

1. **Retreat:** this involves no effort to protect the land from the sea. The coastal zone is abandoned and areas of human habitation, infrastructure and natural ecosystems shift landward. This choice can be motivated by excessive economic costs or environmental impacts of protection. Thus, the most severely impacted areas may be abandoned. Assuming that land for settlement is available, retreat can be implemented through anticipatory land use regulations, building codes, or economic incentives.
2. **Accommodation:** this implies that people continue to use the land at risk but do not attempt to prevent the land from being flooded. This option includes erecting emergency flood shelters, elevating buildings on piles, converting agriculture to fish farming, or growing flood or salt tolerant crops. Accommodation may evolve without governmental action, but could be assisted by strengthening flood preparation and flood insurance programmes.
3. **Protection:** this involves hard structures such as sea walls and dykes, as well as soft solutions such as dunes and vegetation, to protect the land from the sea so that existing land uses can continue. The appropriate mechanism for implementation depends on the particular response. Protection can be implemented by the authorities currently responsible for water resources and coastal protection.

Adaptation options to climate change and sea level rise require education, provision of new and improved infrastructure, enhancement of management skills and research to collate and analyze historical climate data and associated meta data on oceans (such as

measurements of currents, waves, sea level and meteorological variables). Specific areas of intervention to address adaptation options in Nigeria involve:

- Developing human and infrastructural capacity to address flooding, salt water intrusion and coastal erosion;
- Building human capacity to conduct research into land-ocean interaction that will identify the impacts of climate change variability and extremes on the Nigerian coastal socio-economic and ecological systems;
- Strengthening of national and local research communities' capacity for assessment of the impacts of climate change variability and extremes for the identification and assessment of adaptive responses;
- Strengthening national capacity by developing and implementing Integrated Coastal/Fresh Water Area Management plans and policies; and
- Developing capacity for modeling, evaluating and designing physical structures (e.g. groins, breakwaters, dykes, and sea walls) to combat sporadic flooding and coastal erosion.

These adaptation options involve financial resources and human and infrastructural facilities through international assistance, cooperation and sponsorship.

For a review of recommended climate change adaptation actions, see Table 5 and Table 6 below.

## **Recommended Climate Change Adaptation Actions**

**Table 5** Hazard-Impacts-Vulnerability-Adaptation Options Matrix for Natural Resources: **Coastal Resources Sub-sector**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: COASTAL</b>			
Storm surge events & long term sea level rise	<ul style="list-style-type: none"> <li>■ oil &amp; gas platforms damaged by intense wave activity</li> <li>■ oil and gas platform workers at risk</li> <li>■ release of oil/gas if platforms damaged</li> <li>■ impact of economy if platforms damaged</li> </ul>	<ul style="list-style-type: none"> <li>■ oil &amp; gas infrastructure is exposed to the elements</li> <li>■ women vulnerable due to their dependence on work related to servicing oil &amp; gas industry</li> <li>■ proximity of sensitive coastal environments</li> <li>■ potential impact of climate induced pollution on fish resources</li> <li>■ low level of preparedness of oil and gas industry for disaster</li> <li>■ lack of ability to predict storm surge events</li> </ul>	<ul style="list-style-type: none"> <li>■ reinforce &amp;/or replace older coastal and sea surge protection structures</li> <li>■ develop &amp; install new protection structures</li> <li>■ improve monitoring of sea and weather conditions for early warning, shutting operations down &amp; moving workers to safety during extreme weather events</li> </ul>
Storm surge events & long term sea level rise	<ul style="list-style-type: none"> <li>■ removes &amp;/or moves sand resources</li> <li>■ weakens coastal infrastructure (e.g. bridges, jetties, etc.)</li> </ul>	<ul style="list-style-type: none"> <li>■ sand supply has been reduced due to dams upstream on rivers</li> <li>■ fishing communities located on coast exposed</li> <li>■ lack of government support for communities and infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>■ stop sand mining in coastal areas</li> <li>■ have seasonal closures of sand mining to allow resource to recuperate</li> </ul>
Storm surge events & long term sea level rise	<ul style="list-style-type: none"> <li>■ sand deposition from storm surges block navigation routes</li> <li>■ coastal settlements eroded &amp; must migrate inland</li> </ul>	<ul style="list-style-type: none"> <li>■ infrastructure built on sand cannot be supported when sand eroded at the foundation</li> </ul>	<ul style="list-style-type: none"> <li>■ develop building standards that are appropriate &amp; can withstand natural cycles of erosion</li> <li>■ release water from dams located on rivers to provide greater sand supply to coastal areas</li> </ul>
Storm surge events & long term sea level rise	<ul style="list-style-type: none"> <li>■ mangrove and coastal swamp ecosystem experience changes in salinity with resulting impacts to biodiversity and fish &amp; shellfish resources</li> <li>■ mangroves &amp;/or other coastal vegetation degrades exposing more coastline to erosion</li> <li>■ degraded ecosystems invaded by non-native species such as Nipa palm</li> </ul>	<ul style="list-style-type: none"> <li>■ important fish spawning sites associated with coastal vegetation communities</li> <li>■ coastal ecosystems not capable of changing (i.e. new species assemblages forming) at a rate fast enough to adapt to climate induced changes</li> </ul>	<ul style="list-style-type: none"> <li>■ reduce the destruction of coastal vegetation that occurs during oil and gas exploration</li> <li>■ restore degraded ecosystems</li> <li>■ control invasive non-native species</li> </ul>
Storm surge events & long term sea level rise	<ul style="list-style-type: none"> <li>■ flooding &amp; inundation of coastal communities</li> <li>■ disruption of socio-economic activities of coastal communities</li> <li>■ destruction of rural &amp; urban infrastructure that support communities</li> <li>■ destruction of farms &amp; aquaculture in areas impacted by storm surge</li> <li>■ increase in water borne &amp; water related diseases</li> </ul>	<ul style="list-style-type: none"> <li>■ coastal communities are particularly vulnerable to flooding due to the interaction between predicted sea level rise &amp; storm surge exacerbated by the release of water from dams upstream from coastal areas that are unable to contain extreme rainfall events that occur inland</li> <li>■ roads have been built to close to coastal areas &amp;/or in low lying areas</li> <li>■ communities are located in low lying areas</li> <li>■ urban areas fill wetlands that provide flood storage during extreme events</li> </ul>	<ul style="list-style-type: none"> <li>■ early warning systems to make communities aware of storm surges &amp; the potential of flooding from inland areas</li> <li>■ improved floodwater management systems</li> <li>■ introduction of flood bypass systems to direct floodwater around communities</li> </ul>

**Table 6** Policies, Programmes, Adaptation Options Addressed, Implementing Agency and Cost:  
**Coastal Resources Sub-sector**

Proposed CCA Policies	Proposed CCA Programmes	Ecozone Addressed by Proposed Policies and Programmes	CCA Options Addressed by Proposed Policies and Programmes	Implementation Agency (s)	Estimated Costs
<b>Immediate Needs</b>					
<ul style="list-style-type: none"> <li>■ Review of existing oil &amp; gas industry policies</li> <li>■ New policies for sand mining</li> </ul>	<ul style="list-style-type: none"> <li>■ Review to ensure climate proofing</li> <li>■ Improved training &amp; enforcement of policies</li> </ul>	<ul style="list-style-type: none"> <li>■ Coastal ecozone</li> </ul>	<ul style="list-style-type: none"> <li>■ reduce the destruction of coastal vegetation due to oil &amp; gas industry</li> </ul>	<ul style="list-style-type: none"> <li>■ Department of Petroleum Resources (DPR)</li> </ul>	<ul style="list-style-type: none"> <li>■ Monitoring low cost</li> <li>■ Strengthening of existing infrastructure high cost</li> </ul>
<ul style="list-style-type: none"> <li>■ Follow through on NIOMR's existing mandate to monitor coastal erosion</li> </ul>	<ul style="list-style-type: none"> <li>■ Need to access funds to implement monitoring program</li> </ul>	<ul style="list-style-type: none"> <li>■ Coastal ecozone</li> </ul>	<ul style="list-style-type: none"> <li>■ Identify most vulnerable coastal areas</li> <li>■ Raise awareness of coastal erosion issues</li> </ul>	<ul style="list-style-type: none"> <li>■ NIOMR under Ministry of Agriculture</li> </ul>	<ul style="list-style-type: none"> <li>■ 15 million Naira per year</li> </ul>
<ul style="list-style-type: none"> <li>■ Implement coastal erosion protection programmes of Ministry of Environment</li> </ul>	<ul style="list-style-type: none"> <li>■ Work with NIOMR on monitoring &amp; identification of existing coastal protection needs</li> <li>■ Construct physical infrastructure needed to protect coastal environments</li> </ul>	<ul style="list-style-type: none"> <li>■ Coastal ecozone</li> </ul>	<ul style="list-style-type: none"> <li>■ Identification of areas that are most in need of protection &amp; areas that can accommodate future predicted sea level rise</li> </ul>	<ul style="list-style-type: none"> <li>■ NIOMR &amp; Ministry of Environment</li> </ul>	<ul style="list-style-type: none"> <li>■ Infrastructure construction costs high</li> </ul>
<ul style="list-style-type: none"> <li>■ New policies for sand mining</li> </ul>	<ul style="list-style-type: none"> <li>■ Develop agency to regulate &amp; prosecute sand mining infractions</li> <li>■ More frequent and larger volume water releases from upstream dams to increase sand supply in coastal areas</li> <li>■ Dredging of shipping channels (Lagos Commodore Channel, Port Harcourt Escravos Oil Terminal)</li> </ul>	<ul style="list-style-type: none"> <li>■ Coastal ecozone</li> </ul>	<ul style="list-style-type: none"> <li>■ stop &amp;/or seasonal closures of sand mining</li> <li>■ release water from dams located on rivers to provide greater sand supply to coastal areas</li> </ul>	<ul style="list-style-type: none"> <li>■ Ministry of the Environment</li> </ul>	<ul style="list-style-type: none"> <li>■ low</li> </ul>
<ul style="list-style-type: none"> <li>■ Federal, State &amp; Urban (Local Government) planning guidelines that address climate change hazards, impacts, vulnerability &amp; adaptation options</li> </ul>	<ul style="list-style-type: none"> <li>■ Resolve Federal and State conflicts in regard to roles &amp; responsibilities</li> <li>■ Identify existing urban development &amp; infrastructure located in areas at risk</li> <li>■ Develop relocation plans for people &amp; infrastructure at risk</li> </ul>	<ul style="list-style-type: none"> <li>■ Coastal ecozone</li> </ul>	<ul style="list-style-type: none"> <li>■ early warning systems to make communities aware of storm surges &amp; the potential of flooding from inland areas</li> <li>■ improved floodwater management systems</li> <li>■ introduction of flood bypass systems to direct floodwater around communities</li> </ul>	<ul style="list-style-type: none"> <li>■ Federal, State &amp; Urban/Local Government planning authorities</li> </ul>	<ul style="list-style-type: none"> <li>■ high</li> </ul>
<b>Long term Needs</b>					
<ul style="list-style-type: none"> <li>■ Policy for early warning of extreme events (storm surge, high rainfall, etc.)</li> </ul>	<ul style="list-style-type: none"> <li>■ Early warning system for coastal communities as well as oil &amp; gas industries working in coastal environments</li> </ul>	<ul style="list-style-type: none"> <li>■ Coastal ecozone</li> </ul>	<ul style="list-style-type: none"> <li>■ early warning systems to make communities aware of storm surges and the potential of flooding from inland areas</li> <li>■ introduction of flood bypass systems to direct floodwater around communities</li> </ul>	<ul style="list-style-type: none"> <li>■ Nigerian Energy Management Agency (NEMA)</li> <li>■ NIOMR</li> <li>■ NIMET</li> <li>■ Ministry of Communications</li> <li>■ Ministry of Ports &amp; Harbours</li> <li>■ Ministry of Aviation</li> <li>■ River Basins Authority</li> </ul>	<ul style="list-style-type: none"> <li>■ high</li> </ul>
<ul style="list-style-type: none"> <li>■ Ongoing review of policies as knowledge of hazards, impacts and adaptation options progresses</li> </ul>	<ul style="list-style-type: none"> <li>■ Form inter-ministerial committee to oversee review of climate change policies</li> </ul>	<ul style="list-style-type: none"> <li>■ Coastal ecozone</li> </ul>	<ul style="list-style-type: none"> <li>■ improved floodwater management systems</li> </ul>	<ul style="list-style-type: none"> <li>■ Ministry of Environment</li> <li>■ Ministry of Ports &amp; Harbours</li> <li>■ Nigerian Maritime Agency (NIMASA)</li> <li>■ NIOMR</li> </ul>	<ul style="list-style-type: none"> <li>■ high</li> </ul>

## Sub-sector 3: Forestry and Biodiversity Resources

### Assessment of Current and Future Trends

Forest resources in Nigeria have undergone changes from both natural and human-induced processes. Global climate change is introducing new challenges that are having a significant negative impact on this natural resource and weakening its capacity to provide critical ecological resources and services.

The primary climate change hazards that affect the forestry sub-sector include:

- Land use change and Deforestation;
- Drought;
- Flooding of low-lying landscapes;
- Erosion;
- Sea level rise;
- Changes in precipitation;
- Warmer temperatures; and
- Greater intensity and frequency of wildfires.

A discussion of these climate change hazards in the forestry sub-sector is provided below.

Forest lands are being decimated in Nigeria at the rate of 350,000 to 400,000 hectares annually (FME, 2006). The alarming rate of conversion of forest vegetation into other land uses such as human settlements, arable farming and infrastructural development is not sustainable in Nigeria. In addition, the loss of forested land is one of the drivers of climate change (IPCC, 2007; Johnston and Williamson, 2007). As land productivity declines, the needs of people are met by utilizing and potentially degrading larger areas of forested land in order to meet basic needs for timber, fuel wood, medicine or for occupation, etc. An increasing rate of land use change is causing deforestation and limiting the ability of the forest system in Nigeria to meet human needs and provide ecological services including acting as a carbon sink.

Drought has been reported globally as among the climatic hazards that would reduce the potentials of forest resources (IPCC, 2006; Locatelli *et al.*, 2008). In Nigeria, drought is a recurring event, particularly in many northern states where there may be longer than normal dry seasons, reduced quantity of annual rainfall and a lowering of the groundwater table. States most affected by drought include Sokoto, Kebbi, Taraba, Niger, Kano, Kaduna, Adamawa, Yobe, Jigawa, Borno, Zamfara and Bauchi States (NBSAP, 2008). All levels of government currently have programmes that mobilize human and economic resources to combat desertification in drought-prone areas of Nigeria. Drought is often the final blow to government Forest Reserves in the northern part of Nigeria (including over 42,000 km<sup>2</sup> of land). These lands are already degraded by encroachment and poor management, resulting in the loss of some of the only remaining areas of forest cover that provide habitat for native plant and animal species (FME, 2006).

A very significant proportion of Nigeria's remaining forest resources is present as lowland forests, fresh water swamp forests and mangrove forests, typically located in low lying and wetland areas of Nigeria (Ayodele, 1992; FME, 2006). These forests are now more frequently flooded for a longer period of time each year as a result of more extreme rainfall events. There have been reports of changing forest structure and function, changes in species distribution, inhibited soil biological activity and suppression of root development as a result of flooding of forest ecosystems (Locatelli *et al.*, 2008). Therefore the impact of flooding on forests is emerging as a significant climate change adaptation and management challenge to forest development in Nigeria due to the changing pattern of rainfall and sea level rise.

Land degradation as result of increasing erosion has had a significant impact on forestry throughout the entire south and eastern parts of Nigeria. According to NEST (2003), such erosion includes sheet, gully and coastal erosion. There are over 600 active gully erosion sites in Abia, Anambra and Imo states. Other states such as Akwa Ibom, Cross River, Delta, Bayelsa and Ondo also face severe problems of coastal erosion (Ojo, 2008). Erosion also produces silt deposits in communities and ecosystems downstream which can, in some cases, affect riparian forests.

Climate change is causing a global rise in sea level resulting in the intrusion of salt water into freshwater bodies, thus increasing the salinity of the soils in the coastal zone. According to IPCC reports, the earth's temperature is expected to rise by 1.4° to 5.8°C leading to an associated sea level rise of 9 to 88 cm. In Nigeria, sea level rise is bringing about shifts in ecological boundaries of coastal ecosystems of the mangrove, swamp forest and tropical high forest. Changes in salinity ultimately negatively transform ecosystems and their associated species composition (Locatelli, 2008).

Forest ecosystems are highly sensitive to changes in precipitation (Hilbert *et al.* 2001; Hughen *et al.* 2004). There is evidence of change in the onset and cessation of the rainy season, as well as the intensity and duration of rainfall events in all parts of Nigeria (NEST, 2003). These changes can affect the physiological and migratory pattern of some species. According to Malcolm *et al.* (2006), changes in the precipitation pattern affect the structure and function of forest ecosystems and ecological interactions among species.

Climate change is resulting in warming surface temperatures that affect the rate and patterns of physiological processes in forest ecosystem including increased photosynthetic and respiration rates and reduced flowering. In a study of tropical rainforests, Hilbert *et al.* (2001) reported that a 1°C warming has the potential to significantly affect the distribution of forest species. Increased surface temperatures are also predicted to increase the incidence of forest pests and diseases leading to increased mortality of species.

According to the Federal Ministry of the Environment (2006), uncontrolled forest fire is one of the most destructive factors causing the depletion and degradation of forest resources. Wildfires have become more frequent and intense partly as a result of increased temperatures. The area of forest resources destroyed annually by wildfires is increasing, in part, because of the dryness of the vegetation caused by changes in rainfall and temperature patterns.

## Climate Change Impacts, Vulnerability and Adaptation Options

### Climate Change Impacts

The impacts of climate change on the forestry sector include:

- Increased rate of habitat loss;
- Effect on flowering behavior of forest species;
- Changes in specialized habitats;
- Changes in migration pattern of animals;
- Changes in distribution of forest species;
- Pest and disease outbreak;
- Loss of regenerating forest species;
- Increased rate of development of erosion gullies;
- Increased salinity as result of salt water intrusion;
- Prevalence of wild fires;
- Declining availability of fuel wood and non-timber forest products; and
- Invasion by new species

These impacts are described in more detail below.

Climate change brings about loss of habitat and soil fertility caused by increased erosion. Frequent and severe drought has increased the rate of vegetation loss in northern part of Nigeria leading to increased conversion of forests by rural farming communities to meet their needs for wood and arable farmland.

As patterns of temperature and rainfall change, changes are introduced in the flowering behavior of forest species and physiological processes of plants and animals. Changes in physiological processes can alter reproductive patterns and dispersal of species which are known to cause disappearance of some forest species as well as change the type and quality of forest resources.

Some forest ecosystems are highly specialized, such as the montane forests of the Mambilla Plateau and Obudu montane forests, as they function within relatively narrow climatic normals. These fragile ecosystems are very vulnerable to the impact of climate change (Pounds *et al.*, 1999; Loope and Giambelluca, 1998).

Many wildlife species undertake routine annual migration for the purpose of reproduction or in response to weather and climate changes. Climate change is expected to affect the pattern of migration of these species which will in turn affect their survival, life expectancy and ecological function. For example drought conditions and reduced ground water volume are capable of forcing migration of wildlife species which could expose them to dangers outside their natural habitat range.

Climate is a major determinant of tree distribution. As rainfall pattern, relative humidity and temperatures change, there are concurrent shifts in the distribution of vegetation. This is evident in the movement of the savannah southwards which is altering the distribution of forest ecosystems from rainforest to tropical dry forests and woodlands. Some species that have a relatively narrow geographical range are driven into extinction while other exotic species with a large ecological amplitude are recruited into new habitats thereby altering the ecological balance in forests.

Climate-related changes in relative humidity, temperature and pattern of rainfall are predicted to introduce conditions that favour the development of pest and diseases, some of which are already being seen in some new locations (IPCC, 2007). Also, a changing climate introduces new species, some of which are pests, while some others may bring pests along with them. In addition, climate change impacts may create additional stressors that will cause some native forest species to become less resistant to invading pests and disease.

The establishment phase for tree seedlings and saplings can be difficult. The impact of climate change may create conditions (e.g. drought, variable rainfall, erosion, flooding, etc.) that may preclude the survival of trees during regeneration or re-planting for plantations or restoration (HBF, 2008).

In the coastal, rainforest and savanna regions there are reports of increased soil erosion and the formation of gullies (BNRCC, 2010). These impacts result in the direct loss of forests, decline in productivity and fragmentation of forest ecosystems.

Coastal woodlands and low lying swamp forests wetlands are being inundated with a surge of saline water from the sea. Tree species in these ecosystems have specific ecological tolerance and cannot survive when the natural features of their habitat are altered (IPCC, 2007).

The prevalence of forest fires is rising due to climate change. Forests within the derived savanna region of Nigeria have reduced productivity and decline in plant survival due to the combined and related climate change impacts of drought and fire (Mwakifwamba and Mwakasoanda, 2001).

There is a decline in the availability of fuel wood and non-timber forest products due to climate change. Climate change impacts exacerbate deforestation caused by a combination of factors such as high rate of population growth, poor land management and high dependence on fuel wood and charcoal for cooking in rural and urban areas.

Climate change may lead to increased invasion of native forests by new species that favour the ecological changes occurring in a particular location. These new species may out-compete and suppress the existence of native species bringing about significant ecological changes. This is visible in Cross River State with the invasion of Nipa palm in coastal mangrove forests.

## Vulnerability Assessment

There are features of forest systems that are particularly vulnerable to climate change.

These include:

- Discontinuity in landscape;
- Low-lying landscape;
- Poverty, increasing population, and lack of alternative livelihoods;
- Poor soil Structure and fragility;
- Human dependence on biodiversity for various needs; and
- Lack of capacity and technology.

These are described in more detail below.

The sensitivity of the forest in Nigeria to the impact of climate change is heightened because of the discontinuity of landscape and high degree of fragmentation of native forests. This is caused by a growing national population and expansion of agricultural and wildfires activities (Nepstad *et al*, 2008). Fragmented forests are less resilient to climate change impacts as plant and animal species are unable to shift across a fragmented landscape in response to a changing regional climate.

Large areas of Nigeria are characterized by low-lying landscapes, such as swamp and mangrove forests, that are highly vulnerable to the predicted flooding and salt water intrusions impacts predicted to occur as a result of climate change.

Nigeria has one of the highest population growth rates in the world and few opportunities for alternative sources of livelihoods. Therefore, the poor are highly vulnerable due to their dependence on the exploitation of forest resources for their survival, which in turn, exacerbates the impact of climate change (IPCC, 2007).

The stability and structure of forest soils are vulnerable to climate change. The soils of some southern parts of Nigeria are coarse and easily eroded by rains making them vulnerable to the predicted increase in rainfall events that are more intense and of longer duration.

Many people in Nigeria are highly dependent on forestry resources and biodiversity for the supply of medicinal and food materials which they use domestically or sell in the market to raise income. This dependence and in some cases, over-exploitation, may be challenged by climate change impacts on forests, with forest degradation further exacerbated as continued exploitation of diminishing resources reinforces the effect of climate change on the survival of species.

The skills, institutional capacity and technology to manage biodiversity and forest resources are lacking in Nigeria. The impact of climate change on forest resources and biodiversity will be greater where the skill and technology to increase their resilience is not available.

## Adaptation Strategies

Despite these challenges and vulnerabilities, there are some adaptation strategies that can be implemented. These include:

- The active protection of existing habitats;
- Increasing the number of conservation areas;
- Increasing the connectivity of existing protected areas;
- Implementing disease and pest control measures;
- Domestication of species;
- Providing irrigation and water schemes;
- Providing alternative livelihoods;
- Afforestation and reforestation projects;
- Providing appropriate flood management;
- Construct stronger dams;
- Enforcement of policies and legal provisions; and
- Integrating community rights

The active protection of existing habitats is an important adaptation strategy. It is necessary to step up the level of support and attention given to all the Forest Reserves, National Parks, Game Reserves, Botanical gardens and other protected areas. This is necessary in order to realize the goals for their establishment, prevent encroachment and reduce the impact of climate change. Further, new conservation areas need to be created in all the ecological zones in response to evolving challenges induced by climate change and to reflect observed hotspots of biodiversity. It is also important to increase the connectivity of existing protected areas. Creating links between existing protected areas will provide corridors for migrating plant and animal species as the climatic conditions shift in Nigeria. Also, introducing species of plant and animals that are tolerant to diseases and pests will minimize the impact of these climatic hazards forest resources and biodiversity.

The exploitation of forest ecosystems and biodiversity can be reduced where species with economic potential can be domesticated. This will reduce the dependence of the local people on forest reserves and biodiversity to satisfy their demand for non-timber forest products such as spices, mushroom, cane rats, bee-keeping etc. It will also reduce the rate of ongoing de-gazetting of protected areas. It is also important to provide irrigation and water schemes. In response to growing incidence of drought and reduced volume of ground water in the northern parts of the country, it will be appropriate to provide water schemes, dams and irrigation facilities to reduce the stress posed upon forest resources as a result of drought.

A major driver of deforestation is poverty. Therefore, if poverty alleviation programmes that encourage the development of alternative livelihoods are successfully implemented in rural areas and neighboring communities to protected areas, it will reduce dependence on forest resources and biodiversity. For example, programmes such craft-making, bee keeping, credit facilities could provide alternative sources of household income.

Afforestation and reforestation programmes involving all levels of government and local communities should be embraced fully to create buffers to remaining forested areas and contribute to rehabilitation of degraded lands including restoration of soil microbial populations.

Flooding can be reduced by creating levees, embankments and drainage channels. Dredging of streams, rivers and harbors to remove accumulated silt is also required to protect native forests from future flooding and siltation.

In addition, some of the increased incidences of floods, particularly in the north, are caused by existing dams that cannot withstand the intensity of rainfall and rising water volume. These overflowing dams endanger natural areas and communities that are located downstream. This can be prevented by improving the strength of existing and new dam infrastructure to ensure that they can withstand extreme rainfall events that may occur as a result of climate change.

There are existing laws and institutions responsible for conserving forest resources and biodiversity. These laws and institutions need to be revised to respond to new challenges occurring as a result of climate change. Also, one of recommendations of NBSAP (2008) is the need to integrate community rights into the legal statutes and the management of the forest reserves and protected areas for biodiversity conservation. This approach is a suitable adaptation measure that provides rural communities a sense of ownership and promotes sustainable management of the resources.

## Assessment of Economic Impacts

Forest resources, including ecological diversity, provide many services in Nigeria including:

- Ecosystem services, including protection water and soil resources; air, water and soil pollution breakdown and absorption; contribution to climate stability; nutrient storage and recycling;
- Biological Resources, including building materials, fuel wood, food, medicinal materials; ornamental plants; diversity in genes and species and future resources; and
- Social benefits, including recreation and tourism; cultural values, research, education and monitoring.

## **Assessment of Gender Considerations and Interactions**

Climate change impacts on biodiversity will diminish the ability of these natural heritage resources to provide these ecological services. It has been said that biodiversity is fundamental to economics (Leahy, 2009) which is highly relevant in Nigeria where over 80% of the population is living below the poverty level and there is a high dependence on biodiversity and natural resources. Richer countries can seek and acquire alternatives to most of the services provided by forest resources and biodiversity but poor countries such as Nigeria will go hungry and remain economically undeveloped as result of depleted biodiversity.

Women and children are generally responsible for collecting firewood in Nigeria. As climate change impacts reduce the availability of forest resources, women and children will need to travel further and spend more time collecting this needed resource. In addition to the time lost, women and children can also be vulnerable to sexual assault when travelling further from home.

Women and children may also be involved in collecting non-timber forest products such as spices, edible mushrooms, honey and medicinal plants, etc. It has been suggested that climate change may result in less food and medicines available for domestic use and as a source of revenue if sold in local markets.

Women's ability to adapt to climate change is hampered by several factors, including the societal barriers for women to access education and new technologies, the barriers to mobility that would allow them to pursue alternative sources of livelihood and their exclusion from decision-making processes that are related to improved forest management. A summary of the hazards, impacts, vulnerabilities and adaptation options are outlined below in Table 7.

**Table 7 Hazard-Impact-Vulnerability-Adaptation Matrix for Natural Resources:  
Forestry and Biodiversity Resources Sub-sector**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozones: ALL</b>			
Increased aridity leading to drought	<ul style="list-style-type: none"> <li>■ deforestation and loss of habitat</li> <li>■ scarcity of fuel wood</li> <li>■ high mortality of species and extinction of species</li> </ul>	<ul style="list-style-type: none"> <li>■ current over-exploitation due to lack of alternative livelihoods</li> <li>■ overgrazing by livestock</li> <li>■ poor management practice &amp; lack of capacity</li> <li>■ dependence of the forest ecosystem on natural rainfall patterns</li> <li>■ lack of alternative energy sources &amp; poverty</li> </ul>	<ul style="list-style-type: none"> <li>■ domesticate economic species</li> <li>■ establish new forest reserves &amp; woodlots</li> <li>■ build capacity on using energy saving stoves</li> <li>■ use better land management practices</li> </ul>
Shift in rainfall seasonality	<ul style="list-style-type: none"> <li>■ threatened survival of species</li> <li>■ changes in distribution of species</li> </ul>	<ul style="list-style-type: none"> <li>■ immobility of forest species</li> <li>■ deforestation from overuse leads to forest fragmentation</li> <li>■ land tenure system is inadequate</li> <li>■ lack of alternative resources to depend on</li> </ul>	<ul style="list-style-type: none"> <li>■ increase afforestation &amp; reforestation</li> <li>■ increase connectivity of forest reserves</li> <li>■ create woodlots to supply fuel wood</li> <li>■ introduce energy efficient wood stoves</li> <li>■ improve land management practices &amp; enforce laws</li> </ul>
Increased rainfall intensity leading to flooding & inundation of wetlands	<ul style="list-style-type: none"> <li>■ invasion by new species</li> <li>■ loss of soil seed bank and suppression of regenerating seedlings</li> <li>■ flooding induces poor soil aeration</li> <li>■ sedimentation load depletes the size of the wetlands</li> </ul>	<ul style="list-style-type: none"> <li>■ topography of the wetlands encourage inundation</li> <li>■ vegetation survives under limited range of ecological conditions</li> </ul>	<ul style="list-style-type: none"> <li>■ provide adequate drainage</li> <li>■ provide suitable embankments</li> <li>■ conserve seed banks</li> </ul>
Increased rainfall intensity causing erosion	<ul style="list-style-type: none"> <li>■ increased loss of soil nutrients</li> <li>■ loss of livelihoods</li> <li>■ increased sedimentation &amp; siltation of water bodies</li> </ul>	<ul style="list-style-type: none"> <li>■ poor soil structure</li> <li>■ dependence of local people on forest resources</li> <li>■ sloping topography that encourage siltation</li> </ul>	<ul style="list-style-type: none"> <li>■ reclaim gullies and degraded areas</li> <li>■ use fertilizers and soil conservation methods</li> <li>■ provide alternative livelihoods</li> <li>■ de-siltation of streams</li> <li>■ encourage regeneration of plant species</li> </ul>
Increased temperature	<ul style="list-style-type: none"> <li>■ increase in diseases &amp; pests</li> <li>■ changes in the phenology of species</li> <li>■ increased incidence &amp; intensity of wild fires</li> <li>■ low harvest from non-timber forest products (NTFPs)</li> </ul>	<ul style="list-style-type: none"> <li>■ environmental conditions favour pests &amp; disease</li> <li>■ growth &amp; reproductive cycle of plant species regulated by temperature</li> <li>■ dependence on forest resources for income &amp; medicine</li> </ul>	<ul style="list-style-type: none"> <li>■ provide more support for existing reserves &amp; create new ones</li> <li>■ domesticate economic species</li> <li>■ use integrated methods to control pests &amp; diseases</li> <li>■ provide alternative livelihoods</li> </ul>
Increased wind storms	<ul style="list-style-type: none"> <li>■ falling of forest stands</li> </ul>	<ul style="list-style-type: none"> <li>■ strength of the species may not withstand storms</li> <li>■ species such as epiphytes lose their supporting tree stands</li> </ul>	<ul style="list-style-type: none"> <li>■ create shelter belts</li> <li>■ embark on reforestation activities</li> <li>■ create corridors that connect forest reserves</li> </ul>

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: SAVANNA and SAHEL</b>			
Higher temperatures & greater rainfall variability	<ul style="list-style-type: none"> <li>■ increased aridity leading to drought &amp; reduced ground water volume</li> <li>■ changes in distribution pattern of biodiversity</li> <li>■ species migration to more favourable habitat</li> <li>■ high mortality &amp; extinction of species</li> <li>■ loss of livelihoods</li> </ul>	<ul style="list-style-type: none"> <li>■ higher evapo-transpiration in these ecozones</li> <li>■ more people in need of water</li> <li>■ limited ecological range of many species</li> <li>■ strong dependence of people on biodiversity for income</li> <li>■ high rates of deforestation leading to loss of habitat and loss of biodiversity &amp; decline in fuel wood supply</li> </ul>	<ul style="list-style-type: none"> <li>■ provide more irrigation schemes</li> <li>■ domestication of species</li> <li>■ create game reserves, parks/wildlife sanctuaries with community participation</li> <li>■ create protected area connectivity</li> <li>■ alternative income generation projects</li> <li>■ introduce fuel efficient wood stoves</li> </ul>
Increased rainfall intensity	<ul style="list-style-type: none"> <li>■ flooding and inundation of wetlands</li> <li>■ invasion by new species</li> <li>■ increase of pests &amp; diseases</li> <li>■ decline of soil fertility</li> <li>■ increased erosion leads to development of gullies &amp; reduced useable land area</li> <li>■ increased sedimentation &amp; siltation of water bodies</li> <li>■ invasion by new species (exotic and indigenous) creating ecological imbalances</li> <li>■ washing away of biodiversity by run off</li> </ul>	<ul style="list-style-type: none"> <li>■ low lying landscapes easily inundated</li> <li>■ higher volume of flood plain</li> <li>■ lack of technology to prevent flooding</li> <li>■ poorly constructed dams</li> <li>■ limited ecological range of species</li> <li>■ flood changes ecological characteristics to favor invading species</li> <li>■ existing low soil fertility</li> <li>■ poor soil structure &amp; increased need for land</li> <li>■ existing water scarcity</li> <li>■ micro-organisms in the soil are easily washed away</li> </ul>	<ul style="list-style-type: none"> <li>■ providing adequate drainage systems</li> <li>■ construct dams with stronger materials- create buffer zones</li> <li>■ create corridors</li> <li>■ introduce water tolerant species</li> <li>■ introduce disease resistant varieties and apply control measures</li> <li>■ introduce soil conservation measures</li> <li>■ reclamation of gullies &amp; degraded areas</li> <li>■ restoration of watersheds</li> <li>■ de-silting of water bodies</li> <li>■ create protected areas</li> <li>■ encourage domestication of NTFPs</li> <li>■ creation of drains</li> <li>■ construction of terraces and bunds</li> </ul>
<b>Ecozone: COASTAL</b>			
Sea level rise	<ul style="list-style-type: none"> <li>■ increased soil salinity making habitat unsuitable</li> <li>■ reduced productivity of species</li> <li>■ changes in growth pattern of species</li> <li>■ decline in size of low lying fresh water wetland</li> </ul>	<ul style="list-style-type: none"> <li>■ low resilience of species</li> <li>■ limited climate &amp; ecological range of some species</li> </ul>	<ul style="list-style-type: none"> <li>■ creation of more protected areas</li> <li>■ building capacity for management of fragile mangrove forest ecosystems</li> </ul>

## Review of Existing Governance, Policies and Programmes

### Federal Level

The Federal Government of Nigeria plays the leadership role in the management of the nation's forest resources by creating enabling institutions, policies and laws. The first institution established by the federal government for the overall protection of the environment and conservation of natural resources was the Federal Environmental Protection Agency (FEPA) in 1988. Subsequent institutions started to evolve such as the Natural Resources Conservation Council formed in 1989 and the Federal Ministry of Environment formed in 1992. These bodies subsumed all other agencies and establishments including National Parks with a mandate on environmental issues. According to NBSAP (2008), the role of the Federal Ministry of Environment is to:

- Define broad policy framework;
- Provide selected service functions such as environmental impact assessment (EIA) and environmental data management;
- Assist in developing and improving environmental legal and regulatory framework;
- Manage ecosystems and promote sustainable use of natural resources; and
- Enforce environmental quality norms.

The other relevant ministries and agencies at the Federal level involved in biodiversity management are:

- National Park Services
- Forestry Research Institute of Nigeria
- National Center for Genetic Resources and Biotechnology (NAGRAB)
- Ecological Fund
- Fifteen agricultural-based research institutions
- Ministries responsible for Water Resources, Agriculture, Education, Transport, Works and Housing, Science and Technology, Solid Minerals, Power and Steel, and Culture and Tourism
- Fifty-two government and private universities and colleges involving agriculture, forestry and fisheries

### **State Level**

The Federal Ministry of Environment maintains offices in all the 36 states of the federation and liaises with the headquarters in Abuja on issues relating to natural disasters, environmental pollution and the implementation of program activities of the Ministry. Also at the state levels, there are key agencies and parastatals that are involved in the work of forestry on the ground with Forest Reserves and local communities. These include the Ministries of Environment, Land Resources and Forestry, Agriculture, State Environmental Protection Agencies, etc.

### **Local Level**

There are 774 Local Government Areas (LGAs) in Nigeria created to bring governance closer to the people. They are empowered to make rules and regulations that are in tandem with national and state laws. The Local Councils are important to forestry development because of their closer supervisory role they provide to the communities.

Within the Local Governments are rural communities that have traditional administrative structures that help in maintaining law and order within the local villages. These communities that depend on forest resources for their livelihood, through cooperation in some cases, play crucial role in determining the sustainable development of forest systems (USAID, 2007).

### **Relevant National Laws And Policies**

Deliberate and systematic efforts are needed to salvage the vulnerable forestry sector of Nigeria. A comprehensive and national approach appears to be the appropriate option in order to support the productivity and sustainability of the country's natural heritage. Considering the potentials and the ecological diversity of the sector, it is best if initiatives are treated nationally with local peculiarities taken into account.

The national constitution (Chapter 2) made legal pronouncements on the harnessing of natural resources sustainably, as well as the protection and improvement of environment and safeguard of water, air, land, forest and wildlife. In actuality, it was the promulgation of the Decree establishing FEPA in 1988 that started the conscious effort towards realizing the goals of protecting the environment, natural resources conservation and sustainable development. Some legislation and policy frameworks relating to the forestry and biodiversity sector include:

- National Forestry Policy, 2006
- National Forestry Act, 1937 (in a process of review in the National Assembly)
- Natural Resources Conservation Council Decree, 1989
- Sea Fisheries (licensing) Regulations, 1992
- Land use Act, 1978
- National Parks Services Act, 1991
- Oil Pipelines Act, 1958
- Live Fish (Importation) Act, 1965
- Quarries Decree, 1972

On the international front, Nigeria has signed to some international conventions and treaties related to forest and biodiversity resources, they include:

- Convention on International Trade I Endangered Species of Wild Fauna and Flora, (CITES), 1973
- Convention on Biological Diversity, 1992
- Convention to Combat Desertification, 1994
- Convention on Conservation of Migratory Species of Wild Animals
- Convention on Law of the Sea, 1986
- The Ramsar Convention on the Conservation of Wetlands of International Importance, especially as Waterfowl Habitat, 1971
- The Convention concerning the Protection of World Cultural and Nature Heritage, 1974
- African Convention on the Conservation of Natural Resources, 1968
- Convention on Climate Change, 1992

There is growing acceptance of the fact that the policies are disjointed. Hence, there is a demand for updating and strengthening of the existing legislations and policy frameworks that deal with forestry and biodiversity in order to enhance their provision as a tool for sanctions and enforcement (NBDSAP, 2008). As outlined by NBDSAP (2008) and NEP (2006), among the limitations existing in the current policy arrangement Nigeria are:

- Weak institutional and legal capacity;
- Policy failures and frequent changes in policy direction;
- Insufficient involvement of local people in programmes for biodiversity protection; and
- Limited community participation and integration into governance.

### **Role of government stakeholders in climate change adaptation**

Integrating adaptation policies into forest resources development requires a multi-sectoral approach with the involvement of diverse stakeholders. Mainstreaming climate change adaptation in this setting appears a challenge (Locatelli *et al.*, 2008). Although the cooperation and involvement of all stakeholders are required, there is an imbalance of power from the government down to the rural communities

The roles of government agencies in addressing climate change adaptation in this subsector include:

- Develop specific policies to encourage protection of biodiversity and expand conservation centers that recognizes local rights to biodiversity;
- Through active participation of all stakeholders, strengthen existing policies and regulations and enforcement provisions preventing uncontrolled depletion of natural habitats for plants and animal species;
- Encourage research into new technologies and practices that promote protection of biodiversity;
- Promote community-based actions in biodiversity through local institution for biodiversity protection and conservation;
- Reduce the effect of changes in government on policies and programmes for biodiversity protection and capacity building;
- Establish integrated protected area system that represent all ecological system, and
- Strengthen institutions and departments, and custodians of forests, fish and wildlife resources.

### **Role of non-government organizations (NGOs) and the private sector**

In addition to government, there are NGOs, CBOs and private-sector actors who are actively working in the area of forestry and on environmental protection and natural resources conservation. The activities of these bodies range from environmental education to community development as well as habitat-centered programmes. These civil society groups have worked hard to build significant public awareness on environmental issues. Among the foremost NGOs and private sector actors are:

- Forestry Association of Nigeria (FAN)
- Nigerian Environmental Study/Action Team (NEST)

- Nigerian Field Society
- National Conservation Foundation
- Center for Environmental Resources and Sustainable Ecosystems (CERASE)
- Savannah Conservation Nigeria
- CERCOPAN
- Birdlife International
- Chevron Oil company
- Leventis

Donor groups are also providing the needed support to local NGOs to promote natural resource protection. These international groups have environmental protection and sustainable development in their mandates. They include the Canadian International Development Agency (CIDA), the British Department for International Development (DFID), the International Union for Conservation of Nature (IUCN) and United States international development agency (USAID).

Among the roles that NGOs could play in climate change adaptation include:

- Engage in environmental education and public mobilization on sustainable use of natural resources;
- Mounting advocacy activities to support environmental protection and natural resources conservation; and
- Develop community pilot projects and other community-based action focusing of forestry resources and domestication for capacity building, training and research.

### **Role of community initiatives**

Another important stakeholder that should not be excluded from biodiversity protection and natural resources conservation programmes and activities is the local community. This is one of major limitations of most existing policies and programmes of government. Therefore it is necessary that community groups become integrated in the decision-making planning and implementation of biodiversity-related policies and programmes as rightful stakeholders.

Among the roles community roles and actions in addressing CCA in biodiversity subsector include:

- Embracing and promoting increased awareness of forest resources and biodiversity values and sustainable exploitation;
- Participating in decision-making and programme development and implementation of the government and NGO programmes aimed at protecting biodiversity; and
- Improving their capacity on domestication of economic species.

## **Recommended Climate Change Adaptation Actions**

Nigeria needs to take action to address the impact of climate change on forestry and biodiversity resources considering the numerous services provided by this heritage. The urgency of the required action is evident considering the rapid rate at which forests and native biodiversity is being lost in Nigeria. The continued growth of Nigeria's already large population of over 140 million people (with a growth rate of about 3%), constituting nearly a quarter of the total population of sub-Saharan Africa and the increasing poverty level places a heavy demand on the natural resources (NBSAP, 2008).

The policies and programmes to be embraced by Nigeria should:

- Reduce the vulnerability of forest resources and biodiversity to climate change; and
- Enable the country's heritage of forestry resources and biodiversity to provide the ecological services sustainable in order to reduce the vulnerability of the local people who depend strongly on them.

The current policies and programmes in Nigeria on natural resources have limited integration of climate change concerns in them. There is need therefore to:

- Develop a national policy and plan on biodiversity conservation and environmental protection;
- Give appropriate legal backing to designated conservation areas in all the states and curtail de-reservation activities to avoid loss of further habitat;

- Revise or put in place local community-sensitive management plans and conservation options in every conservation area;
- Increase the connectivity or networks of existing conservation areas that will take into consideration the projected changes in local climate conditions;
- Form corridors in protected areas and other areas that have significance for biodiversity conservation. This will provide a kind of refuge and buffer zone for wildlife species;
- Provide adequate funding and infrastructure for capacity building in biodiversity conservation;
- Take measures to restore and maintain native ecosystems;
- Improve management systems including control of deforestation, and promotion of reforestation and afforestation programmes;
- Promote agroforestry to improve forest goods and services; and
- Reduce poverty.

Table 8 provides a summary of the policies, programmes, adaptation options addressed as well as the implementing agency and cost. Table 9 provides an evaluation of the proposed programmes relating to the forest and biodiversity sub-sector.

**Table 8** Policies, programmes, adaptation options addressed, implementing agency and cost:  
**Forestry and Biodiversity Resources Sub-sector**

Proposed CCA Policies	Proposed CCA Programmes	Ecozone Addressed by Proposed Policies and Programmes	CCA Options Addressed by Proposed Policies and Programmes	Implementation Agency (s)	Estimated Costs
<b>Immediate Needs</b>					
National Policy on Forestry & Biodiversity (Natural) Resources Conservation and Management	Integrate climate change challenges in forestry resources conservation & management	All ecozones	<ul style="list-style-type: none"> <li>■ Increase effectiveness of conservation of threatened and endangered species</li> <li>■ Provide corridors and connectivity between existing protected areas</li> <li>■ Increase community participation in management of Protected Areas</li> <li>■ Provide drainage and embankment, irrigation facilities</li> <li>■ Introduce resistant varieties to vulnerable areas</li> <li>■ Increased afforestation and reforestation activities</li> <li>■ Increase use of fertilizers and soil conservation methods</li> <li>■ Improve awareness &amp; dissemination of information on importance of conserved or protected areas</li> </ul>	Federal and State Ministries of Environment, Agriculture, Water resources; National Planning Commission; NAGRAB Ecological Fund;	Medium  (Related to the GDP contribution of Forestry Resources and Biodiversity)
National Land Use and Protection Policy	Reduce the vulnerability of forestry resources and biodiversity to climate change	All ecozones	<ul style="list-style-type: none"> <li>■ Create new protected areas e.g. National Parks/Forest Reserves</li> <li>■ Increase afforestation &amp; reforestation activities</li> <li>■ Increase efforts to reclaim gullies and degraded areas</li> <li>■ Restore wetlands- Promulgate legal provisions for protected areas.</li> <li>■ Provide official Land use and protection policy</li> <li>■ Enforce relevant legal conservation policy</li> </ul>	National Assemblies  Federal and State Ministries of Environment; Water Resources;  Forestry Research Institute of Nigeria; The Ecological Fund	
<b>Long term Needs</b>					
National Policy on Poverty Eradication	Improve livelihoods	All ecozones	<ul style="list-style-type: none"> <li>■ Improve capacity of people to domesticate economic &amp; threatened species</li> <li>■ Provide alternative livelihood opportunities</li> <li>■ Introduce the use of flood, drought, disease and salt resistant species</li> <li>■ Popularize alternatives to fuel wood use and other critical NTFPs</li> <li>■ Improve awareness &amp; dissemination of information on efficiency of resource use</li> </ul>	Ministries of Agriculture, Environment, Labour, Women's Affairs, NAPEP, The Presidency, the National/ State Assemblies	

**Table 9** Evaluation of Proposed Policies: **Forestry and Biodiversity Sub-sector**

CCA Options Addressed by Proposed Policies & Programs	Criteria to Evaluate Effectiveness of Policy Implementation	Implications if Policy IS Implemented (individuals, communities, private sector)		Implications if Policy NOT Implemented (individuals, communities, private sector)	
		Positive Impacts	Negative Impacts	Positive Impacts	Negative Impacts
<b>Immediate Needs</b>					
National Policy on Forestry Resources Conservation and Management National Land Use and protection Policy	<ul style="list-style-type: none"> <li>■ Number of endangered species whose population status has improved</li> <li>■ The number of protected areas linked</li> <li>■ Number of communities involved in management of protected areas- Number of flood, drought, disease and salt resistant varieties distributed to vulnerable areas</li> <li>■ Size of land area under afforestation &amp; reforestation programmes</li> </ul>	<ul style="list-style-type: none"> <li>■ Enhanced livelihoods for many</li> <li>■ Reduction in the rate of de-gazetting of protected areas</li> <li>■ Reduced conflict between communities &amp; government on rights to use protected areas</li> </ul>	None	None	<ul style="list-style-type: none"> <li>■ Livelihoods will be threatened</li> <li>■ Limited community and institutional adaptive capacity</li> <li>■ Increased rate of de-gazetting of protected areas</li> </ul>
<b>Long Term Needs</b>					
National Policy on Poverty Eradication	<ul style="list-style-type: none"> <li>■ Number of households domesticating economic &amp; threatened species</li> <li>■ Percentage reduction in unemployment rate- Number of farmers using flood, drought, disease and salt resistant varieties</li> <li>■ Number of community training workshops on efficiency in resource use</li> </ul>	<ul style="list-style-type: none"> <li>■ Improved livelihoods and reduced vulnerability</li> </ul>	None	None	<ul style="list-style-type: none"> <li>■ Increased poverty and more victims of extreme weather events</li> </ul>

## Assessment of Current and Future Trends

### Sub-sector 4: Fishery Resources

There are abundant near-shore and inshore fish resources in Nigerian waters that include demersal, pelagic and shellfish resources. The total fishing area is estimated at 26,700 km<sup>2</sup> with a potential yield of 201,000 tonnes per year for the inshore waters. The major freshwater rivers and associated habitat are: Niger River, Benue River, and River Rima. The lakes and reservoirs include Lake Chad (Natural) in Borno State, Lake Kainji, Lake Asejire and Lake Eleiyele. In addition, artificial lakes created for electrical power generation, domestic water supply and irrigation have added to the potential fisheries production in Nigeria.

Fishing engages a significant proportion of the labour force in Nigeria, especially in the coastal and riverine areas. It is reported that small-scale (artisanal) marine and freshwater fishing contributes over 90% of the 800,000 tonnes of local fish production (NEST, 1992).

There has been a decline in fish catch in the country's water bodies over the years (from 756,728 tonnes in 1969 to 483,000 tons in 1988). This is attributable to:

- The escalating costs of outboard engines and spare parts;
- the reduction/removal of subsidy on these items by the government;
- the pollution of inland lakes and rivers as a result of oil exploration activities in the Niger delta areas; and
- over fishing as a result of increasing fishermen per unit area.

Variable water levels can also affect fish resources, both natural stocks and from fish farming. Climate fluctuation, such as the late onset of the rainy season (i.e. June instead of March) can lead to delayed fish breeding. As mentioned in the earlier section in this report on Water Resources, according to Ojo (2008), Nigeria's coastal ecosystem and the 3.68 million people which live in these areas, are at risk from a predicted 1.0 m rise in sea level. Also coastal erosion, which is already occurring along the shores of Cross River, Akwa Ibom and Ondo States has implications for the associated coastal mangrove/swamp vegetation and resources.

In addition, more severe water level fluctuations have been observed, including seasonal flooding and drying up of water ways (e.g. Lake Chad has been reduced to less than 50% of its former size). There has been a significant 10-11 metre draw down of water levels in Kainji Lake, resulting in a smaller volume of water for fish production as well as for the generation of hydro-electric power. These changes in the available water resources, which may be linked in part to climate change, have resulted in rising fish prices in Nigeria despite the support given to fish farming by public and private agencies.

Efforts have been made to introduce rural technologies that manage water resources using concrete tanks for fish culture such as the Lagos State experience in Homestead Pond and Cage culture (Ojeniyi *et al.*, 2001; Adekoya *et al.*, 2004; Olukunle, 2004). The supplementing of unreliable rain and surface water can be accomplished by sinking deep wells or boreholes, and more recently, through the use of rainwater harvesting techniques that collect water during the wet season for use during the dry season (Olukunle, 2004).

The problem of spoilage of harvested fresh fish has been addressed through the introduction of improved processing units such as smoking kilns and modified drum and mura kilns that do not depend on scarce and expensive sources of wood, kerosene, and coal, relying instead on electricity, gas and solar power in fishing communities around Kainji Lake, Lake Chad and in Sokoto State. These processing units were supplied by the Federal Fisheries Department to the Catfish Farmers Association of Nigeria (CAFAN, 2009) at a cost of N10,000 per unit. These improved kilns reduce infestation by destructive pests like the *Desmestes* beetle larvae, reduces the microbial load and improves physicochemical and organoleptic (i.e. taste, sight, smell, touch) characteristics of the dried fish products.

## Climate Change Impacts, Vulnerabilities and Adaptation Options

General observations on the vulnerability of freshwater fisheries and capture fisheries to climate change hazards and impacts include:

- Fisherfolk including men, women, youth and children are generally poor, their subsistence livelihoods rely directly on the quantity and quality of water resources and yet they are not engaged in decision making for natural resource management nor do they have ready access to alternative livelihoods;
- Climate change hazards are resulting in greater water level fluctuations from season to season; leading to flooding in the wet season and lowering of the water level or even drying up in the dry season;
- Adaptation options can include integrated fadama (floodplain) farming for growing rice and various vegetables as well as fish culture as has been shown in Kebbi State (FISON, 2007);
- Fisherfolk can migrate to floodplains and basins which provide potential suitable places for aquaculture and integrated fish farming during the dry season and be trained through the Unified Extension System (UES) to manage and control the small amount of water which is available (FISON, 2007);
- Fisherfolk can engage in alternative livelihood options, for example in Oyo State they have become farmers of crops, making mounds for yams for the following year and in the Chad basin they dig for potash which they market economically; and
- Recognition that in some areas overfishing is leading to low fish landings which in turn reduces the income of women involved in fish processing and marketing.

### Climate Change Impacts

Fluctuating water levels through drying and flooding destroy breeding sites of fish species, exposes the products (fry, fingerling) reducing and probably eliminating recruitment of future fish populations e.g. in Eleiyele and Asejire reservoirs there has been reduction in fish landed by fisherfolk. In addition, fluctuating water levels affect fisherfolks' livelihood, because there is less fish/landings for fishermen and for fisher women who process them. Further, the fluctuating water levels affect the economy of the fisherfolk, e.g. in River Numa in Kebbi State and Kainji Lake the fish landings have been declining.

The fluctuating water levels lead to less water for agricultural reservoirs. Flooding leads to the washing away of dikes of ponds associated with aquaculture, a problem that is particularly acute in the southwest of Nigeria. Also, unpredictable flooding periods lead to unpredictable water levels for crop and fish production e.g. *fadama* rice/fish production in Savannah and Sahel ecozones.

Fish physiology is adapted to certain temperature ranges, therefore increasing water temperatures will affect fish by altering physiological functions such as thermal tolerance, growth metabolism, food consumption, reproductive success and ability to maintain internal homeostasis in the face of a variable external environment (Fry, 1971) leading to a reduction of "sterothermal" (narrow thermal range) fish species and an increase in "eurythermal" (wide tolerance range) species. Additionally, increases in water temperature will also decrease water quality by enhancing eutrophic conditions and stimulating explosive growth of aquatic macrophytes. Kankaala *et al.* (2002) found a 2-3°C temperature increase caused a 300 to 500% increase in shoot biomass of the aquatic macrophyte, *Elodea canadensis*. As macrophytes take up the phosphorus in the sediment, the amount of phosphorus immediately available for other primary producers decline, subsequently, macrophytes die and decompose releasing nutrients such as nitrogen and phosphorus into the water column (Cooper, 1996; Kankaala *et al.*, 2002). This in turn leads to depressed levels of dissolved oxygen which can cause fish kills (Klapper, 1991). Floating of rafts of emergent, floating or subsurface also result in decreased wind mixing and increased periods of stratification, conditions that may be unfavourable to fish (Welcome, 1979)

Vegetation cover that favours fish production in wetlands may be reduced because of reduced groundwater levels. Lowered water levels lead to an overall reduction of fish habitat and fish resources and an increase in fisherfolk per unit of available fishing area further depleting resources and lowering fish catch.

## Climate Change Vulnerabilities and Adaptation Options

Presently, fisherfolk are deeply affected by climate change hazards that result in fluctuation of water levels of natural and artificial water resources. The primary areas of vulnerability include:

- The population of fisherfolk per unit area of water surface is generally too high and this increases due to climate change impacts;
- Poverty and low economic power puts fisherfolk at a disadvantage, and favours wealthy intermediate fish buyers who finance the purchase of fishing gears and buy fish landings cheaply to then sell fish at exorbitant prices to consumers who can afford them. Thus fresh fish, as a source of protein, is too expensive for the average Nigerian and a only small income is returned to fisherfolk;
- Government subsidies for the purchase of fishing gears has been discontinued;
- Fisherfolk's financial contributions to fish cooperatives are declining, as such the ability of fish cooperatives to assist them in buying fishing gears is also declining;
- The government undertakes fish restocking in some reservoirs (e.g. Asejire reservoir) but the control of fishing is not effective; and
- Some licensing of fisherfolk was undertaken in Oyo State, however they evaded taking a license and without adequate control the catch per unit effort dwindled as the number of fisherfolk per unit area was high, hence poverty became magnified.

Adaptation options that could address some of these vulnerabilities include:

- The government should provide climate change awareness raising and training in sustainable fishing techniques to fisherfolk through extension officers at the location of fishing activities (i.e. by the reservoir side);
- The government should reinstate programmes that provide partial subsidies in combination with closed fishing seasons to allow fish stocks to recover and this program should be rigorously monitored and enforced; and
- Government, private organizations and NGOs should support fisherfolk to become involved in fish-farming using cages, pen culture and the "adkaja" local method of fish culture on lakes; reservoir and deep reservoirs so that when water level goes down at the edges, the cages and adkaja can be moved to deeper water areas.

## Assessment of Economic Impacts

Developing countries are particularly vulnerable to the impacts of climate change because their economics are generally more dependent on natural resources that are directly affected by climate such as agriculture, forestry, fisheries and livestock. Fish production remains the main source of livelihood for riverside and coastal rural communities where a significant proportion engages in artisan fisheries. Nigeria, along with all countries of sub-Sahara Africa, are considered highly vulnerable to the impact of climate change according to the fourth assessment reports of the Intergovernmental Panel on Climate Change (IPCC) for the following reasons:

- Water resources are under serious threat which in turn will affect fish resources and energy supply, particularly the Kainji and Shiroro reservoirs;
- Changes in rainfall timing, drought and intensity will seriously impact two thirds of the Nigerian population who depend primarily on rain fed agriculture and fishing activities for their food and/or livelihoods;
- Nigeria's existing high population of 140 million people with one of the fastest growth rates in the world, depend on fish as an important local source of protein;
- Capture fisheries is still by far the largest source of fish in Nigeria. Statistics from the Federal Department of Fisheries shows that over 86% of fish production is from capture fisheries, with the other 14% from aquaculture. Most of the capture fisheries is done by artisanal fishermen who live along the coastline of Nigerian fishing within continental shelf areas and along the banks of major rivers in the country;
- People involved in artisanal fisheries are generally involved in small scale fishing operations holdings with some people involved in as fishermen, some as fish processors and fish sellers and others as part of the allied industry of gear and boat making and mending;
- Climate change will affect the livelihoods of those involved in various aspects of small scale fishing operations; and

## Assessment of Gender Considerations and Interactions

- Climate change may also impact species diversity of aquatic systems and terrestrial species that are dependent on the health of aquatic systems.

Climate change, with the attendant lowering of water levels in waterways, reservoirs and natural lakes and flooding that affects the major rivers, will reduce available fish stocks and fish catches thereby impacting the livelihood of persons related to fisheries. The impacts on both genders include:

- Both men and women fisherfolk will be able to provide less food and income for their families;
- Women fisherfolk will face additional challenges as they have less access to credit to purchase fishing gears and are less able to travel to deeper water to fish;
- Fish processors, who are most often women, will have less fish to process to earn income from; and
- children that rely on fish protein for nutrition and growth will have less fish available for consumption.

Table 10 provides a summary of the climate change hazards, impacts, vulnerabilities and adaptation options.

**Table 10** Hazard-Impact-Vulnerability-Adaptation Matrix for Natural Resources: **Fishery Resources Sub-sector**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: ALL</b>			
<ul style="list-style-type: none"> <li>Increased aridity from temperature increase</li> </ul>	<ul style="list-style-type: none"> <li>drying up of waterways, drawing down of water levels in reservoirs and wetlands and ground water</li> <li>loss of biological diversity of fisheries resources due to habitat degradation (e.g. fish, clams, water snails, etc.)</li> <li>loss of sources of livelihood</li> <li>shortage of fuel wood for smoking fish</li> <li>lower water level in reservoirs</li> <li>water quality for fish declines because less water flow and less amount of water for dilution of nutrients</li> <li>lowered groundwater levels cause reduction in vegetation cover along margins of wetlands</li> <li>increase in aquatic vegetation (e.g. water hyacinth) along the edge of waterways</li> <li>pollution/eutrophication of fresh water through the decay of aquatic vegetation and animals trapped in areas of lower water levels</li> <li>reduced groundwater available for fish culture</li> </ul>	<ul style="list-style-type: none"> <li>high poverty levels</li> <li>prohibitive cost of protecting habitat and infrastructure: fishing gear is expensive</li> <li>lack of financial resources to use coal and smoking kilns</li> <li>not enough Fish Extension Officers employed by government</li> <li>people no longer manage fish resources effectively (e.g. closed season, type of gear used)</li> <li>lack of education and use of traditional knowledge to manage fish resources</li> <li>competition for groundwater for drinking, for agriculture and for fish farming</li> </ul>	<ul style="list-style-type: none"> <li>alternative livelihoods (e.g. farming of crops, aquaculture, trading etc.)</li> <li>where natural water bodies and fish resources declining switch to aquaculture</li> <li>refinement of early warning and monitoring systems (e.g. meteorological. water levels, fish catch) to improve fish resource management</li> <li>research into alternative fish processing strategies e.g. utilization of solar energy</li> <li>fish cooperatives should be encouraged</li> <li>physical harvesting and chemical destruction of macrophytes e.g. water hyacinth. Alternative utilization of weeds</li> <li>dredge silted water ways</li> </ul>

## Review of Existing Governance, Policies and Programmes

### Role of Government at Federal, State and Local levels

The fisheries sub-sector is governed by a directorate at both the Federal and State levels headed by the Minister of Agriculture and Commissioner respectively. At the Local Government Agency level, fisheries are addressed under Agriculture.

At the federal level, there are field officers who supervise federal programmes on data collection associated with reservoirs, rivers, aquaculture and cooperatives. Fisheries policy addresses factors such as:

- Afforestation of wetlands;
- Recycling of nutrients from aquacultural recirculation systems
- Prevention of soil erosion; and
- Integrated aquaculture of flooded rice and fish production, poultry and fish production etc.

Currently at the state level, the Departments of Fisheries are not educating fisherfolk on climate change, though when the Department of Fisheries was contacted in the course of the preparation of this report, they expressed a willingness to provide climate change information to them if they are provided relevant training. Institutions such as the University of Ibadan do encourage academic seminars and lectures to create climate change awareness.

### Role of other Stakeholders such as NGO's and Private Sector

Workshops, such as those organized by the BNRCC project, can be organized to collect information and to bring awareness to government regarding climate change including information from international sources. Private companies such as Ajanla Farms, Zartech and Durante are involved in the production of fish and can demonstrate how they have introduced water recirculation systems that economize water use while also producing a large quantity of fish in a small space.

### Role of Community Initiatives

The fisherfolk, fish processors, and fish marketers constitute the most direct stakeholder in the fisheries sector and community-based initiatives related to climate change adaptation need to be encouraged.

People engaged in the fisheries sector need to be taught scientific and technical innovations that will assist them in adapting to climate change hazards. Community-based adaptation options could include:

- Integrating and expanding local knowledge of adaptation techniques that can be integrated into development initiatives to help communities adapt to climate change hazards;
- Assisting local communities with the purchase of fishing gears because of their vulnerability. They could be given 'soft loans' and supported with subsidies;
- Local communities should be assisted to organize themselves into groups or cooperatives to better develop adaptation strategies for climate change; and
- Fishing communities could be made more aware of and assist in the development of early warning mechanisms to protect themselves from natural hazards (NEST, 2003).

## Recommended Climate Change Adaptation Actions

Recommended policies, programmes for adaptation are presented in Table 11. An evaluation of these is presented in Table 12.

**Table 11** Policies, programmes and adaptation options addressed and implementing agency:  
**Fishery Resources Sub-sector**

Recommended/ Suggested CCA Policy Actions	Proposed CCA Programmes	Ecozone Addressed by Proposed Policies and Programmes	CCA Options Addressed by Proposed Policies and Programmes	Implementation Agency (s)
<b>Immediate Needs</b>				
1. Climate Change Awareness Policy	<ul style="list-style-type: none"> <li>■ Educate and create awareness of the implications of CC to fisheries (e.g. water level changes in waterways and watershed)</li> <li>■ Communicate through workshops, radio, seminars of the effect of CC on water resources</li> <li>■ Assess vulnerability of communities to CC hazards</li> </ul>	All Ecozones	<ul style="list-style-type: none"> <li>■ CC awareness should make people consider what are the CCA options they may need to implement to address CC hazards</li> <li>■ Alternative livelihoods (e.g. farming of crops, aquaculture, trading etc.)</li> <li>■ Where natural water bodies and fish resources are declining, switch to aquaculture</li> <li>■ Fish cooperatives should be encouraged</li> </ul>	<ul style="list-style-type: none"> <li>■ Federal Government and Universities involved in training Field Officers</li> <li>■ State Government Fisheries Officers</li> <li>■ Stakeholders (e.g. CAFAN Catch Fishers Association of Nigeria)</li> <li>■ NGOs</li> <li>■ Private Sector, Individuals</li> </ul>
2. Climate Change Monitoring Policy	<ul style="list-style-type: none"> <li>■ Waterways monitoring and data collection program for fisheries (e.g. water levels, water quality and fish landing quantity and quality, type of gears used etc.)</li> <li>■ Train field officers to collect reliable data</li> <li>■ Train agents or field officers to make reliable forecasts</li> <li>■ Train stakeholders in risk perception and decision-making</li> </ul>	All Ecozones	<ul style="list-style-type: none"> <li>■ Refinement of early warning and monitoring systems (e.g. meteorological. water levels, fish catch) to improve fish resource management</li> <li>■ Physical harvesting and chemical destruction of macrophytes (e.g. water hyacinth).</li> <li>■ Alternative utilization of aquatic weeds</li> <li>■ Dredging of silted water ways</li> </ul>	All stakeholders
3. Watershed Management Policy	<ul style="list-style-type: none"> <li>■ Afforestation</li> <li>■ Waterways &amp; dam management</li> </ul>	All Ecozones	<ul style="list-style-type: none"> <li>■ Research &amp; alternative fish processing strategies (e.g. utilization of solar energy)</li> <li>■ Dredging of silted water ways</li> </ul>	All levels of government & all stakeholders
<b>Long term Needs</b>				
1. CC Monitoring Policy 2. Watershed Management Policy	<ul style="list-style-type: none"> <li>■ Programmes noted above should be continuous long term programmes</li> </ul>	All Ecozones		

**Table 12** Evaluation of Proposed Policies: **Fishery Resources Sub-sector**

CCA Options Addressed by Proposed Policies & Programs	Criteria to Evaluate Effectiveness of Policy Implementation	Implications if Policy IS Implemented (individuals, communities, private sector)		Implications if Policy NOT Implemented (individuals, communities, private sector)	
		Positive Impacts	Negative Impacts	Positive Impacts	Negative Impacts
<b>Immediate Needs</b>					
Climate Change Awareness Policy	<ul style="list-style-type: none"> <li>■ Level of awareness in government circles, among stakeholders and the public</li> </ul>	<ul style="list-style-type: none"> <li>■ Individual communities and private sector have relevant information to handle CC hazards</li> </ul>	None	None	<ul style="list-style-type: none"> <li>■ The status quo is maintained or the situation gets worse</li> </ul>
Climate Change Monitoring Policy	<ul style="list-style-type: none"> <li>■ Number of monitoring programmes in place</li> </ul>	<ul style="list-style-type: none"> <li>■ Ability to predict CC hazards accurately</li> </ul>	None	None	<ul style="list-style-type: none"> <li>■ Fisheries resources lost</li> </ul>
Watershed Management Policy	<ul style="list-style-type: none"> <li>■ Number of monitoring reports prepared</li> </ul>	<ul style="list-style-type: none"> <li>■ Improvement of all resources including fisheries</li> </ul>	None	None	<ul style="list-style-type: none"> <li>■ Watersheds destroyed</li> </ul>
<b>Long Term Needs</b>					
Programmes noted above should be continuous long term programmes					

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# Climate Change Adaptation Strategy Technical Report

## Health and Sanitation Sector

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## Introduction to Health and Sanitation Sector

Health is a state of complete physical, mental, psychological and social well-being, and not just merely the absence of disease or infirmity (WHO, 1996). Health depends on the adequate supply of nourishing food, safe and adequate drinking water, and secure shelter for protection (WHO & UNICEF, 2006).

Sanitation refers to the set of plans used to achieve the protection of public health by removing and treating wastes in land, water and air. The World Health Organization (WHO) refers to sanitation as a process of disposing of human excreta in a manner that protects public and environmental health (WHO & UNICEF, 2006). Bracken *et al.* (2005) define sustainable sanitation as a system which protects and promotes human health, does not contribute to *environmental* degradation or depletion of the natural resource base, and is technically and institutionally appropriate, economically viable and socially acceptable. Improved sanitation is defined by the World Health Organization as connection to a public sewer, connection to a septic system, a pour-flush latrine, a simple pit latrine or a ventilated improved pit latrine.

Fewtrell *et al.* (2005) noted that improved sanitation had a direct positive effect in reducing morbidity and mortality, especially for vector-borne and water-borne diseases. The Joint Monitoring Programme (JMP) of the WHO and the United Nations Children's Fund (UNICEF) reported in 2004 that the number of people lacking basic sanitation services rose from 2.1 billion in 2001 to 2.6 billion by 2004. Progress in improvement of water-borne sanitation systems will be further challenged by climate change and climate variability.

There is a relationship between water contamination due to inappropriate sanitation and the spread of diseases like diarrhea, cholera, typhoid, polio, schistosomiasis, hookworm, amoebiasis and enteritis. WHO (2006) reported that diarrhea alone from unsafe water sanitation and lack of hygiene causes 1.8 million deaths per year, 90% of which are children under five years of age (SIWI, 2005).

Good sanitation positively affects an individual's nutritional status, diseases resistance, income opportunities, self-esteem and personal security (EcoSanRes, 2008). Improper sanitation on the other hand impacts human health and environmental safety when individuals are unhygienic and contaminate the human and natural environment.

Sanitation is vital for health: poor hygiene and lack of access to toilets together account for 1.5 million diarrhea-related children's (under-five) deaths each year (UNICEF, 2009). Children weakened by frequent episodes of diarrhea are more vulnerable to malnutrition and opportunistic infection such as pneumonia. This implies that four in ten children will not reach their full educational potential. Each year, 443 million school days are lost due to diarrhea (Watkins *et al.*, 2006). Sanitation is a good economic investment: Improved sanitation has positive impacts on economic growth and poverty reduction. Sanitation contributes to social development via less illness, improved nutrition among children, increased learning and retention among schoolchildren, higher work productivity among adults and more dignity and privacy for everybody, especially women and girls. Sanitation also helps the environment through improved disposal of waste products and the quality of drinking-water sources.

## Assessment of Current and Predicted Hazards, Impacts and Vulnerabilities

### Sub-sector 1: Sanitation

A climate hazard is a physically defined climate event with the potential to cause harm (such as heavy rainfall, drought, storm) or long-term change in climatic variables (such as temperature and precipitation) (UNDP, 2005). Vulnerability to climate change is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change (IPCC, 2001)

There are at least 2.6 billion people in the world without adequate sanitation (WHO & UNICEF, 2000). In Nigeria, estimates from 2004 show that less than half of the Nigerian population has access to improved sanitation facilities (UNICEF, 2009). Close to 6,000 children die each day from diseases related to inadequate sanitation and hygiene (UN, 2002). The main health risk associated with poor sanitation is an increase in the frequency of parasites that have human fecal origin. More than 60% of the population in urban areas in Nigeria depends on water for flushing or pouring into toilets to carry away excreta to septic tanks. Changes in rainfall pattern, their seasonality and spatial distribution will influence quantity and quality of water resources. Water-based sanitation systems will be most vulnerable to water scarcity and will affect health by increasing vector- and water-borne diseases. Urban areas of Nigeria are therefore most vulnerable to water scarcity due to climate change. Urbanization and increasing population will exacerbate water shortages in urban areas. In Nigeria, domestic waste is generally disposed of in uncontrolled and unmanaged dump sites, where it is frequently burnt at low temperatures, releasing airborne contaminants into the atmosphere. Leachates (contaminants leaching from landfill sites into water sources) and unconsolidated wastes from uncontrolled dump sites enter surface and groundwater.

EcoSanRes (2009) indicate that about one billion people are infected with roundworm and 700 million with hookworm that arise from uncontained and untreated human excreta that pollutes groundwater tables, streams, lakes and coastal zones. The common approach of using water to carry away unwanted residuals and valuable nutrients increases the likelihood of further water contamination, which will increase in areas where climate change is predicted to cause increased flooding.

Sommer (2008) made reference to adolescent girls dropping out of school due to a lack of sufficient sanitation, to parental concerns about inadequate and unsafe facilities, and to girls' fears – and real experiences – of sexual violence in and around unsafe toilets. Poor sanitation is a contributing factor in Nigeria's low enrolment rates for girls (UNICEF, 2005). Girls may need to walk long distances in order to fetch water, thus preventing them from attending school. Where climate change exacerbates these latter conditions, children and particularly young women will be at greater risk to the impacts of climate change.

More than 2.3 billion people globally still live without access to sanitation facilities (Burgers, 2008) and are unable to practice such basic hygiene as washing their hands with soap and water. Diseases related to poor sanitation and water availability cause many people to fall ill or even die and children are the most vulnerable to these health hazards. Inadequate sanitation is the cause of diarrhea in Nigeria (WaterAid, 2008). It is the second largest direct cause of childhood mortality in Nigeria, and is a major contributing factor to malnutrition and other diseases such as pneumonia. Poor sanitation leads to infestation of nearly 20 million people, the majority of whom are children, with a variety of diarrhea, trachoma, (eye infection), schistosomiasis, scabies and guinea worm, roundworm, whip-worm, hookworm, fluke and other parasitic infections. Poor sanitation also affects nutrition, aggravating malnutrition and retarding children's physical development. As well, parasites and worms destroy the tissues and organs in which they live, causing pain and various additional health problems. These diseases also compromise children's attendance and performance at school. The impact of climate change on water resources both in terms of reduced water availability in some areas and flooding causing contamination of water in other areas will have a negative impact on the already poor sanitation situation in Nigeria.

## Assessment of Climate Change Impacts, Vulnerability and Adaptation Options

Nigeria is one of the countries in the northern hemisphere that the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC-AR4) concluded global warming is unequivocal (IPCC, 2007). The report indicates global temperature increases of 1.1°C to 6.4°C and sea level rise of 0.18 to 0.59 metres may occur by 2099. Adaptation – which moderates harm or exploits beneficial opportunities (IPCC, 2007) – is an adjustment in natural or human system in response to actual or expected climatic stimuli or their effects.

This report assesses the impact of climate change in Nigeria in a framework cutting across all sectors of the socio-economic segments and gender. For example, climate change will affect water quality and quantity in Nigeria; this in turn will affect health, which will lead to a reduction in education enrolment, participation and learning. As education is affected, there are social and economic development and productivity impacts related to poverty, wealth creation, employment, and social security and crime (kidnapping, for example).

There are many examples of high vulnerability in Nigeria. For example, 54% of toilets installed in Nigeria do not function, or they are under lock and key, or they have been converted to other uses, like storage rooms, etc. (Ogwo & Agukoronye, 2009). The toilet systems that are working in Nigeria are already overstressed, with more than 100 students in a school using one toilet. Water scarcity due to climate change will exacerbate these stresses.

The following table assembles information on climate change hazards, impacts, vulnerability and adaptation options regarding the sanitation sector.

**Table 1** Hazards-Impacts-Vulnerability-Adaption Options Matrix for the Health and Sanitation: **Sanitation Sub-sector**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: COASTAL/RAINFOREST</b>			
Increased rainfall intensity leading to flooding	<ul style="list-style-type: none"> <li>■ flooding</li> <li>■ dump sites provide breeding ground for pathogen, vectors, pests</li> <li>■ dump sites produce leachates, which floods carry to surface water and groundwater through seepage</li> <li>■ garbage blocks roads &amp; water channels, barriers to road traffic</li> <li>■ toilets will back flow</li> </ul>	<ul style="list-style-type: none"> <li>■ poorly equipped health centre leads to spread of water-borne and vector-borne diseases</li> </ul>	<ul style="list-style-type: none"> <li>■ provide adequate drainage, clearing of blocked channels; implement integrated solid waste management</li> <li>■ recycle and reuse waste water and flood water instead of discharging into surface water: sanitary landfills with leachate protection systems</li> <li>■ extend waste collection and disposal beyond the state capitals</li> <li>■ devise dry/ecological sanitation</li> <li>■ create awareness, waste management education</li> </ul>
High temperatures	<ul style="list-style-type: none"> <li>■ excessive heat and rapid decomposition of organic waste causing foul odour &amp; methane emission</li> </ul>	<ul style="list-style-type: none"> <li>■ generally poor sanitation systems exist</li> </ul>	<ul style="list-style-type: none"> <li>■ methane capture facilities for subsequent incineration to produce electricity</li> <li>■ provide biogas collection and utilization system</li> </ul>
<b>Ecozone: SAVANNA</b>			
High temperature	<ul style="list-style-type: none"> <li>■ pathogens have optimum temperature for proliferation and spread of diseases</li> </ul>	<ul style="list-style-type: none"> <li>■ poor health &amp; sanitation infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>■ waste composting to convert waste to manure</li> </ul>
High rainfall intensity	<ul style="list-style-type: none"> <li>■ flooding, erosion and water logging causes movement of debris and silting of surface water, eutrophication*, algal bloom†, proliferation of weeds, etc.</li> </ul>	<ul style="list-style-type: none"> <li>■ high local dependence on local water bodies for water source</li> </ul>	<ul style="list-style-type: none"> <li>■ flood water harvesting, recycling and reuse</li> <li>■ rainwater harvesting</li> </ul>
<b>Ecozone: SAHEL</b>			
High temperatures	<ul style="list-style-type: none"> <li>■ water scarcity</li> <li>■ heat stress for humans &amp; livestock</li> </ul>	<ul style="list-style-type: none"> <li>■ dependence on declining water supplies</li> <li>■ lack of health and sanitation infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>■ waste composting</li> <li>■ rainwater harvesting</li> </ul>
Extreme weather events (windstorms, heat waves, dust storms, dust haze)	<ul style="list-style-type: none"> <li>■ low visibility for road, air traffic</li> <li>■ increase in respiratory diseases</li> <li>■ increase in cholera</li> <li>■ reduced labour productivity</li> <li>■ reduced school environment due to ill-equipped medical centre</li> <li>■ increased methane emissions</li> <li>■ fire hazards from burning dump sites</li> </ul>		

\*Excessive enriching by nutrients

† Rapid growth of algae

## Review of Existing Governance, Policies and Programmes

Some of the relevant existing policies for domestic and industrial sanitation in Nigeria include:

- Waste management regulation. S.I. 15 of 1991;
- Pollution Abatement in Industries and Facilities Generating Wastes Regulation. S.I.9 of 1991;
- National Effluent Limitation Regulations. S.I.8 of 1991;
- National Guidelines and Standards for Environmental Pollution Control in Nigeria (March, 1991);
- Harmful Waste [special criminal provision] Act cap 165 LFN 1990;
- National Policy on the Environment (1989; revised in 1999);
- Green Agenda of the Vision 2010;
- Report of the Vision 2020 National Technical Working Group on Water and Sanitation July, 2009;
- Chapter 11 of the Constitution of the Federal Republic of Nigeria, which deals with environmental objectives and states that the State shall protect and improve the environment and safeguard the water, air and land, forest and wildlife in Nigeria;
- The Constitutional provision in Nigeria that the Local Government Areas (LGAs) shall be responsible for waste disposal;
- The Fourth National Development Plan (1981-1985) recognized environmental impact assessment (EIA) as a tool for development. Some form of EIA started in the oil industry in the mid-1980s and has gradually been included in various national documents on environment, construction and agricultural policies, with the passage of the EIA Act in 1992;
- National Policy on the Environment (1989);
- The Harmful Wastes Act (1990);
- National Water-sanitation policy;
- National Environmental sanitation policy;
- New strategy for scaling-up rural sanitation; and
- National water and sanitation policy.

Relevant government institutions and stakeholders in Nigeria include:

- The Ministry of Petroleum Resources (1960-1970's);
- Urban Development and Environmental Division in the Ministry of Economic Development (1975);
- Federal Ministry of Works and Housing (1979);
- Federal Environmental Protection Agency (1988);
- Federal Ministry of Agriculture and Water Resources;
- Federal Ministry of Mines, Power and Energy; and
- The Ministry of Environment (1999), which took over the activities and functions of FEPA and the environmentally relevant units such as forestry from Ministry of Agriculture and environmental health and sanitation from the Ministry of Health.

A review of policy documents in Nigeria indicates climate change has not yet been included in policies or programmes at the national, state and local government levels, suggesting an urgent need to integrate climate change adaptation into existing and future policies in the Nigeria.

**Table 2** Policies, Programmes, Adaptation Options Addressed, Implementing Agency, and Costs for Health and Sanitation: **Sanitation Sub-sector**

Proposed CCA Policies	Proposed CCA Programmes	Ecozone Addressed	CCA Options Addressed by Proposed Policies and Programmes	Implementation Agency (s)	Estimated Costs
<b>Immediate Needs</b>					
Climate Change Policy Bill	<ul style="list-style-type: none"> <li>■ Awareness programmes in communication, water and sanitation, programme monitoring and evaluation</li> </ul>	All ecozones	<ul style="list-style-type: none"> <li>■ Improve awareness of CC† adaption options</li> </ul>	Ministry of Information, Ministry of Environment, NESREA	Medium
Resource Recovery Policy Integrated Water Resource Management	<ul style="list-style-type: none"> <li>■ Flood harvesting programme</li> <li>■ Rooftop rainwater harvesting</li> <li>■ Aquifer recharge programme</li> <li>■ Water use efficiency recycling, reuse programmes</li> <li>■ Erosion control</li> <li>■ Nutrient enrichment programmes</li> </ul>	All ecozones	<ul style="list-style-type: none"> <li>■ Protection of sanitation infrastructure &amp; groundwater from pollution</li> <li>■ Increase water availability</li> </ul>	Water Resource Management Ministry, UNDP, CIDA, DFID, NGOs, Ecological Fund	Medium
Waste Management Policy	<ul style="list-style-type: none"> <li>■ Domestic littering</li> <li>■ Industrial/commercial discharge control</li> <li>■ Leachate control programme and better drainage</li> <li>■ Waste management</li> </ul>	All ecozones	<ul style="list-style-type: none"> <li>■ Reduce emissions levels from burning of waste</li> </ul>	Ministry of Environment NGOs	Medium
Sanitation Diversification Policy	<ul style="list-style-type: none"> <li>■ Dry sanitation</li> <li>■ Low-flush toilets</li> <li>■ Ecological sanitation programme</li> <li>■ Resource-oriented sanitation</li> <li>■ Waste composting</li> </ul>		<ul style="list-style-type: none"> <li>■ Reduce dependency on water as medium for conveying waste</li> </ul>	Ministry of Environment	

CC = climate change; CCA = climate change adaptation; CIDA = Canadian International Development Agency; DFID = Department for International Development; NESREA = National Environmental Standards and Regulations Enforcement Agency; NGO = non-governmental organization; UNDP = United Nations Development Programme.

## Sub-sector 2: Health

### Introduction

The earth is warming, the warming is accelerating, and human actions are responsible. If the current climate change trends remain uncontrolled, humanity will face more injury, disease and death related to natural disasters and heat waves; high rates of food-borne, water-borne and vector-borne illness; and more premature death and disease related to air pollution. Moreover, in many parts of the world (including Nigeria), large populations will be displaced by rising sea levels, flood, drought and famine.

There is an urgent need address a wide range of issues related to human health, including:

- provision of clean water and sanitation;
- safe and adequate food;
- deepening of existing earth dams;
- establishment of irrigation projects;
- disease surveillance;
- immunization and treatment;
- safe and effective disease and vector control;
- protection of people from heat waves, sea level rise, and flood and erosion; and
- strengthening of primary health structure and facilities to be responsive to emergencies associated with climate change.

Effective adaptation to climate change in Nigeria requires the building of partnerships to leverage the expertise of government agencies, intergovernmental and nongovernmental organizations, industry and professional groups and local communities. There is need to put public health at the heart of the climate change agenda and adaptation strategies. There is an immediate need for health education and mass media campaigns strong enough to spark commitment and action among governments, international organizations, donors, and civil society, and most importantly amid the communities, for sustainable adaptation strategies to health challenges associated with climate change.

Global socio-economic development and health interventions have improved the general standard of living in recent times, but the resulting deteriorating global environmental conditions or factors are now affecting human health (Nwoke & Nwoke, 2008). The major global environmental changes significantly affecting health according to WHO (1996) and McMichael (1996) include climate change and ozone layer depletion.

The primary activity in Nigeria that adds to climate change is the release of harmful substances into the atmosphere from the oil and gas extraction sector, mainly from gas flaring throughout the Niger Delta and offshore. The secondary activity is the cutting of trees and loss of forest from logging, and the use of trees as firewood and for wood products. In fact, Nigeria destroys about 600,000 hectares of her forest annually in feeding these industries.

Nigeria as a developing nation has a large part of its economy dependent on natural resources, which are particularly vulnerable to climate change impacts. When these resources are affected, the whole range of the socio-economic life of its people is greatly affected.

The potential health impact of climate change is grouped into direct and indirect effects (Patz and Balbus, 1996) depending on whether they occur predominantly via the impact of climate variables upon human biology or are mediated by climate-induced changes on biological and biogeochemical systems.

In Nigeria, direct impacts of climate change stem from extreme events such as heat waves, floods, landslides, droughts, windstorms, and wildfires. Indirect effects of climate change on health may arise from the disruption of natural systems, causing infectious disease, malnutrition, food- and water-borne illness, and increased air pollution.

## Assessment of Current and Future Trends

### Direct Impacts

#### Heat Waves

An increase in mean summer and winter temperatures would mean a direct increase in thermal-related diseases and deaths. The National Science and Technology Council of the USA (2008) reported that there has been a 50% increase in the number of unusually warm nights, which deprives the body of breaks from the heat. The elderly and young children are most susceptible to the effects of heat stress. Most heat-related deaths occur in cities, where what is known as the urban heat island effect can potentially amplify temperatures as much as 10°C. Low-income families are especially vulnerable to heat because they may have less access to adaptive features such as thorough insulation or air-conditioning (Hoerner & Robinson, 2008).

#### Sea Level Rising/Floods, Droughts, and Wildfires

Human settlement in Nigeria is affected by climate change in a variety of ways. These include extreme climatic changes such as sea-level rise, tropical storms, floods, landslides, winds, heat and cold. Sea-level rise has disrupted urban and rural populations and led to their relocation. It has already threatened the facilities of low-lying coastal populations at risk, as evidenced in Lagos and some of the coastal communities in the Niger Delta region.

The intense rainfall increases the risk of flooding, which can introduce chemicals, pesticides, and heavy metals into water systems and increase the risk of water-borne disease outbreak.

Nigerians already suffer from nutritional imbalances. Droughts destroy crops and grazing land, reduce the quantity and quality of water resources and cause famine because they ruin crops; all of which consequently result in malnutrition.

The frequency and intensity of wildfires have been increased by drought. In addition to destroying homes and property, these wildfires can cause eye and respiratory diseases. Strong tropical storms, like Hurricane Katrina in 2005, are also likely to become more common with climate change (the USA's National Science and Technology Council, 2008). The trauma associated with such intense wildfires lead to post-traumatic stress disorder, grief, depression, anxiety disorders, somatoform disorders, and drug and alcohol abuse.

### Indirect Impacts

#### Food Production

One of the major indirect impacts of global climate change upon human health could occur via effects upon cereal crop production. Cereal grains account for around 66% of all foodstuffs consumed by humans. These impacts would occur via the effects of variations in temperature and moisture upon germination, growth, and photosynthesis, as well as via indirect effects upon plant diseases, the predator-pest relationship, and supplies of irrigation water. Globally, approximately 800 million people are currently undernourished. Climate change is likely to further affect food production, distribution, and storage, especially in sub-Saharan Africa (Epstein, 2005). Water availability is also projected to decrease with climate change (Epstein, 2005). Resource scarcity coupled with population growth can lead to war, political instability, poverty, substance abuse, crop failure, rising consumer prices, and the disruption of social structure.

#### Food and Water-Borne Disease

Global climate change interferes with ecological systems interaction, thereby altering the hydrologic cycle not only by altering mean meteorological measures but by increasing the frequency of extreme events such as excessive precipitation, storm surges, floods and droughts. These extreme weather-related events can affect water availability, quality, or access, posing a threat to human populations. Water-borne pathogens often act in concert through two major exposure pathways: drinking water and recreational water use.

WHO (1996) noted that with global climate change, outbreaks of food and water-borne infectious diseases such as diarrhea, *Cryptosporidium*, *Giardia*, *Salmonella*, *E. coli*, and rotavirus are projected to increase. These diseases occur as a result of the contamination of water supplies through the disruption of water and sanitation systems, which can be caused by toxic runoff from increased rainfall and flooding. Food contamination can result from lack of air-conditioning or refrigeration; for example, higher temperatures in Europe were found to contribute to an estimated increase of 30% of cases of *Salmonella*

(Patz, 2005; Kovats *et al.*, 2004). Developing countries are particularly susceptible to this, as water carries wastes, shallow water provides breeding conditions for mosquitoes, and drainage and sewage systems can become backed up. Water treatment facilities can become damaged, which can result in the distribution of untreated or improperly treated water. Sewer and water pipes can break, which can cause drinking water to become contaminated with sewage. Floods can also transport fecal matter from the ground or from sewers that have overflowed, and contaminate wells, boreholes and surface waters. Children are especially vulnerable to food and water borne-diseases because they are more likely to die from dehydration from diarrhea and vomiting. Minority children and children of lower socio-economic status in areas that lack adequate capacity to provide food and water supplies are at the greatest risk (Kovats *et al.*, 2004)

While droughts minimize the amount of runoff, they can also cause the water quality to decrease. Sediment and minerals, such as iron and manganese, are more concentrated toward the bottom of the water supply. During a drought, when the level of water decreases, the concentration of sediment and minerals in the water increases.

### **Air Pollution and Aeroallergens**

Climate change is projected to cause more respiratory disease. Higher temperatures cause ground-level ozone to increase, and short-term exposure to ozone increases the rate and severity of asthma attacks, causes nasal and eye irritation, coughs, bronchitis, and respiratory infections. Higher temperatures also enhance the production of various secondary air pollutants or aeroallergens. The increased production of these aeroallergens (spores, pollens) – concentrations of which are projected to increase with increasing temperature – exacerbates asthma and other allergic diseases. Consequently, there is an increase in the frequency of allergic and cardio-respiratory disorders and deaths caused by these air pollutants.

The International Panel on Climate Change (IPCC) 2007 report states that children are more vulnerable to these effects because they take in more air per body weight than adults and have narrower airways. For example, ragweed is a particularly important risk to human health: It has highly allergic pollen and is spreading in several parts of the world (IPCC, 2007). Moore *et al.* (2008) further noted that allergic reactions to poison ivy may also increase because these plants grow faster and become more potent when carbon dioxide levels are higher. Furthermore, algal blooms, which may cause respiratory irritation, are increasing on a global scale.

### **Climate Change and Vector-Borne Diseases**

One of the indirect effects of climate change on health is that the resulting changes in temperature and precipitation, as well as other climatic factors, influence the behavior, incidence, and geographical distribution (as well as emergence and re-emergence) of vector-borne diseases (Patz *et al.*, 1996).

The important determinants in the spread of vector-borne parasitic diseases are especially influenced by fluctuation in climatic variables, notably temperature, precipitation, humidity, surface water availability and wind, as well as biotic factors. Against this background, the current climate change scenario is expected to cause a widespread shift in the pattern of a number of infectious diseases, and alter the life-cycle dynamics of vectors and parasites (Nwoke *et al.*, 2005). According to WHO (1996), vector-borne diseases that are most likely to be affected by rising temperatures are malaria, schistosomiasis, river blindness (onchocerciasis) and dengue fever. Others that are less likely to include lymphatic filariasis, guinea worm, African and American trypanosomiasis, leishmaniasis and yellow fever.

The influence of climate change on these vector-borne parasitic diseases can be direct or indirect on the vector biology. For instance, an increase in temperature accelerates the vector's metabolic rates, which consequently affects the nutritional requirement of the vector. Under such conditions, the blood-sucking vectors, such as mosquitoes, sand flies and black flies, feed more frequently, leading to increased egg production. This in turn increases the transmission potential of these vectors.

Rising temperatures linked to climate change led to malaria epidemics and its re-emergence in Rwanda in 1987 (Loevinsohn, 1994), in Tanzania (Matolo *et al.*, 1987), in Pakistan's northeast (Bourma *et al.*, 1994) and in the deforested East Africa highlands

(Lindsay and Martens, 1998), as well as in Western Kenya (Githeko *et al.*, 2000). Costello *et al.* (2009) noted that, by 2080, it is estimated that 260 to 320 million more people around the world will be affected by malaria as a result of climate change. Children are most at risk and about 75% of malaria deaths occur in children under five (Krause, 2000).

Other vector-borne diseases have been observed to shift from known geographical boundaries. For instance, since 1953, the climatic conditions in the Sahel region of Africa (including Nigeria) have become drier and harsher and, as a result, the northern boundaries of tsetse fly and African trypanosomiasis distribution has shifted 50 km to 100 km southwards (Laveissière & Hervouët, 1991). This no doubt has contributed to negatively impacting the trypanosomiasis transmission and distribution in the Sahel region (Cattand, 1993). Linked also to higher temperature and low humidity, the cerebrospinal meningitis endemicity boundary has now shifted southwards in Nigeria and leishmaniasis, which previously did not exist in Nigeria, is now being reported in the northern part of the country. Onchocerciasis (river blindness) studies on the impact of climate change on the black fly vector population in West Africa have shown that if temperature and precipitation change across areas immediately south of the Sahel region, as predicted by the General Circulation Model (GCM), the onchocerciasis vector population of black flies could increase by as much as 25% at the current breeding sites (Garms *et al.*, 1979; Walsh *et al.*, 1993; Mills, 1995; Nwoke, 1988; Nwoke *et al.*, 2007 and 2009). Schistosomiasis is another major parasitic disease with a water-related vector (aquatic snails) that climate change will definitely affect through the disease emergence and re-emergence (Prah & James, 1997; WHO, 1996; Nwoke *et al.*, 2005; Nwoke & Nwoke, 2008).

The following table assembles information on climate change hazards, impacts, vulnerability and adaptation options in regard to the health and sanitation sector.

**Table 3 Hazards-Impacts-Vulnerability-Adaptation Options Matrix for Health and Sanitation: Human Health Sub-sector**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: COASTAL/RAINFOREST</b>			
<p>Increased intensity of rainfall</p> <p>Rising sea level, with resultant coastal flooding and erosion</p> <p>Extreme weather conditions: severe windstorms and thunderstorms</p> <p>Late onset of rain and irregular rainfall pattern</p> <p>Delayed onset and shorter harmattan (dry, hot and dusty wind)</p>	<ul style="list-style-type: none"> <li>■ Flooding with resultant water contamination by the introduction of chemicals, pesticides &amp; heavy metals into water systems, as well as increased erosion</li> <li>■ Reduced access to potable water for domestic use &amp; resultant infections</li> <li>■ Outbreaks of water- and food-borne diseases through destruction &amp; disruption, as well as contamination of drinking &amp; recreation water supplies (diarrhea diseases: cholera, <i>E. coli</i>, <i>Cryptosporidium</i> infection, giardiasis (<i>Giardia</i>), shigellosis and typhoid, &amp; viruses such as hepatitis A)</li> <li>■ Destruction of homes, property &amp; health infrastructure by extreme weather events</li> <li>■ Displacement &amp; resettlement of communities</li> <li>■ Creation of breeding sites for vector-borne diseases resulting in outbreaks &amp;/or increased prevalence, as well as mortality and morbidity due to malaria, yellow fever, dengue</li> <li>■ Reduced food production &amp; consequent malnutrition</li> <li>■ Destruction of fishing &amp; fishing/farming populations</li> <li>■ Southward shift in the prevalence &amp; pattern of trypanosomiasis (transmitted by the tsetse fly) favouring areas with vegetation; &amp; emergence of cerebrospinal meningitis favouring higher temperature &amp; low humidity in the south of the country</li> </ul>	<ul style="list-style-type: none"> <li>■ Use of weak asbestos pipes for water system and supplies</li> <li>■ Poorly established primary health care framework &amp;/or poorly constructed infrastructure</li> <li>■ Children are more vulnerable to food and water-borne diseases because they are more likely to die from diarrhea and vomiting. Women of lower socio-economic status &amp; their children in areas that lack adequate capacity to provide food &amp; water supplies are at the greatest risk</li> <li>■ Complete dependence on rain-fed agriculture</li> <li>■ Complete dependence on fishing</li> <li>■ The very old, the very young &amp; the frail are very susceptible</li> <li>■ People in cities with less access to air-conditioning are at risk</li> </ul>	<ul style="list-style-type: none"> <li>■ Construction of water systems with strong materials</li> <li>■ Rain water harvesting &amp; boreholes</li> <li>■ Construction of flood-protecting structures</li> <li>■ Rebuilding &amp; maintaining of public health infrastructure to be responsive to emergencies</li> <li>■ Strengthening of primary health care system/framework to be responsive to emergencies</li> <li>■ Protection of population from disease transmission (immunization &amp; treatment, use of insecticide-treated nets)</li> <li>■ Diversification of occupations- Introduction/rehabilitation of irrigation, as well as de-silting of existing earth dams, where applicable</li> <li>■ Protection of population, especially children, mothers and non-immune population from disease transmission (immunization &amp; treatment, use of insecticide-treated nets)</li> <li>■ Education, awareness-raising that enables people to make well-informed, long-term, sustainable decisions</li> </ul>
<b>Ecozone: SAVANNA and SAHEL</b>			
<p>Low rainfall frequency (late arrival and early cessation of rain) resulting in decreased volume of surface water bodies (wells, dams, ponds, rivers), sometimes due to siltation</p> <p>Extreme weather conditions: increased windstorms, heat waves</p> <p>Increased aridity leading to more</p>	<ul style="list-style-type: none"> <li>■ Reduced food production &amp; consequent malnutrition</li> <li>■ Displacement and resettlement of communities by drought, wildfire or flooding/storm</li> <li>■ Destruction of health infrastructure by extreme weather events</li> <li>■ Outbreaks of water- and food-borne diseases through destruction and disruption, as well as contamination of drinking &amp; recreational water supplies</li> <li>■ Thermal-related diseases &amp; death</li> <li>■ Enhancement of breeding sites of vectors of human diseases, which may result in the outbreak &amp;/or emergence of vector-borne diseases</li> </ul>	<ul style="list-style-type: none"> <li>■ Areas completely dependent on rain-fed agriculture</li> <li>■ Children &amp; low-income women are highly vulnerable to malnutrition &amp; food- and water-borne diseases</li> <li>■ Male herders are vulnerable</li> <li>■ Areas with poorly established primary health framework/ infrastructure are vulnerable</li> <li>■ Women of lower socio-economic status &amp; their children in areas that lack adequate capacity to provide food &amp; water supplies are at the greatest risk</li> <li>■ Communities with less access to adaptive features such as air-conditioning, especially in cities, are at risk; persons with pre-existing diseases, especially cardiovascular &amp; respiratory disorders, are most vulnerable</li> <li>■ The very old, the very young &amp; the frail are very susceptible</li> </ul>	<ul style="list-style-type: none"> <li>■ Introduction/rehabilitation irrigation</li> <li>■ Deepening of existing earth dams, where applicable</li> <li>■ Rainwater harvesting and boreholes</li> <li>■ Strengthening primary health care system/framework to be responsive to emergencies</li> <li>■ Protecting population from disease transmission (immunization and treatment, use of insecticide-treated nets)</li> <li>■ Provision of adaptive features against thermal-related diseases &amp; death (insulation of housing, air conditioners, tree planting)</li> <li>■ Better education, awareness-raising that enables people to make well-informed, long-term, sustainable decisions</li> </ul>

## Review of Existing Governance, Policies and Programmes

The Nigerian government has made great strides in the provision of modern health care to its population in the years since World War II, particularly in the period after independence. Among the most notable accomplishments has been the expansion of medical education, the control of many infectious diseases and disease vectors, and the provision of primary health care in many urban and rural areas. In the late 1980s, a large increase in vaccination against major childhood diseases and a significant expansion of primary health care became the cornerstones of the government's health policies.

In August 1987, the federal government launched its Primary Health Care plan (PHC), which President Ibrahim Babangida announced as the cornerstone of health policy. Intended to affect the entire national population, its main stated objectives included accelerated health care personnel development, improved collection and monitoring of health data, ensured availability of essential drugs in all areas of the country, implementation of an Expanded Programme on Immunization (EPI), improved nutrition throughout the country, promotion of health awareness, development of a national family health programme, and widespread promotion of oral rehydration therapy for treatment of diarrheal disease in infants and children. Implementation of these programmes was intended to take place mainly through collaboration between the Ministry of Health and participating local government councils, which received direct grants from the federal government. Of these objectives, the EPI recorded the most success initially, but its goal of 90% coverage was not attained.

The National Health Policy and Strategy to achieve health for all Nigerians was promulgated in 1988 and revised in 2004. The main policy thrust focuses on the national health system and its management, national health care resources, national health interventions and services delivery, National Health Information Systems, Partnership for Health Development, Health Research and National Health Care Laws. The overall policy objective is to strengthen the national health system such that it would be able to provide effective, efficient, quality, accessible and affordable health services that will improve the health status of Nigerians through the achievement of the health-related Millennium Development Goals (MDGs).

Based on primary health care, the revised national health policy aims at bringing about a comprehensive health care system that is promotive, protective, preventive, restorative and rehabilitative to every citizen of the country within the available resources. Through this policy, it is hoped that individuals and communities are assured of productivity, social well-being and enjoyment of living. The revised national health policy also aims at a guaranteed minimum health care package for all Nigerians.

The health services, based on primary health care, include among other things: an articulated programme of information, education and communication, which includes specific programmes on school health services concerning prevailing health problems and the methods of preventing as well as controlling them; promotion of food supply and proper nutrition; adequate supply of safe water and basic sanitation; maternal and child care, including family planning; immunization against the major infectious diseases; prevention and control of locally endemic and epidemic diseases; appropriate treatment of common diseases and injuries; provision of essential drugs and supplies; promotion of a programme on mental health; and promotion of a programme on oral health.

The national health care system is built on the basis of the three-tier responsibilities of the federal, state and local governments. Health service management is thus decentralized at the three-tier levels: primary health care, secondary health care, and tertiary health care. Primary health care involves the provision of health care services by the local governments, with support from the State Ministry of Health and within the overall national health policy. Private medical practitioners also provide health care at this level. At the secondary health care level, specialized services are provided to patients referred from the primary health care level through out-patient and in-patient services of hospitals for general medical, surgical, pediatric patients and community health services. Secondary health care is available at the district, divisional and zonal levels of the states. Adequate supportive services such as laboratory, diagnostic, blood bank, rehabilitation and physiotherapy are also provided. Tertiary health care consists of highly specialized services provided by teaching hospitals and other specialist hospitals which provide care for specific diseases such as orthopedic, eye, psychiatric, maternity and pediatric cases. Care is taken to ensure an even distribution of these hospitals. Also, appropriate support services are incorporated into the development of these tertiary facilities to provide

effective referral services. Similarly, selected centres are encouraged to develop special expertise in advantageous modern technology to serve as resources for evaluating and adapting these new developments in the context of local needs and opportunities.

The long-term goal is that eventually all Nigerians shall have easy access not only to primary health care facilities, but also to secondary and tertiary levels, as required. Particular attention is placed on the needs of remote and isolated communities that have special logistic problems in providing access to the referral system.

To further the overall national health policy, the state governments and the Federal Ministry of Health work closely with voluntary agencies, private practitioners and other NGOs to ensure that the services provided by these other agencies are in line with the overall national policy. The coordination process is enhanced with the establishment of a National Hospital Services Agency.

The national health policy also has mechanisms established to ensure that all sectors related to health and all aspects of national and community development – in particular, agriculture, animal husbandry, rural development, food, industry, education, social development, housing, transportation, water supply, sanitation and communications – are involved and their health-related activities are coordinated.

The revised national health policy has in place measures to ensure effective community involvement in health care, and these include the following:

1. Appropriate mechanisms for involving communities in the planning and implementation of services on matters affecting their health, as devised by the governments of the Federation.
2. Such mechanisms provide for appropriate consultations at the community level regarding local health services, based on increasing self-reliance. The traditional system and community organizations (cultural and religious associations) are to be fully utilized in reaching Nigerians.
3. Consultation of accredited groups and associations representing various interests within society, including the various professional associations by the Federal and State Ministries of Health shall therefore, be responsible for the health care of the citizens living in such communities.
4. The Armed Forces and Police Barracks are usually not taken care of by the LGAs in which they are located. The Ministry of Defense and Police shall, therefore, be responsible for the health care of the citizens living in such communities.

In order to achieve the stated policy objective, the Federal Ministry of Health developed the following policies and programmes, in collaboration with all of the relevant stakeholders:

- National Health Act;
- Health Sector Reform Programme, 2004 - 2007;
- Strategic Plan for Accelerating the Attainment of the Millennium Development Goals, 2004 - 2007;
- Recommendations on Repositioning the Federal Ministry of Health, 2004;
- Recommendations on Strengthening the Coordination and Management of the Tertiary Health Institutions, 2004;
- Blueprint for Revitalization of Primary Health Care in Nigeria, 2004;
- Blueprint for Accelerating the Implementation of the National Health Insurance Scheme; and
- Strategic Plans for the Priority Health Problems (e.g., Roll Back Malaria, HIV/AIDS, Reproductive Health, Polio Eradication and Routine Immunization, Tuberculosis and Leprosy, etc.).

These policies, if adequately implemented, have the capacity to effectively handle health challenges arising from climate change in Nigeria.

## Recommended Climate Change Adaptation Actions

The earth's climate will continue to change; hence, adaptation strategies must be considered to reduce disease burdens, injuries, disabilities and death. Adaptation actions are adjustments in natural or human systems in response to actual or expected climatic stimuli or effects, which moderates harm or exploits beneficial opportunities; and the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or cope with consequences is the adaptive capacity. Following are key recommendations for policies and programmes to address climate change adaptation related to injury and disease, and death related to natural disasters and heat waves. Other health problems associated with climate change include high rates of food-borne, water-borne and vector-borne illness; and premature death and disease related to air pollution, as well as large human populations displaced by rising sea level, flood, drought and famine.

## Immediate Adaptive Strategies

### Rain Harvesting and Boreholes

Extreme weather-related events can affect water availability, quality, or access, posing a threat to human populations. Water-borne pathogens often act in concert through two major exposure pathways: drinking water and recreational water use. Outbreaks of food and water-borne infectious diseases such as diarrhea, *Cryptosporidium*, *Giardia*, *Salmonella*, *E. coli*, and rotavirus are projected to increase. These diseases occur because of the contamination of water supplies through the disruption of water and sanitation systems, which can be caused by toxic runoff from increased rainfall and flooding. Rainwater harvesting and boreholes will create immediate alternative domestic water supplies, thereby reducing the outbreak of these water- and food-borne diseases. The implementing agencies are the communities, LGAs, and state and federal Water and Sanitation, in collaboration with the United Nations Children's Fund (UNICEF).

### De-silting of Earth Dams and Diversification of Occupation

Nigerians already suffer from nutritional imbalances. Droughts arising from climate change destroy crops and grazing land, reducing the quantity and quality of water resources. This causes famine because of crop ruination, consequently resulting in malnutrition. To reduce the malnutrition resulting from total dependence on rain-fed agriculture, there is a need for the immediate de-silting of dams, especially earth dams. As well, diversification of livelihoods will reduce malnutrition and ensure good health. The Ministry of Agriculture and the River Basin Development Authority should lead in this adaptive strategy.

### Immunization and Treatment

In addition to vector-borne diseases such as malaria, schistosomiasis, river blindness (onchocerciasis), dengue, lymphatic filariasis, African trypanosomiasis, leishmaniasis and yellow fever, other infectious diseases – especially water- and food-borne disease (diarrhea, *Cryptosporidium*, *Giardia*, *Salmonella*, *E. coli*, and rotavirus) – are on the increase or projected to be on the increase with climate change. The immediate immunization and/or treatment of affected populations or at-risk populations will help to minimize mortality and morbidity associated with these diseases. LGAs, and State and Federal Ministries of Health, have leading roles to play in this strategy. Sustainability of such programmes can be achieved by community ownership of such control/preventive adaptations.

### Distribution of Insecticide-Treated Nets

Indoor biting insects transmit vector-borne diseases like malaria, dengue, lymphatic filariasis, and yellow fever; the distribution and use of insecticide-treated nets have proved very useful in their control and prevention. As in immunization and treatment, LGAs, and State and Federal Ministries of Health, have leading roles to play in this strategy. Again, sustainability of distributing these nets is achievable by community ownership of this adaptation.

### Health Education and Awareness

Public awareness on how to identify and manage health disorders associated with climate change in Nigeria has an immediate priority. Building capacity is an essential preparatory step in adaptive strategy in climate change. Adapting to climate change

requires more than financial resources, technology, and public health infrastructure. Education and awareness-raising enable people to take well-informed sustainable decisions necessary to effectively adapt to health impacts of climate change. All the tiers of government and communities are important in this strategy.

There is immediate need for education and mass media campaigns strong enough to spark commitment and action among governments, international organizations, donors, civil society, business and communities (especially amongst the youth) to anchor health to the heart of the climate change agenda.

### **Maintenance of Primary Health Infrastructure to be Responsive**

Immediate maintenance of primary health infrastructure specifically designed to reduce vulnerability to climate variability (such as sanitation facilities, wastewater treatment system, laboratory buildings, etc.) enhance adaptive capacity. Other maintenance approaches include surveillance of diseases, early warning systems for impending weather extremes (e.g., heat wave, storms), as well as disaster preparedness. The Federal and State Primary Health Department working with LGAs and communities will likely achieve the desired adaptation.

### **Provision of adaptive features against thermal related disorders**

Enhancing urban planning such as green-spacing (planting tree within cities) and selecting materials with a high albedo (high reflection) for roads, parking lots and roofs to reduce the urban "heat island" effect reduce thermal-related disorders. Implementation of climate-proofed housing design (shade, insulation, ventilation, and air conditioning), as well as implementation of work schedules for outdoor workers that avoid peak daytime temperature, are also immediate adaptive strategies. All the tiers of government and communities are important in this strategy.

## **Long-term Adaptive Strategies**

#### 1. Construction of water systems with strong materials

- To reduce constant destruction of water pipes by flood and the consequent water contamination and outbreak of water- and food-borne diseases, the need to build water systems with strong material becomes obvious. The commitment of individuals, LGAs, state and federal water boards and public utilities is required to achieve this long-term strategy.

#### 2. Construction of sea-level rising and flood control-protecting structures

- To reduce the destructive impact of flooding, the need for a relevant Environmental Protection Agency policy to implement the construction of flood-protecting structures becomes very important. This will involve the implementation of engineering measures such as strengthening of sea walls and ensuring strict adherence to building regulations and standards in hurricane-prone areas.
- To minimize erosion, flash flooding, poor siting of residential areas, and deforestation, land-use planning will have to be adopted.

#### 3. Strengthen the primary health structure to be responsive to emergencies associated with climate change

- In addition to health education, successful climate change adaptation requires access to information and skills. In general, countries and regions with more "human capital" or knowledge have greater adaptive capacity. Illiteracy increases a population's vulnerability to many problems. Health systems are labour-intensive and require qualified and experienced staff, including those trained in the operation, quality control, and maintenance of public health infrastructure. This requires both immediate and long-term actions from all the tiers of government.
- Maintenance and strengthening of emergency management and disaster preparedness programmes, including local public health service capacity to conduct rapid health needs assessment and to make psychological support interventions, is required.

**Table 4** Policies, Programmes, Adaptation Options Addressed, Implementing Agency, and Cost for Health and Sanitation: **Health Sub-sector**

Recommended Policy Actions	Proposed CCA Programmes	Ecozone Addressed	CCA Options Addressed by Proposed Policies and Programmes	Implementation Agency (s)	Cost Implications
<b>Immediate Needs</b>					
<ol style="list-style-type: none"> <li>1. Implement relevant state &amp; national health policy for water and sanitation</li> <li>2. Implement relevant national policy on agriculture &amp; poverty alleviation</li> <li>3. Implement state and national policy on control of endemic diseases &amp; neglected tropical diseases</li> <li>4. The national policy on emergency response, primary health care to be implemented</li> </ol>	<ol style="list-style-type: none"> <li>1. Provision of potable water to reduce water and food-borne diseases</li> <li>2. To reduce the malnutrition resulting from total dependence on rain-fed agriculture</li> <li>3. Protection of population from vector-, water- and food-borne diseases</li> <li>4. Protection of population from thermal-related diseases and death</li> </ol>	All ecozones	<ul style="list-style-type: none"> <li>■ Rainwater harvesting</li> <li>■ Boreholes</li> <li>■ Diversification of livelihoods</li> <li>■ De-silting of earth dams</li> <li>■ Immunization and treatment, distribution of insecticide-treated nets, &amp; health education and awareness &amp; maintenance of primary health infrastructure to be responsive</li> <li>■ Provision of adaptive features against thermal related disorders, housing design and protection of outdoor workers</li> </ul>	<ul style="list-style-type: none"> <li>■ Communities, LGAs and water and sanitation/ UNICEF</li> <li>■ Ministry of Agriculture; River Basin Authority</li> <li>■ State, LGA Ministry of Health, LGA and state and communities</li> <li>■ Federal and state Primary Health and individuals, LGA, state and federal governments</li> </ul>	Low to moderate costs
<b>Long-Term Needs</b>					
<ol style="list-style-type: none"> <li>1. Public Utility Policy</li> <li>2. Environmental Protection Policy</li> <li>3. Implement the National Policy on Emergency Response, Primary Health &amp; Disease Control</li> <li>4. Implement housing and environment policy that reduces thermal disorders &amp; death</li> </ol>	<ol style="list-style-type: none"> <li>1. To reduce constant destruction of water pipes by flooding, and the consequent water contamination &amp; outbreak of water- &amp; food-borne diseases</li> <li>2. Reduction of the destructive impact of flooding</li> <li>3. Minimize the emergence &amp;/or increased prevalence of vector- borne diseases, as well as mortality &amp; morbidity associated with displacement &amp; resettlement</li> <li>4. Reduction of thermal- related diseases &amp; death</li> </ol>	All ecozones	<ul style="list-style-type: none"> <li>■ Construction of water system with strong materials</li> <li>■ Adoption of land-use planning, construction of flood- protecting structures, education and disaster management</li> <li>■ Immunization and treatment, distribution of insecticide-treated nets, health education and awareness, &amp; maintenance of primary health infrastructure to be responsive</li> <li>■ Insulation of houses &amp; air conditioners</li> </ul>	<ul style="list-style-type: none"> <li>■ Individuals, LGAs, state &amp; federal water boards &amp; public utilities</li> <li>■ LGAs, state &amp; federal governments</li> <li>■ All tiers of government</li> <li>■ Individuals &amp; government</li> </ul>	Moderate to high costs

CCA = climate change adaptation; LGAs = local government areas; UNICEF = United Nations Children's Fund.

**Table 5** Evaluation of Proposed Climate Change Agreement Actions for Health and Sanitation: **Health Sub-sector**

Proposed CCA Action	Criteria to evaluate effectiveness of CCA Action Implementation	Implications if CCA Action IS implemented (individuals, communities, private sector)		Implications if CCA Action IS NOT implemented (individuals, communities, private sector)	
		Positive Impact	Negative Impact	Positive Impact	Negative Impact
<b>Long Term Needs</b>					
<ul style="list-style-type: none"> <li>■ Rain harvesting</li> <li>■ Boreholes</li> </ul>	<ul style="list-style-type: none"> <li>■ Percentage of communities that use rainwater or boreholes</li> </ul>	<ul style="list-style-type: none"> <li>■ Reduced water- &amp; food-borne diseases</li> </ul>	<ul style="list-style-type: none"> <li>■ If not well maintained, rain harvesting can create breeding sites for mosquito vectors</li> </ul>	<ul style="list-style-type: none"> <li>■ Water vendors make more income</li> </ul>	<ul style="list-style-type: none"> <li>■ Outbreaks of water- &amp; food-borne diseases</li> </ul>
<ul style="list-style-type: none"> <li>■ Diversification of livelihoods</li> </ul>	<ul style="list-style-type: none"> <li>■ More than 50% of the population are involved in more than one occupation</li> </ul>	<ul style="list-style-type: none"> <li>■ Reduced malnutrition</li> </ul>			<ul style="list-style-type: none"> <li>■ Exacerbation of poverty &amp; malnutrition</li> </ul>
<ul style="list-style-type: none"> <li>■ De-silting of earth dams</li> </ul>	<ul style="list-style-type: none"> <li>■ Percentage of farmers who use irrigation</li> </ul>	<ul style="list-style-type: none"> <li>■ Increased food production; reduced malnutrition</li> </ul>	<ul style="list-style-type: none"> <li>■ Could lead to creation of breeding sites for black fly vectors of river blindness (onchocerciasis)</li> </ul>	<ul style="list-style-type: none"> <li>■ Decreased breeding of mosquitoes</li> </ul>	<ul style="list-style-type: none"> <li>■ Exacerbation of poverty &amp; malnutrition</li> </ul>
<ul style="list-style-type: none"> <li>■ Immunization &amp; treatment</li> </ul>	<ul style="list-style-type: none"> <li>■ Percentage of the population immunized &amp;/or treated</li> </ul>	<ul style="list-style-type: none"> <li>■ Reduced outbreaks of infectious diseases</li> </ul>	<ul style="list-style-type: none"> <li>■ Mild reactions (e.g., fever) contracted by immunized people</li> </ul>		<ul style="list-style-type: none"> <li>■ Outbreaks of infectious diseases &amp; death</li> </ul>
<ul style="list-style-type: none"> <li>■ Distribution of insecticide-treated nets</li> </ul>	<ul style="list-style-type: none"> <li>■ Percentage of the population that use insecticide-treated nets</li> </ul>	<ul style="list-style-type: none"> <li>■ Reduced transmission of insect-borne diseases</li> </ul>	<ul style="list-style-type: none"> <li>■ Inconvenience of using bed net</li> </ul>	<ul style="list-style-type: none"> <li>■ Population no longer inconvenienced by net</li> </ul>	<ul style="list-style-type: none"> <li>■ High insect-borne disease transmission &amp; death</li> </ul>
<ul style="list-style-type: none"> <li>■ Health education &amp; awareness</li> </ul>	<ul style="list-style-type: none"> <li>■ Percentage of the population aware of the health implications of climate change</li> </ul>	<ul style="list-style-type: none"> <li>■ Many people now have the capacity to adapt with climate change health problems</li> </ul>			<ul style="list-style-type: none"> <li>■ People are unable to adapt to climate change problem</li> </ul>
<ul style="list-style-type: none"> <li>■ Maintenance of primary health infrastructure to be responsive</li> </ul>	<ul style="list-style-type: none"> <li>■ Percentage of primary health infrastructure maintained to be responsive to health problems</li> </ul>	<ul style="list-style-type: none"> <li>■ People now have access to good primary health care; reduced death and morbidity due to endemic diseases</li> </ul>			<ul style="list-style-type: none"> <li>■ People are unable to access good primary health care delivery; high mortality &amp; morbidity from preventable diseases</li> </ul>
<ul style="list-style-type: none"> <li>■ Provision of adaptive features against thermal-related disorders, housing designs, &amp; protection of outdoor workers &amp; death</li> </ul>	<ul style="list-style-type: none"> <li>■ Percentage of houses now have climate-proofed housing designs (shade, ventilation, insulation &amp; air conditioning)</li> </ul>	<ul style="list-style-type: none"> <li>■ Reduced thermal-related diseases &amp; deaths</li> </ul>	<ul style="list-style-type: none"> <li>■ Noise associated with air conditioners</li> </ul>		<ul style="list-style-type: none"> <li>■ High incidence of thermal-related diseases &amp; deaths</li> </ul>
	<ul style="list-style-type: none"> <li>■ Percentage of outdoor workers have rescheduled to avoid peak daytime temperature</li> </ul>	<ul style="list-style-type: none"> <li>■ Reduced thermal-related diseases &amp; deaths</li> </ul>	<ul style="list-style-type: none"> <li>■ Economic loss because activities are reduced in the daytime</li> </ul>	<ul style="list-style-type: none"> <li>■ Man-hour gained &amp; greater economic activities</li> </ul>	<ul style="list-style-type: none"> <li>■ High incidence of thermal-related diseases &amp; deaths</li> </ul>
<ul style="list-style-type: none"> <li>■ Tree planting</li> </ul>	<ul style="list-style-type: none"> <li>■ Percentage of households that now plant trees around homes</li> </ul>	<ul style="list-style-type: none"> <li>■ Reduced impacts of heat waves (very cool homes &amp; environment)</li> </ul>	<ul style="list-style-type: none"> <li>■ No direct sunshine into homes may create good sites for biting insects such as sand flies</li> </ul>		<ul style="list-style-type: none"> <li>■ Increased heat stress</li> </ul>
<b>Long Term Needs</b>					
<ul style="list-style-type: none"> <li>■ Construction of water systems with strong materials</li> </ul>	<ul style="list-style-type: none"> <li>■ Percentage of homes now with water systems built with strong materials</li> </ul>	<ul style="list-style-type: none"> <li>■ Reduced incidence of broken &amp;/or destroyed water systems; reduced contamination of water supplies, &amp; fewer outbreaks of water- &amp; food-borne diseases</li> </ul>	<ul style="list-style-type: none"> <li>■ Water vendors will not be making more money</li> </ul>		<ul style="list-style-type: none"> <li>■ Destruction of water system by flood and erosion, contamination of water supplies, &amp; outbreak of water- &amp; food-borne diseases</li> </ul>
<ul style="list-style-type: none"> <li>■ Construction of flood-protecting structures (e.g., strengthening of sea walls &amp; strict adherence to building standards)</li> </ul>	<ul style="list-style-type: none"> <li>■ Percentage of flood-protecting structures and percentage of primary health care facilities that are adequately staffed to be able to respond to emergencies associated with climate change</li> </ul>	<ul style="list-style-type: none"> <li>■ Reduced flooding &amp; water contamination</li> </ul>	<ul style="list-style-type: none"> <li>■ Creation of barriers &amp; obstruction of movement due to the construction</li> </ul>		<ul style="list-style-type: none"> <li>■ Continued destructive flooding, water contamination and outbreaks of infectious diseases</li> </ul>
<ul style="list-style-type: none"> <li>■ Strengthen the primary health structure to be responsive to emergencies associated with climate change</li> </ul>	<ul style="list-style-type: none"> <li>■ At least one functional irrigation project is established in every drought-prone area</li> </ul>	<ul style="list-style-type: none"> <li>■ Effective handling of health issues arising from climate change</li> </ul>	<ul style="list-style-type: none"> <li>■ Increase in wage bill due to increased staff strength</li> </ul>	<ul style="list-style-type: none"> <li>■ Private clinics will make more income</li> </ul>	<ul style="list-style-type: none"> <li>■ Uncontrollable outbreaks of diseases, increased mortality &amp; morbidity</li> </ul>
<ul style="list-style-type: none"> <li>■ Construction of new irrigation projects and facilities in drought-prone areas</li> </ul>		<ul style="list-style-type: none"> <li>■ Agriculture will no longer depend only on rain; increased food production &amp; reduced malnutrition</li> </ul>	<ul style="list-style-type: none"> <li>■ Unmanaged irrigation project may lead to emergence or re-emergence of parasitic diseases such as malaria, lymphatic filariasis, schistosomiasis, etc.</li> </ul>	<ul style="list-style-type: none"> <li>■ There will not be diseases associated with the irrigation project</li> </ul>	<ul style="list-style-type: none"> <li>■ Exacerbation of famine and malnutrition</li> </ul>

CCA = climate change agreements.

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## Abbreviations

CC	climate change
CCA	climate change agreements
CIDA	Canadian International Development Agency
DFID	Department for International Development
EPI	Expanded Programme on Immunization
GCM	General Circulation Model
IPCC	International Panel on Climate Change
JMP	Joint Monitoring Programme
LGA	Local Government Area
MDG	Millennium Development Goals
NESREA	National Environmental Standards and Regulations Enforcement Agency
NGO	non-governmental organization
PHC	primary health care plan
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
WHO	World Health Organization

# Climate Change Adaptation Strategy Technical Report

## Cross-Sectoral Issues

(Finance, Disaster Management, Migration and Security, Rural and Urban Livelihoods, Gender and Youth, and Education)

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## Introduction to Cross-Sectoral Issues

Climate change represents the latest challenge to sustainable human development. Scientific evidence indicates that climate change is likely to frustrate and further compound efforts of achieving the Millennium Development Goals (MDGs). Particularly, efforts to reduce poverty and ensure equity in the distribution of development benefits, especially gender equity, and to promote sustainable livelihoods that go beyond simply coping with climate-related hazards will be challenged. In addition, the impact of climate change will exacerbate ecosystem degradation, reduce the availability of water and food, and will likely become a major driver of human conflict. To respond to climate change appropriately now will be costly, but the cost of inaction is estimated to be far greater.

The global climate system is being influenced by interaction with human factors related to increased greenhouse gas (GHG) emissions and reduced carbon uptake, resulting in significant changes to the complex, non-linear functioning of climate, with equally complex non-linear outputs to human systems. In that regard, climate change affects every aspect and sector of socio-economic development. Thus, climate change has multi-sectoral and cross-sectoral effects. It transcends the traditional focus on environmental issues, because its cross-cutting nature affects all aspects of human well-being and economic growth.

Despite recognition of the complex impact of climate change, the work undertaken to date has largely followed a traditional approach, focusing on select sectors such as natural resources, infrastructure, water resources, coastal and marine ecosystems, agriculture (including livestock and fisheries), tourism, health, energy, transport, communication and human settlements. What is often lacking in this work are studies on key social consequences of climate change impacts such as studies on gender and youth dimensions, livelihoods, population migration, and security. Disaster risk reduction and financing adaptation efforts, both of which are cross-cutting efforts to address climate change impacts, have been minimally covered and are only now just beginning to receive the required attention they deserve in the climate change discourse.

Unpredictable weather and more frequent and more severe extreme weather events are the most adverse hazards of climate change. There are many examples of extreme weather events such as the devastating floods in Pakistan (2 million people homeless, in excess of 1 million acres of cropland flooded, and a cholera epidemic) or unusual weather patterns such as floods due to heavy rains occurring in the normal dry season of Colombia (more than 400,000 people displaced). Drought-induced famine, intense flooding, variable onset of the rainy season, and coastal erosion are among the many climate change-related disasters currently affecting Nigeria.

These recent events point to the fact that climate change hazards can impact many aspects of human survival in multiple ways. Russian President Dmitry Medvedev<sup>1</sup> has been quoted as saying that "what's happening with the planet's climate right now needs to be a wake-up call to all of us, meaning all heads of state, all heads of social organizations, in order to take a more energetic approach to countering the global changes to the climate." To prepare for and respond to the unavoidable impacts of climate change, adaptation in all aspects of human endeavor is essential. Unlike coping strategies that focus on what to do when things go bad, adaptation strategies focus on taking the necessary actions to make things go well. Responding effectively to climate change requires the creation of an enabling environment facilitated by suitable adaptation policies, strategies and programmes at all levels of governance.

Cross-cutting issues of climate change that have serious implications for consideration when developing adaptation measures are subsequently discussed as they pertain to finance, disaster risk reduction, migration and security, rural and urban livelihoods, and vulnerable groups.

<sup>1</sup> Jay Gullede, Senior Scientist and Director of the Science and Impacts Programme at the Pew Center on Global Climate Change.

# Issue 1: Financing Climate Change Adaptation<sup>2</sup>

## Current and Future Trends

Climate change will exacerbate development challenges and, if not addressed, will make it harder to achieve and sustain the achievements of the MDGs and the goals of Vision 2020 in Nigeria. Managing the inevitable impacts of climate change is critical for ensuring and sustaining development achievements. Adaptation to climate change will bring with it additional costs for the public and private sectors.

Assessing the costs, and especially the benefits, of adaptation is complex, as many factors are involved. Many cost estimates have been published over the past few years that try to quantify the sums necessary to pay for mitigation and adaptation measures globally. Estimating methods and analyses differ, and there remains a high degree of uncertainty given the unpredictability over future factors including "policy costs;" however, there appears to be a convergence toward a close global cost range. Thus, estimates vary widely, ranging from up to US\$ 86 billion annually for adaptation by 2015 according to the 2007 United Nations Development Programme (UNDP) Human Development Report (UNDP, 2008), to the estimate by the United Nations Framework Convention on Climate Change (UNFCCC) secretariat that the additional investment and financial flows needed worldwide will be \$60 billion to \$182 billion by 2030.

Nigeria is yet to undertake a detailed estimation of the costs of adaptation to climate change in different sectors of national socio-economic development. Information is widely scattered and remains largely conjectural. In a recent study by HBF (Heinrich Boll Foundation) (2009), some estimates of the cost of climate change were given, taking into consideration what is known about the sectors and the amount of resources that had been committed to the programmes. Table 1 gives a summary of some costs by sector. Caution should be used with the estimates provided in Table 1, as they are assembled from many sources and these sources do not indicate that intensive research was conducted to obtain them.

**Table 1** Cost of Adaptation Projects by Sector in Nigeria (HBF, 2009)

Sector	Options	Costs	Source	Cost
<b>Water Resources</b>	Small dams – about 1,000 ha	\$50M	Bakalori Dam span 8,000 ha costing \$400M	In excess of \$1B
<b>Livestock Production</b>	Enrichment of rangeland	\$500 initial cost & \$200/year for 5 years	Estimates by Siyanbola <i>et al.</i> , 2002	In excess of \$300m
<b>Crop Production</b>	Breeding of hardier crops	\$200,000/tract/crop	<a href="http://www.agra-alliance.org/">http://www.agra-alliance.org/</a>	\$10.5B
<b>Fish Production</b>	Cropping of hardier breeds	\$150,000/tract/crop	Personal communication (Professor Omitogun)	In excess of \$10B
<b>Forest &amp; Forestry</b>	Establishment of plantation, protection of forests	\$500/ha (initial cost) & \$250/ha for 10 years \$1,000/ha	Estimates by Siyanbola <i>et al.</i> , 2002	Minimum of \$3.8B
<b>Coastal areas</b>	Coastline stabilization, settlement relocation	Between \$6B & \$18B, up to year 2030	About \$4.3M by Lagos State Government	\$5B
<b>Human Health</b>	Primary health care immunization	Between \$6B & \$18B, up to year 2030	IRIN 2008 Report	\$6B
<b>Sensitization</b>	Climate change education			
<b>Energy</b>	Electric power generation*	\$10bn	Guardian, May 29, 2008	

B = billion; ha = hectare; M = million

\* Nigeria's Vision 20:2020 envisages a five-fold increase in the amount of electricity to be generated to drive socio-economic development in the country. This will have implications for energy supplies, including hydro, oil and gas, and thermal power, all of which depend on water at some stage of their production. In addition, the anticipated increase in temperatures will cause an increase in demand for electricity, thereby increasing the vulnerability of energy infrastructure and necessitating putting in place structural and non-structural adaptation measures in the sector.

<sup>2</sup> Most of the information in this section is drawn from a recently commissioned study on Nigeria's National Economic Empowerment and Development Strategy (NEEDS) Study for Climate Change by the Special Climate Change Unit of the Federal Ministry of Environment for which the lead author of this section was the main contributor.

In the Nigeria's NEEDS study, an attempt was made to provide reasonable estimates of the costs for development in agriculture and water resources, and health and transport sectors, which are very critical to climate change adaptation in Nigeria. The study used the cost estimates provided in the national development vision document by the National Planning Commission (NPC, 2010) for the three sectors. In the study, the sectoral plans detailed in the NPC report were taken as providing good costing of the development needs in the various sectors of Vision 20:2020 for the short-term plan of 2010-2013. These were extrapolated to 2020 and 2050 using a number of assumptions, including a 2% change in the growth of each sector. The approach used in NEEDS also took into account the fact that most of the estimates provided in the NPC Implementation Report concern the federal interest, and, therefore, incorporated possible needs at the state and local levels.

The NEEDS study indicated that the incremental cost in agriculture and water resources would be about US\$3.06 billion per year by 2020 and about US\$5.50 billion in 2050. The health sector will require about US\$3.06 billion in 2020. This is expected to increase to US\$5.50 billion by the year 2050. Because of the poor transport conditions, the incremental cost for its adaptation will be high. The transport sector will require about US\$5.33 billion and US\$9.69 billion per year by 2020 and 2050, respectively.

Considering the information in Table 1, together with the NEEDS estimates, it is obvious that the cost of sustainable development and adaptation to a changing climate will be high. It will, at minimum, cost Nigeria US\$10 billion to \$15 billion per year over the next 10 (2020) to 40 (2050) years, if all the sectors of the country's socio-economic development, including infrastructure, are taken into account.

More comprehensive and country-specific work is urgently needed to more fully understand the additional costs of implementing climate resilient development in Nigeria. Appropriate empirical methodology based on published material and expert opinion on current expenditures at the national level, as well as other methods described in Parry et al. (2009), must be used in future to determine the appropriate cost of adaptation to climate change in different sectors in the country.

## **Existing Financial Instruments**

An obvious concern is where will the money come from? The emerging and yet incomplete cost estimates of additional investments needed in Nigeria for climate change adaptation can be sourced from national, regional and international levels as previously discussed.

### **National Level**

There is an increasing national awareness of the need to mainstream climate change into national development policies and programmes in Nigeria. Thus, the federal government is increasingly devoting a significant proportion of its national budget to climate change or climate change-sensitive sectors of the economy. There has been an ongoing assessment of the national budget over the past five years to determine the quantity of national resources that have been devoted to issues of climate change. At the state level, some states of the Federation have taken keen interest in addressing issues of climate change. Lagos State, for example, has hosted regional summits on climate change in 2009 and 2010, and is devoting a substantial proportion of its annual budget to study the impacts of sea-level rise on its coastal and marine environments. Delta State is also actively involved in the activities of the United Nations Territorial Approach to Climate Change (TACC). All these efforts point to the increasing recognition of the imperative to carry the issues of climate change along with national development needs – a fact that should facilitate the mobilization of internal resources for climate change in the country.

Nigeria could also mobilize resources for both climate change mitigation and adaptation through internal reforms such as putting resources aside out of core budget, or fiscal or pricing reform. In addition, non-concessional financial and investment flows in the public sector and private sector could be encouraged and philanthropic donations facilitated. This mobilization of resources – together with informed formulation and proper implementation of appropriate macroeconomic policies and programmes targeted at economic growth, along with improved access to social services and infrastructure – is an essential ingredient in any strategy for poverty alleviation in Nigeria. Such macroeconomic policies should involve the deliberate manipulation of policy instruments such as public expenditure to achieve basic macroeconomic objectives.

## **Regional Level**

Nigeria is sufficiently actively involved in the climate change-related activities of the Economic Community of West African States (ECOWAS) and the African Union

(AU) to source additional and complementary flows of financial resources at the regional level to tackle climate change.

## **International Level**

Possible sources of financial flows for climate change may be categorized as:

- Climate-specific additional resources under the aegis of UNFCCC (Global Environment Facility or GEF, Adaptation Fund, etc. UNFCCC GEF-administered Least Developed Country Fund (LDCF) and Special Climate Change Fund (SCCF), and the Adaptation Fund (AF);
- Resources from the carbon market;
- Concessional funding (Official Development Assistance or ODA) from the Development Co-operation Directorate (DAC) community, specifically for mitigation and adaptation;
- Other than climate-specific ODA from the DAC community; and
- Non-DAC donor support.

Details about these varied sources of finance for climate change are given in Tables 2 and 3.

**Table 2** Main Instruments for Financing Climate Change Mitigation and Adaptation (World Bank, 2009)

Climate-specific additional resources under the aegis of UNFCCC		
<b>Adaptation Fund</b> US\$300-600 million by 2012 adaptation-fund.org	A	Funding mainly comes from a 2% levy on Certified Emission Reductions (CERs) issuance. Adaptation Fund Board (AFB) as operating entity served by a secretariat (GEF) and a trustee (WB).
<b>Global Environment Facility (GEF)</b>  US\$1 billion over 2007-10 gefweb.org	M  (A)	Largest source of grant-financed mitigation resources. SPA is a funding allocation within the GEF TF to support pilot and demonstration projects that address local adaptation needs and generate global environmental benefits in all GEF focal areas.
<b>UNFCCC GEF-administered Special Funds</b>  US\$270 million gefweb.org	A	Least Developed Countries Fund (LCDF): helps in the preparation and financing of implementation of national adaptation programs of action (NAPAs) to address the most urgent adaptation needs in the least developed countries  Special Climate Change Fund (SCCF): supports adaptation and mitigation projects in all developing countries, with a large emphasis on adaptation.
Resources from the carbon market		
	M	Primary CDM transactions: US\$6.5 billion (2008), US\$22.9 billion (2002-08) Voluntary market (OTC): US\$54 million (2008), US\$260 million (2002-08) Size of Carbon funds and facilities: US\$16.1billion <sup>25</sup>
Dedicated concessional funding (ODA) from the DAC community		
<b>Climate Investment Funds</b>  US\$6.3 billion climateinvestmentfunds.org/	M	The Clean Technology Fund: to finance scaled-up demonstration, deployment, and transfer of low-carbon technologies.
	A	The Strategic Climate Fund: (i) Pilot Program for Climate Resilience (PPCR) to help build climate resilience in core development; (ii) Forest Investment Program; (iii) Program to Scale up Renewable Energy for Low Income Countries.
	M	
US\$ 10 billion US\$ 1.6 billion US\$ 180 million p.a. US\$ 580 million  US\$ 180 million US\$ 160 million US\$ 135 million US\$ 100 million US\$ 52 million	M&A M&A M&A M&A  M&A A M&A M	<b>Cool Earth Partnership (Japan)</b> <b>Environmental Transformation Fund – International Window (UK)</b> <b>International Climate Initiative (Germany)</b> <b>Climate and Forest Initiative (Norway)</b> <b>International Forest Carbon Initiative (Australia)</b> <b>Global Climate Change Alliance (European Commission)</b> <b>International climate Change Adaptation Initiative (Australia)</b> <b>UNDP-Spain MDG Achievement Fund</b> <b>UN Collaborative Program on Reduced Emissions from Deforestation and Forest Degradation<sup>26</sup></b>

A = adaptation; CDM = Clean Development Mechanism; GEF = Global Environment Facility; M = mitigation; SPA = Strategic Priority on Adaptation; TF = trust fund; UK = United Kingdom; UNFCCC = United Nations Framework Convention on Climate Change; WB = World Bank.

**Table 3** Examples of Sources of Financing Climate Change (World Bank 2009)

Examples of non climate-specific support from Donors and MDBs		
<b>Global Facility for Disaster Reduction and Recovery</b>  US\$15 million for adaptation	A	Partnership within the UN International Strategy for Disaster Reduction (ISDR), focusing on building capacities to enhance disaster resilience and adaptive capacities in changing climate. In addition, there are specific instruments for climate risk management
<b>Trust Funds and Partnerships; Guarantees</b>	M	Grant financing for knowledge products, capacity building, upstream project work/pilots, such as the MDTF for Strategic Framework for Development and Climate Change (under design); Partial risk guarantees to support development / adoption / application of clean energy technologies, including those not fully commercialized, in client countries.
	A	

MDG = Millennium Development Goals; MDTF = Millennium Development Trust Fund; United Nations

## Current Initiatives

Nigeria is in the process of putting in place a National Strategic Climate Change Trust Fund (NSCCTF) as a response to the need to broaden the scope of national interventions leading to an improved response at all levels of governance. This is to be done through strategic alliances among development partners, and mobilization of additional resources for the sustainability of activities to address the impact of climate change. The approach for the proposed NSCCTF will consist of partnership building, fungible programme components, extensive stakeholder participation, technical expertise and a broad range of contribution from traditional and non-traditional sources.

The NSCCTF will be designed to tackle climate change impacts to reduce the vulnerability and increase the resilience of Nigerians, as well as to improve the overall well-being of people living in the most vulnerable areas of the country. The vulnerable segments of the population, in particular, will be provided with enhanced opportunities to manage their natural resources for sustainable livelihoods and poverty reduction in the face of climate change consequences.

The overall objective of the NSCCTF will be to implement short- to long-term climate change-related actions, activities, and measures that will not only increase the resilience of national development sectors to the impacts of climate change, but also enable Nigeria to chart the course of sustainable low carbon economic development. Projects would mostly focus on long-term planned response strategies, policies, and measures, rather than short-term (reactive) activities. The NSCCTF would serve as a catalyst to leverage additional resources from bilateral and other multilateral sources for: (i) implementing international climate change deals and protocols, and (ii) promoting the overall economic development of Nigeria in a sustainable manner that reduces the country's vulnerability and enhances its resilience to climate change.

The scope of the NSCCTF will be broad to cover many activities related to climate change and sustainable development in Nigeria. These activities will include, but may not be limited to, the following:

- Projects that will enhance the adaptation capacity of Nigeria to cope effectively with the impacts of climate change.
- Schemes designed to strengthen agricultural production systems (crop and livestock) to integrate biodiversity concerns and make them more resistance to climate change-induced weather extremes such as drought.
- Schemes for the promotion of energy efficiency in various sectors such as buildings, transport, etc.
- Initiatives to strengthen national capacity to undertake consistent research to analyze and monitor climate change impacts.
- Projects that will increase the level of awareness of climate change among Nigerians at all levels of governance.
- Other partners' support that will facilitate improved access of technology transfer to support economic diversification and transition from fossil-dependent economy to green economy.
- Implementation of global and regional policy initiatives and strategies for a coherent global approach to climate change.

The sources of funding of the NSCCTF, its implementation arrangement and overall structure, are under discussion with stakeholders. By the time the process is completed, issues concerning the role of the Fund in harmonizing development resources, resource mobilization for the Fund, its institutional management arrangement, as well as the implementation and execution of projects using the Fund's resources will be properly articulated and launched, possibly before the end of 2010.

## Recommended Actions

The existing funding mechanism for climate change adaptation is grossly inadequate. It relies on annual budgetary allocation and support from donors and development partners. Nigeria needs to do a lot more to mobilize additional and substantive financial resources for adaptation to climate change, which is expected to bring with it additional costs for both the public and private sectors. To do this effectively, the country must:

- Undertake a detailed financial needs assessment to properly determine the economic costs of climate change adaptation in Nigeria.

- Review all multilateral climate financing mechanisms to assess their accessibility and capacity needs to mobilize funds from them.
- Situate climate change adaptation financing within the broader context of national development financing and development goals of Vision 20:2020.
- Build adequate national capacity to enable Nigeria to access resources from the Adaptation Fund
- Review national fiscal policy to incorporate the cost of climate change adaptation.
- Expedite the development of the innovative, non debt-creating national financing mechanisms – the proposed NSCCTF – and ensure its implementation.
- Develop and implement a resource mobilization strategy for NSCCTF and collect disaggregated socio-economic data to ensure the fund meets its targets.
- Ensure the NSCCTF has appropriate implementation guidelines, targets, capacity building and other initiatives that support sustainable adaptation strategies and that make provisions for vulnerable populations (including for women and youth) and their participatory decision-making at all stages, including design, implementation, monitoring and evaluation.
- Implement gender budgets and gender accounting for climate change adaptation projects and programmes at national and international levels.
- Implement the "polluter pays" principle to fund climate change mitigation and adaptation efforts.
- Ensure climate financing policies and resource allocations are gender-sensitive and responsive to population needs.
- Encourage direct foreign and domestic investments toward adaptation through the provision of subsidies and incentives.

**Table 4** Hazards-Impacts-Vulnerability-Adaptation Options Matrix for the Cross-Sectoral Issues: **Finance Sub-sector**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<ul style="list-style-type: none"> <li>■ Increase in temperature</li> <li>■ Variability in rainfall</li> <li>■ Sea-level rise</li> <li>■ Increase in extreme weather events</li> </ul>	<ul style="list-style-type: none"> <li>■ Adaptation to climate change will bring with it additional costs beyond Nigeria's economic capacity</li> </ul>	<ul style="list-style-type: none"> <li>■ Climate change will affect all sectors of Nigeria's environmental and socio-economic development, so adequate financing will be required for adaptation within Nigeria's total national development programme</li> </ul>	<ul style="list-style-type: none"> <li>■ Managing the inevitable impacts of climate change will be critical in ensuring and sustaining development achievements</li> <li>■ Financing adaptation must be done within the broader context of development policy</li> </ul>

**Table 5** Policies, Programmes, Adaptation Options, Implementing Agency and Cost: **Finance Sub-sector**

Proposed CCA Policies	Proposed CCA Programmes	Ecozones Addressed	CCA Options Addressed	Implementing Agency(s)	Estimated Costs
<ul style="list-style-type: none"> <li>■ Instituting climate finance instruments such as a gender-sensitive "Climate Change Trust Fund"</li> <li>■ Instituting climate finance instruments such as a gender-sensitive "Climate Change Trust Fund"</li> <li>■ Promoting public-private partnerships to generate new creative financial instruments to address the impacts of climate change</li> </ul>	<ul style="list-style-type: none"> <li>■ Follow through on the proposed NSCCTF to become a legally binding financial instrument for Nigeria's response to climate change</li> <li>■ Ensure the transparency and accountability of domestic public resources (received or given), which are devoted to funding climate change actions and the way the government uses them.</li> <li>■ Take initiative in establishing national gender-inclusive climate funding</li> </ul>	<p>All ecozones: Adequate financing for CCA in all sectors' ecozones to ensure inclusion of all stakeholders (including women and youth) in the decision-making elements of the financial instruments</p>	<p>SCCU of the Federal Ministry of Environment and the Ministry of Finance</p>	<p>Concept paper has been developed, which needs stakeholders' input for finalization and launch</p>	<p>NGN100M</p>

CCA = climate change adaptation; NSCCTF = National Strategic Climate Change Trust Fund; SCCU = Special Climate Change Unit.

# Issue 2: Disaster Risk Reduction

Natural disasters can significantly compromise development progress, reduce the effectiveness of aid investments, and halt or slow progress towards the achievement of the MDGs. For example, progress on MDG 1 – halving poverty and hunger by 2015 – may be halted or reversed as a result of a natural disaster. This presents a significant threat to development.

Globally, climate change will modify risk characteristics through:

- increased frequency and intensity of extreme climatic hazards, such as drought and flood;
- occurrence of hazards (such as malaria) in areas previously free from their impacts; and
- increased vulnerability as climate-induced hazards exacerbate underlying risk conditions, such as sea-level rise.

According to the African Development Bank and others (2002), the disaster-related impacts of climate change are likely to encompass the following:

- increases in droughts, floods, windstorms and other extreme climate phenomena that will negatively affect water resources through reduced freshwater availability, food security, human health (such as the spread of malaria in the arid zones), industrial production and a weakened physical infrastructure base for socio-economic activity, resulting in reduced development;
- changes in rainfall combined with more intense land use will result in increased deforestation, loss of forest quality, and woodlands degradation that will worsen desertification. This will exert greater pressure on already strained coping strategies and will very likely result in increased poverty;
- sea-level rise leading to coastal erosion and flooding. With more than one-quarter of the population living within 100 km of the coast and most cities concentrated along the coastline, the vulnerability to marine-induced disaster from tidal waves and storm surges will increase;
- decrease in river basin run-off and water availability for agriculture and hydropower generation due to changes in rainfall and river sensitivity to climate variation will likely result in increased cross-boundary tensions. This will result in more conflicts, intensification of existing conflicts, or a reduced ability to resolve them.

There is overwhelming evidence that natural disasters disproportionately affect developing countries. Between 1991 and 2005, more than 90% of natural disaster deaths and 98% of people affected by natural disasters were from developing countries. Moreover, disasters are increasing in number and size every year due to a number of factors including rapid population growth, urbanization, and climate change. The enormity of the December 2004 Boxing Day Indian Ocean tsunami in the Asia-Pacific region provided a catastrophic reminder that the world is vulnerable to low likelihood-high consequence large scale natural disasters (Scott & Simpson, 2009).

By the virtue of its geographical location and spatial extent, Nigeria is prone to a wide variety of climate-induced hazards and disasters. Phenomena such as floods, storms, ocean surges, droughts, wildfires, pest plagues, and air and water pollution cause extensive losses to livelihoods and property, and claim many lives. In 2009, a total of 331 disaster cases were recorded by the National Emergency Management Agency (NEMA) in Nigeria. Out of the total number, fire claimed the highest number, with 123 cases representing 37.16%, followed by rainstorm (29.91%), flood (19.95%), communal/religious crises (8.46%), erosion (2.72%), oil spillage and boat mishap 0.60%. Epidemics and bomb explosions claimed 0.30% each (NEMA, 2009). Of the over 87,000 of Nigeria's inhabitants affected by various disasters in 2009, 36,146 were displaced by floods, 19,418 were affected by rainstorm, while fire and erosion accounted for the displacement of 5,860 and 3,638 inhabitants, respectively.

In the coastal area of the Niger Delta, it is estimated that a climate change-induced accelerated sea-level rise of about 0.5 m could lead to the disastrous submergence of about 35% of the delta, turning about 2.1 million people into environmental refugees.

Flooding has become unusually common in the last two decades during the rainy season across northern Nigeria, in line with a number of climatic scenarios that have predicted wetter than normal conditions in the arid and semi-arid Sub-Saharan Africa, with a high frequency of intensive rainstorms. In 1988, a major flood in Kano displaced more than 300,000 people, and in 1999 more than 200,000 people were displaced by flooding in Niger. Also in 2001, 200 people died and tens of thousands were made homeless when torrential rain led to a flood that devastated Kano; in neighbouring Jigawa State, 180 deaths were registered, 800 people injured, and 35,500 displaced. Equally in 2005, dozens of people were killed, over 50 houses were swept away, and more than 3,000 were displaced by flash floods in Taraba when the River Jalingo overflowed its banks following heavy rains. Four years ago in Gusau, a burst dam claimed over 100 lives and at approximately 500 houses; in that same year in Kaduna, the Birnin Gwari dam burst, claiming an estimated 50 people and 1,500 houses. In 2010, the northern part of the country experienced a higher than normal intensity of floods with disastrous consequences (see Box 1). In Sokoto State alone, more than 10 people were killed, 130,000 people displaced, and 50 villages affected, with 20 of them completely washed away (*Daily Trust*, 14 September 2010).

Climate change-induced heavier and steadier than normal rainfall being experienced in the southeastern part of Nigeria has inevitably begun to subject the region to increased rainfall-induced erosion. These are extremely serious situations given that soil erosion is already of catastrophic proportions in that part of the country. For example, it is estimated that in Abia, Anambra and Imo States, there are no fewer than 600 gully erosion sites. The recent massive landslide in one of the southeastern states attests to the possible climate change-induced changes in erosion intensity and attendant disasters.

### **Floods kill 3, displace thousands in northern Nigeria**

**Agence France-Presse, September 1, 2010)**

Heavy rains in recent weeks have killed at least three people and displaced thousands in northern Nigeria, where entire villages have been submerged and farms destroyed, officials said Wednesday.

**Katsina:** "We lost a whole village and its crop fields to the flood," said Hassan Suleiman, a director in Katsina State emergency relief agency.... At least three people were killed Monday (August 30) and over 2,000 others made homeless from flooding in Katsina State, officials said. The destruction of the village resulted in two deaths and 400 displaced. Another 1,700 were displaced in the town of Dutsin-Ma when a dam broke and flooded more than 200 homes, said Suleiman.

**Jigawa:** In neighbouring Jigawa State, flooding submerged 25 villages, displacing 7,000 people and washing away 3,000 hectares of crops in the last two weeks, Umar Kyari, the state governor's spokesman told AFP. A river burst its banks due to torrential rains, inundating the 25 villages along its banks, Kyari said.

**Kano:** The flooding swept away more than 2,000 farms and destroyed crops in neighbouring Kano state's Gabasawa district, according to Sabo Nanono, who heads the Kano State farmers' union. Local officials said that more than 3,000 people were displaced two weeks ago when two villages in Kano were hit by flooding.

**Zamfara:** Hundreds were also displaced while more than 2,000 farms were destroyed three weeks ago following flooding in Gummi town in northwestern Zamfara State, residents said.

**Sokoto:** Heavy rainfall in September 2010 led to the washing away of the bridge linking the Usmanu Dan fodiyo University, Sokoto, and Sokoto township, with thousands of people living around the University Campus totally isolated as the other bridge on Ilela Road that could be used was already under reconstruction. As a result of the collapse of the bridge on the University Campus, the linkage road between Nigeria and Niger from Sokoto was totally cut off. But the rainy season is still continuing, so victim numbers may rise even further.  
(*Mohammed Bello in Sokoto, personal communication*)

## Existing Governance, Policies and Programmes

The federal government has been in the forefront of providing national leadership for disaster management in Nigeria. In 1976, the Federal Government of Nigeria established the National Emergency Relief Agency (NERA) to coordinate its disaster response activities. Unfortunately, the Agency was purely a relief organisation focusing only on post disaster management. In 1999, NEMA was established to replace NERA and to manage disasters in Nigeria in their entire ramifications. NEMA, among other things, has the mandate to:

- formulate policy on all activities relating to disaster management in Nigeria, and coordinate the plans and programmes for efficient and effective response to disaster at the national level;
- coordinate and promote research activities relating to disaster management at the national level;
- monitor the state of preparedness of all organizations or agencies which may contribute to disaster management in the country;
- collate data from relevant agencies so as to enhance forecasting, planning and field operation of disaster management;
- educate and inform the public on disaster prevention and control measures; and
- coordinate and facilitate the provision of necessary resources for search and rescue and other types of disaster curtailment activities in response to distress calls. NEMA has Zonal Offices in the six geopolitical zones of the country. The law establishing NEMA requires the state governments to have their autonomous State Emergency Management Agencies (SEMAs) take charge of disaster management in the states.

With these well-laid out and well-planned objectives and institutional structures at the federal and state levels, climate change-induced hazards have continued to have debilitating effects on Nigerians. Most of the states are yet to have functional SEMAs, and disaster management remains largely uncoordinated between NEMA and other relevant agencies at all levels. Thus, disaster phenomena has continued repeatedly without any significant measure being put in place to avoid their occurrences or, better still, the loss of lives and other property.

While the likelihood of these events happening cannot be prevented or reduced, nor their intensity or frequency, their effects can be limited. Although disasters are generally triggered by a natural hazard event, the impact on communities is a direct result of vulnerability related to complex development factors, along with poverty, disability and gender inequality. Pre-emptive risk reduction is, therefore, the key, with an emphasis on resilience and disaster planning. Sound response mechanisms after the event, however effective, are never enough. A risk management approach can determine the likelihood of a given natural hazard event, how vulnerable the community may be, and what mitigation strategies can be applied. The challenge to this approach is managing the risk and likelihood of large and/or rare events.

The implementation of the Hyogo Framework provides Nigeria with a good strategic approach for the reduction of underlying risks. It does this by integrating risk reduction measures and climate change adaptation to substantially reduce disaster losses, in lives as well as the social, economic and environmental assets of communities. Its priorities include:

- making disaster risk reduction a priority;
- knowing the risks and taking action;
- building understanding and awareness;
- reducing risk; and
- being prepared and ready to act.

To promote an effective national response to climate-induced disasters, Nigeria must integrate climate change adaptation and disaster risk reduction through:

- identifying climate-related disaster risks;
- designing specific risk reduction measures; and
- improved and routine use of climate risk information by planners, engineers and other decision-makers.

## Recommended Adaptation Actions

Current and future efforts for climate change adaptation in Nigeria should benefit from practical experience in disaster risk reduction. Disaster risk management, which is the systematic observation and analysis of disasters to improve measures relating to prevention, mitigation, preparedness, emergency response and recovery, provides a good adaptation mechanism against climate change.

Promoting climate change-responsive risk management in Nigeria requires mainstreaming climate factors into development policies and programmes to prevent major impacts of climate change and to promote effective responses to the impacts. The main strategic approach to mainstreaming climate change in disaster reduction is to reduce vulnerability through pertinent and feasible adaptation measures, and to also embody an enabling environment that promotes strengthening of climate change adaptation measures and opportunities for business actions.

The following general strategies for adapting to climate change should form the basis for developing adaptation responses to be mainstreamed into development instruments:

- preventing losses; for example, increasing the resilience of infrastructure and physical development, and reforestation of degraded areas;
- reducing losses to tolerable levels, such as improving management of climate-sensitive natural resources and economic production systems;
- promoting economic diversification to reduce over-reliance on climate-sensitive primary industries;
- sharing or spreading risk to ease the burden on those directly affected by climate change, such as through insurance or disaster assistance; and
- restoring sites, such as reclamation of degraded coastal land.

For an effective adaptation response to disaster management in a changing climate, Nigeria needs to continuously and systematically assess the risk that development processes are exposed to and how such risks can be reduced in a comprehensive manner. Specifically, Nigeria should:

- facilitate the harmonization of risk reduction and climate change adaptation using a cross-sectoral approach at national, state, local, and community levels. In this regard, the government must ensure that disaster risk reduction and climate risk management are core elements of adaptation to climate change;
- build interdisciplinary adaptation measures on risk reduction approaches;
- vigorously pursue adequate developmental policies and planning that focus on climate-induced hazard awareness and preparedness by both individuals and the government;
- support NEMA to develop a comprehensive national policy that specifically targets climate change risk;
- support NEMA to strengthen natural hazard risk assessment capacity in the country by providing support and access to technical expertise, methodologies, and appropriate tools, as well as promoting a strong context for local initiatives;
- establish and implement a Comprehensive Participatory Disaster Management Programme (CPDMP) that will put greater emphasis on disaster preparedness and risk reduction, as well as adaptation to climate change, such as the one that currently operates in Bangladesh. The CPDMP will have a number of disaster management components, among them to establish an integrated approach to climate change and disaster management, expanding risk reduction approaches across a broader range of hazards, with specific reference to climate change. The programme may focus on the following:
  - capacity building for NEMA and SEMAs and the Special Climate Change Unit of the Federal Ministry of the Environment to coordinate and mainstream climate change into their existing activities;
  - strengthening existing knowledge and information accessibility on impact prediction and adaptation; and
  - awareness-raising, advocacy, and coordination to promote climate change adaptation into development activities.
- establish mechanisms to provide sufficient funding for adaptation to climate change and risk reduction, especially to protect the most vulnerable; and

- take immediate action to implement adaptation to climate change and risk reduction in the implementation of the short-term plan for Vision 20:2020 in the period 2010 to 2013.

In the final analysis, Nigerians need to use the guidance of the Hyogo Framework for Action 2 to facilitate a systematic rather than project-based approach to adaptation to climate change.

## Issue 3: Migration and Security

Migration is as old as humankind. It has always been and still is a very important mechanism used by people to adapt to changed living circumstances. This can be a short-term, regular occurrence, as part of a specific natural, resource-based livelihood (e.g., pastoralism, seasonal movement of fishing communities), as well as a longer-term or even permanent phenomenon (Ketel, 2004). In a general sense, migration is a form of adaptation to environmental degradation and socioeconomic deprivations.

Climate change could have a significant impact on the living environment of large populations. Extreme climatic occurrences such as drought and flood cycles, and sea-level rise in particular, could have a huge and lasting effect on many highly populated regions in the world. As already indicated, it is estimated that climate change-induced accelerated sea-level rise of about 0.5 m could lead to the submergence of approximately 35% of the Niger Delta region, turning about 2.1 million people into environmental refugees and forcing people to move inland, further encroaching on lands that are already under severe pressure. In a similar manner, climate change-induced intensified drought condition, desertification, and sand-dune encroachment in the northern part of the country could push people further south. Thus, there is a real concern that climate change may lead to a new class of *environmental refugees* – from communities that have been destabilized by climate, or where climate change exacerbates existing land degradation caused by prolonged, uncontrolled exploitation of natural resources.

The circumstances under which people leave their homes and migrate usually do little to explain the structural or root causes. There is a clear link between the number of environmentally displaced persons and the level of poverty in their points of origin. Environmental pressures often exacerbate issues such as economic marginalization, insecurity, social upheaval, and political mismanagement. Climate change, as a factor of migration, commonly acts by aggravating key socio-economic causes.

Migration may lead to conflict in receiving areas in a very complex manner, operating through many channels that include competition, ethnic tension, distrust, socio-economic fault lines, and other auxiliary conditions (Reuveny, 2007).

The arrival of environmental migrants can burden the economic and resource base of the receiving area, promoting native-emigrant competition over resources. Pressures are expected to rise with the number of migrants and residents, particularly when resources are scarce in the receiving area and property rights are underdeveloped. The excess in demand for resources may also generate lateral pressure and expansion of economic and political activities beyond a region's or state's borders in order to acquire resources, which increases the risk of conflict.

When environmental migrants and residents belong to different ethnic groups, the migration may promote *tension*. Situations involving long-standing ethnic disputes between migrants and residents are likely to be particularly prone to conflict. Environmental migration may generate *distrust* between the area of the migration's origin and host area. The conflict may also follow existing socio-economic fault lines. For example, migrant pastoralists and resident farmers may compete over land, or migrants and residents may compete over jobs.

In general, while developed economies can absorb migrants in various sectors, underdeveloped economies, reliant on the environment for survival, are limited in this regard, particularly if their resources are scarce. Therefore, they are more prone to conflict due to the arrival of environmental migrants. Political instability and civil strife in the receiving area also increase the likelihood of conflict. For example, migrants may join antagonizing groups or intensify the violence through any of the aforementioned channels.

Climate change has the potential to displace more people by increasing the frequency and severity of natural disasters, particularly hydro-meteorological events. Climate change will cause an increase in the number and severity of sudden-onset natural disasters, which in turn will displace people. Those displaced by sudden-onset natural disasters, who remain within the borders of their own country, are internally displaced persons, while those who cross international borders as a direct result of natural disasters are considered to be migrants. In the long-term, climate change will have specific long-term environmental effects such as desertification and other changes in weather patterns, which means that people's livelihoods are no longer sustainable and they are forced to migrate to other places. It is, however, important to note that the relationships are not all that straightforward. The evidence remains largely conjectural. It is not known how many people are likely to be displaced by these events, but their number will likely rise. There will also be significant differences in the intensity and pattern between the coastal, the savanna, and the Sahel ecozones. Significant migrations are expected in the coastal and the Sahel areas of the country, while the savanna region may become a critical location for the resettlement of climate change refugees.

Climate change will force significant migration along the coastal areas, and contribute to political and economic turmoil. The impact of climate change-induced sea-level rise on the Niger Delta has been mentioned previously in this report. In this regard, climate change-induced 0.5 m sea-level rise will exacerbate the existing internal conflict over oil production in the Niger Delta if over 2 million people who might be displaced are forced to migrate inland.

The current situation in the Lake Chad region in the Sahel of northeastern Nigeria provides good empirical evidence of apparent linkage between climate change, migration, conflicts, and insecurity (Fasona & Omojola, 2005; Onuoha, 2010) in a non-linear and complex manner. The Nigerian portion of Lake Chad shares international boundaries with Niger, Chad, and Cameroon to the north, northeast, and east, respectively. In 2003, it was estimated that of the 20 million people who lived in the Lake Chad basin, 11.7 million lived in Nigeria, mainly in the northeast zone. The remainder of the population included five million in Chad, 2.5 million in Cameroon, 193,000 in Niger, and 634,000 in the Central African Republic.

Climate change-induced reduced rainfall and run-off has led to increased desertification of the belt near Lake Chad and a dramatic shrinkage of this unique trans-boundary watercourse, from about 25,000 km<sup>2</sup> in 1964 to less than 1,000 km<sup>2</sup> in 2007 (Lake Chad Basin Commission, 2008). Given its relevance to local livelihoods and economic progress, the shrinkage of the lake resulting from climate change has continued to undermine the very base of human development in the basin, including in the northeast zone of Nigeria. In particular, there is water scarcity, which is greatly compromising the population's entitlement to water security in the region. The overall implication of climate change-induced water scarcity in the region include, but are not limited to, insecurity, falling health standards, food insecurity, poverty and intensified migration, with the tendency to instigate resource and identity conflicts within and beyond the basin.

The climate change-related diminution of Lake Chad has blurred international boundaries in the region. Fishermen, particularly Nigerians and Nigeriens, have crossed political borders in pursuit of the receding waters. This has resulted in a complex web of social, economic, environmental and political issues, threatening to spill over into human rights issues and interstate conflicts in the basin.

The drifting of the lake away from Nigerian and Nigerien territories towards Chadian and Cameroonian territories, is propitious to interstate conflicts and tensions. With the surface water of the lake diminishing because of demographic and climate factors, some reallocations among users and sectors are inevitable, which could lead to competition and deprivation. The overall effect of intensive migration in the region is an apparent increase in the number of cross-border communal clashes, making climate change a new security threat. For example, Lake Chad's diminution has also increased the influx of Udawa nomadic cattle herders from the Republic of Niger, as well as the migration of citizens of Chad and Niger further south in search of optimum opportunities. These "long-distance migrants," usually referred to as Udawa, have been well-armed since the mid-1990s and are willing to use violence to assure their grazing. This has contributed to the violent conflicts between herders and farmers in the northeastern part of Nigeria (Onuoha, 2010). A recent study (Folami and Karimu, 2010) established a nexus between climate change and cross-border crime in Nigeria that could lead to an international security

breach. Similar evidence has been documented for Ghana and Burkina Faso (Brown and Crawford, 2008) and Kenya (CDC/IIISD/Saferworld, 2009).

Nigerian government policies recognized the right of individuals to migrate but realized how developmental disparities between rural and urban areas were intensifying flows from the former to the latter areas, simultaneously creating rural denudation and urban sprawl and congestion. Specific strategies were not put in place to redress the imbalances and no development options in the rural areas were implemented that would first halt these flows and then reverse them. Owing to the fact that policies have not addressed the fundamental bases of these disparities – i.e., governance deficits in resource-constrained environments – which are often ecologically disadvantaged as well, attempted policies and strategies have not worked. In addition, the policies did not examine the gender dimensions of internal migration. They also did not identify the ethnic factors and livelihood systems that stimulate surplus migration and patterns of it that vary with climate and are, therefore, associated with conflict and security. For these reasons, existing policies are detached from the practical everyday issues that compromise development planning and complicate progress in forging the bases of inter-ethnic unity, which leverages diversity as a core goal of national development.

## Gender Dimensions

Migration is defined as the permanent or semi-permanent movement from one place to another. It can be classified as internal and international migration, depending on its occurrence within or across national boundaries, respectively. Internal migration can further be classified according to the demographic and socio-economic characteristics of giving and receiving areas into rural-rural, rural-urban, urban-rural, and urban-urban forms.

This classification is fairly popular but not nuanced enough. It takes an essential human activity and strips it of the intentions that lie behind it, in order to classify it in terms of inconstant attributes of a community. Also, complications arise when one migrates across national boundaries from one urban area to another. Its most serious shortcoming is that it presents a fluid and flexible flow as dichotomous – as though migration is to be understood in zero-sum matrices. Modern mobile conditions have constructed individuals into members of multiple communities simultaneously. It is essential to bear these multiplicities in mind as strategies are developed that respond to conflicts that arise through the migration not only of individuals but also of lifestyles and group-level ideologies.

Distances covered in each type of migration are positively correlated with the economic benefits available to the migrant, particularly when a gendered life course perspective is used to appreciate the dynamics of local migration. Men are more likely to cover longer physical and social distances in their migration than women, with the result that they also move *further* away from the adverse conditions that necessitated their migration in the first place. They thus increase and improve on their life chances with each move, unlike women who obtain only marginal comparative advantage with their movement. Accordingly, migration is strategic but central to the maintenance of gender inequality and important for understanding local conflicts when different lifestyles and livelihood systems (such as a mobile pastoralist economy and a sedentary farming population) come into contact and a collision of values results. In this sense, male migration is more prone to conflict.

By contrast, women tend to migrate for shorter distances, typically in the rural-rural pattern, calculated to enable them to retain physical presence in their homes while utilizing short spells of migration as part of a comprehensive strategy for household subsistence. This form of migration is less intrusive in the area of destination. It is usually symbiotic and fits into local economic practices that are supported by shared norms and practices. But women are easily disrupted by effects of climate change such as flash floods (which wipe out their typical migratory trajectories) and droughts (which make these local migratory flows impossible).

In this respect, gender patterns of migration are predictors of economic inequality in a regime of climate change: the patterns and modes of migration that correspond to one sex can expose it to sudden negative economic impacts, depending on the distances covered by the routine forms of migration. Women are primary victims of climate-related changes to the directions of their migration. Their form of movement is normally situated within the same ecological zone and, in fact, counts on its stability for such economic

activities as petty trading. Climate change has the immediate impact of disrupting the organic ties between environmental and behavioural factors that help create and shape an economic system. This is especially true of the market movements in southern Nigeria, where women are the principal actors in the circular movements and connections that are maintained through a network of local markets established to take advantage of goods that are surplus in one environment and scarce in others. Climate change affects this symbiosis and women are instant victims because it is their economic life plans that are undermined no matter where such changes occur.

### **Migration, security and climate change - the case of the Fulani**

Security issues arise when populations are displaced when their livelihood systems are compromised. The sudden appearance of these displaced people in other communities within the national boundaries or as refugees across borders can complicate development planning since they represent unregistered and undocumented hundreds, thousands, or millions of persons who compete for resources in areas that were already fragile and resource-poor. An influx of persons without sustainable means of livelihood gives rise to a complex cycle of "alienation of aliens," reinforces "otherness," and may also generate expressions of prejudice and xenophobia. Tense relations may reduce chances of regular employment, severely stigmatize and traumatize the migrants or displaced persons, and possibly set the stage for a rise in criminal gang activity among this population.

In Nigeria, migration is part of a comprehensive economic strategy. This is especially true of the practices of the nomadic Fulani, whose affinity for their cattle is well known and documented. The movements of the nomadic Fulani are governed by livelihood norms associated with the needs of their cattle for pasture. Against this background, insecurity and increased conflict can occur as climate changes and the seasonal patterns of migration also change.

Centuries of stability in climate, as well as slow growth in the southern population, allowed for the historical presence of abundant grazing fields. As the population increased due to declining mortality rates and the introduction of national immunization and vaccination programmes, the demand for more protein also increased, intensifying the need for more privately owned land in the south for farming and residential purposes. Thus, the once-abundant grazing fields were greatly reduced, unable to support the periodic appearance of cattle, which graze in fields where crops are cultivated.

This situation is a recipe for conflict and insecurity as two livelihood systems are set on a collision course by the periodic migration and economic requirements of one mobile group set against another sedentary one. Climate change reinforces and aggravates these forces and creates conditions for earlier migrations southwards as well as longer times spent in the south.

These trends make conflict almost inevitable in the areas where the two systems merge. Destroyed crops and dying cattle are indications of strife and insecurity, and of the economic impacts of climate change as shown through human behaviour. The attacks and reprisals that have come to characterize inter-ethnic relations in contemporary Nigeria have all too often been explained away in terms of ethnic or religious differences, or even competition for scarce economic resources. Their underlying basis is climate change and the behavioral reactions of affected human populations have seldom been explored. Interventions that do not take into account of these fundamental climate factors will only exacerbate these impacts, not solve them. It is necessary to develop an operational framework comprehensive enough to integrate climate change adaptation with strategies for inclusive governance at the institutional level and behavioural change at the individual level.

**Table 6** Hazards-Impacts-Vulnerability-Adaptation Options Matrix for Cross-Sectoral Issues:  
**Migration and Security Sub-sector**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: SAHEL and SAVANNA</b>			
Increased temperature	Increased southward cattle migration	<ul style="list-style-type: none"> <li>■ limited economic options</li> <li>■ low educational attainment</li> </ul>	<ul style="list-style-type: none"> <li>■ re-green ecozone for pastoral farming</li> <li>■ adopt cattle-rearing practices of non-nomadic peoples</li> </ul>
<b>Ecozone: ALL</b>			
Increased temperature	Low crop yield	<ul style="list-style-type: none"> <li>■ non-mechanized farming practices</li> </ul>	<ul style="list-style-type: none"> <li>■ eco-responsive farming practices including environmentally sound mechanization</li> </ul>
<b>Ecozone: COASTAL/RAINFOREST</b>			
Increased intensity of rainfall	Floods lead to disrupted internal migration among southern women	<ul style="list-style-type: none"> <li>■ limited economic options</li> <li>■ low educational attainment</li> <li>■ patriarchal moral economy</li> </ul>	<ul style="list-style-type: none"> <li>■ expand access to micro-credit &amp; micro-insurance</li> </ul>

## Existing Governance, Policies and Programmes

The issues of migration and security as they relate to climate change reveal complex interactions that show that climate change is not a mere environmental problem but more a development challenge. Climate change-induced environmental degradation will, in many instances, generate environmental migration both within national and across international borders. Environmental migration, due to climate change impacts, more often than not plays a role in conflict. When it does, the conflict intensity can be high, with serious security implications, as being witnessed in the northeastern part of Nigeria. Climate change-induced migration from the country's coastal zone due to a rising sea level and its attendant socio-economic consequences, particularly in the Niger Delta, has also become a reality for Nigeria.

The policy implication of these facts is the imperative for the Nigerian government to put in place a comprehensive adaptation response strategy that will minimize climate change-induced migration and conflict, as well as promote national and regional security. The country is about to finalize a national policy and response strategy on climate change. The issues of migration, conflicts and security, including food security, as they are impacted by climate change should be given a priority in the policy document that is being formulated. To do this effectively, all the relevant institutions and agencies (e.g., Ministries of the Interior and Foreign Affairs, Customs, etc.) critical to the nexus between climate change, sustainable management of disaster-prone areas in the country, migration and conflicts, as well as maintenance of security, should be comprehensively involved in participatory development and implementation of the National Climate Change Policy and Response Strategy for Nigeria.

## Recommended Adaptation Actions

Climate change is expected to bring about significant changes in migration patterns between Nigeria and its neighbours, and within Nigeria. Adaptation must focus on the full range of development problems affecting the country and be fully integrated within wider national plans for development. Adaptation also needs to be properly funded to be able to address effectively some of the key issues that could become contentious as a result of climate change (natural resource sharing, food security, national security, controlled migration and water allocation, and so on). It must be done within the framework and context of other national issues of the rapidly growing population, rapid urbanization, and the need for Nigeria to adjust to a swiftly globalizing world in the face of a changing climate.

Climate insecurity could be an additional burden to Nigeria's development. As well as developing a comprehensive climate change response strategy, improving climate security in Nigeria requires that the country undertakes to:

- ensure climate change strategies are conflict-sensitive; in this regard, the development and implementation of national climate change response strategies must be informed by an analysis of local and regional conflict dynamics and

community-based consultations to effectively address insecurity and conflict prevention;

- support and build upon local adaptation mechanisms for livelihood security to reduce the likelihood of migration in areas that are becoming increasingly harsh as a result of climate change;
- establish a climate change/conflict working group to provide a forum where members from different sectors of the society could share knowledge and best practices, and develop and implement joint strategies for adapting to climate change;
- promote more extensive and in-depth research on the socio-political impact of climate change to strengthen an understanding of the relationship between climate change and conflict, and to inform the development of conflict-sensitive climate change response policies (e.g., mapping of areas most likely to experience insecurity and conflict as a result of natural resource scarcity exacerbated by climate change, detailed analysis of existing community governance structures and mechanisms in the areas most vulnerable to climate change, analysis of the extent to which the effects of climate change on natural resource scarcity and competition will influence internal and cross border migration patterns to help policy-makers to identify and prepare for the potential security and conflict consequences);
- strengthen systems for recording and monitoring climate and migration data, as well as reporting on the state of the environment in the conflict-prone areas of the country; the information should be readily accessible to policy-makers to help them develop climate change-sensitive strategies, and specifically to inform climate change/conflict scenarios.
- improve early warning mapping of conflict-prone areas; promote awareness on the nexus between climate change and natural resources conflicts, and work toward implementing the guiding principles on migration (internal and external) of people displaced by extreme climate and weather events;
- develop a climate change-sensitive national policy on peace-building and conflict management;
- include conflict prevention and security in the proposed National Climate Change Policy and Response Strategy;
- improve capacities to respond to climate change such as the enhancement of coastal defenses (in the case of coastal states); and
- strengthen the national climate change governance structures.

## **Issue 4: Rural and Urban Livelihoods**

Livelihoods may be defined as the bundle of different types of assets, abilities and activities that enable a person or household to survive (Stamoulis and Zezza, 2003). These assets include physical assets such as infrastructure and household items; financial assets such as stocks of money, savings, and pensions; natural assets such as natural resources; social assets, which are based on the cohesiveness of people and societies; and human assets, which depend on the status of individuals and can involve education and skill. These assets change over time and are different for different households and communities in both rural and urban areas. The amounts of these assets that a household or community possesses or can easily gain access to are key determinants of sustainability and resilience (FAO, 2008).

Climate change has substantial implications for the sustainability of rural and urban livelihoods in Nigeria. It poses a serious threat to livelihoods and enhances risks and vulnerabilities of the people and ecosystems through the increased frequency of natural disasters and extreme weather events. In particular, people's livelihoods in coastal areas and the desertification-prone Sahel ecological zones of the country are highly vulnerable to climate change. The anticipated sea-level rise and extreme and erratic weather conditions all have serious implications for over 17 million people occupying the coastal environment of the country and over 35 million people that heavily depend on the climate-sensitive resources of the desertification-prone areas of Nigeria. The change in seasonality attributed to climate change can lead to certain food products becoming scarcer at certain times of the year. Such seasonal variations in food supply, along with vulnerabilities to flooding and fire, can render livelihoods defenceless at certain times of the year and further worsen the poverty level of the very vulnerable in the society.

The impacts of climate change on agriculture, natural resources, biodiversity, health and infrastructures all impinge on livelihood sources. The impacts affect all people, but the most affected are women and children – especially young girls who often adopt similar roles as women – poor people, and the marginalized in each of the zones. A close look at the hazards and impacts of climate change on the various sectors reveals that, in both the short- and long-term, most Nigerians will be affected due to the existing vulnerabilities of geographical location and the natural physical characteristics associated with the locations. The impacts are interlinked to aggravate the vulnerabilities and further undermine livelihoods.

In rural Nigeria, agriculture is at the heart of the means of sustainable livelihoods. According to FAO (2008), livelihood groups in the agriculture sector that warrant special attention in the context of climate change include:

- low-income groups in drought- and flood-prone areas with poor food distribution infrastructure and limited access to assets and emergency response;
- low- to middle-income groups in flood-prone areas that may lose homes, stored food, personal possessions, and means of obtaining their livelihood, particularly when water rises very quickly and with great force, as in sea surges or flash floods;
- farmers whose lands become submerged or damaged by sea-level rise or saltwater intrusions;
- producers of crops that may not be sustainable under changing temperature and rainfall regimes;
- producers of crops at risk from high winds;
- poor livestock keepers in drylands, where changes in rainfall patterns will affect forage availability and quality;
- managers of forest ecosystems that provide forest products and environmental services;

- fish producers whose infrastructure for fishing activities (such as port and landing facilities), storage facilities, fish ponds and processing areas, becomes submerged or damaged by sea-level rise, flooding, or extreme weather events;
- fishing communities that depend heavily on coral reefs for food and protection from natural disasters; and
- fishers and aquaculture farmers who suffer diminishing catches from shifts in fish distribution and the productivity of aquatic ecosystems caused by changes in ocean currents or increased discharge of freshwater into oceans.

Agriculture-based livelihood systems that are already vulnerable to climate change face the immediate risk of increased crop failure, loss of livestock and fish stocks, increasing water scarcities and destruction of productive assets. These systems include small-scale, rain-fed farming, pastoralism, inland and coastal fishing and aquaculture communities, and forest-based systems. Rural people inhabiting coasts, flood plains, and drylands in the country are most at risk.

The urban poor, particularly in coastal cities and flood plain settlements, also face increasing risks. Among those at risk, pre-existing socio-economic discriminations are likely to be aggravated, causing nutritional status to deteriorate among women, young children and elderly, ill and disabled people. All wage earners face new health risks that could cause declines in their productivity and earning power. Climate change will also affect people differently depending on such factors as land ownership, asset holdings, marketable skills, gender, age and health status (Majid, 2003).

Climate change, together with an increasing demand for freshwater, will increase water stress in many parts of Nigeria, particularly in the north. This will be critically important to agricultural production, food security, and rural development. Increasing water stress combined with increasing uncertainty and extreme weather events will affect food production and will expand food insecurity across the country. Changes in the characteristics of the rainfall may further reduce productivity as the West African Monsoon may be unstable due to climate change. Increased natural hazards and extreme weather events may also increase risks and vulnerabilities in rural areas, and accelerate rural-urban migration and the number of environmental refugees in urban areas, further compounding the rural-urban livelihood dynamics in the country. Migration is in general an adaptive strategy to the loss of means of livelihoods under a changing climate scenario.

It is noted, however, that while climate change poses serious challenges, it may also create new opportunities for rural livelihoods through the requirement for better management of natural ecosystems and their services. Carbon trading through the CDM, Reducing Emissions from Deforestation and Forest Degradation (REDD), and Payment for Environmental (or ecosystem) Services (PES) could be important sources of income for rural communities in the near future. For Nigeria to benefit from these climate change financing mechanisms and instruments, there must be in place appropriate policies; institutional, legal, knowledge, and technological support; and appropriate property rights for the institutionalization of ecosystem services. Enhanced benefits could also be gained from the promotion of niche products with improved potential in urban markets. Without such support from the government, rural people, in particular, will not be able to tap into the opportunities for improving their livelihoods and well-being in the face of an increasingly changing climate.

## Governance, Policies and Programmes

Most of the policies and initiatives pertinent to sustainable livelihoods and their adaptation to climate change are covered elsewhere in this report for the relevant sectors such as infrastructure, agriculture, natural resources, and health, and need not be repeated here. Other related policies include those on rural development, environment, tourism, trade, micro-credit and micro-financing, and national security. For example, relevant adaptation strategies for sustainable livelihoods include combating agricultural soil degradation and soil fertility management (e.g., through improved land clearing), water management techniques (e.g., anti-erosive small dykes, water pocket or zai and half-moon practices), crop diversification, agro-pastoralism, production and sale of animals, mutual aid and cooperation, diversification of economic activities, migration, intensive farming, and conservation of the natural resources utilized by people for rural livelihoods.

## Recommended Adaptation Actions

Building climate-resilient livelihoods is the key overarching strategy to increased adaptive capacity of communities and families. Recent research (MONRE/UNDP/DFID, 2009) indicates that it can be done. To do this effectively, Nigeria needs to:

- improve environmental governance at national, state, and local/community levels to reduce environmental degradation and resource depletion, in order to strengthen livelihoods in the face of increasing climate variability and change; in particular, adhere to bottom-up planning processes in the development of long-term adaptation strategies to climate change;
- put in place strong local institutions such as rural extension services for improved adaptive livelihood strategies in response to climate change;
- ensure right sequencing of adaptation measures and strategies;
- empower vulnerable groups to diversify income sources, including migration to encourage remittances back to families in climate change-induced ecologically degraded areas of the country (e.g., coastal and desertification-prone areas), to maintain aged and female household members that are usually left behind in these areas;
- ensure intra-generational and inter-generational equity in the strengthening of the processes for successful livelihood adaptation to climate change;
- support vocational and skills training needs for migrants in the urban centres;
- mainstream climate change into development planning;
- integrate hazard risks into the planning, development, and provision of basic needs such as housing, water, and hard and soft infrastructure, in order to build ecological resilience; and
- adopt sectoral climate-resilient approaches to agriculture by introducing climate-resilient species.

Specific programmes may include (MONRE/UNDP/DFID, 2009):

- building climate-resilient agriculture to improve existing local adaptation measures - e.g., adjustment of when to plant and harvest, where to plant (cropping patterns), what to plant (switching to climate-resilient crop varieties), and how to plant (diversified farming, inter-cropping, crop rotation etc.);
- building climate-resilient fishing and aquaculture (e.g., introduction of aquaculture species adapted to high temperatures and changed salinities).
- building climate-resilient livelihoods (e.g., ensuring access to more diverse and better targeted credit, insurance and other financial services, particularly for the poor; "hazard-proofing" residential housing; accessible, secure, safe storage and protection from climatic hazards to enable primary producers to avoid selling when prices are least favourable; improved access of the most at-risk to information on climate risks, adaptation measures, and market information by enabling timely access to communication infrastructure);
- building climate resilience of the livelihood resource-base, including:
  - incorporating social and ecological perspectives into adaptive management strategy formulation
  - undertaking ecological rehabilitation of degraded areas
  - reducing coastal erosion
  - using biological methods, such as planting mangroves or coconuts as "bio-shields" to stabilize shoreline areas
  - combating deforestation
  - re-foresting strategic areas
  - supporting "hazard-proof" construction and adaptation measures
  - facilitating credit for farmers, fishers, and pastoralists to encourage a reduction in environmental impacts
  - linking farmers to carbon market options (e.g. promoting community-based conservation and natural resources management to offset climate change effects that promote unsustainable resource use).
- improving water storage and management to meet the needs of future generations through increased public awareness and participation in sustainable water use and management;

- mainstreaming emergency response planning and early warning systems into the comprehensive development plans of the vulnerable areas along the very vulnerable coastal and the northeastern parts of Nigeria, using a participatory approach;
- planning and managing early responses to sea-level rise, including:
  - the construction of hard flood defense infrastructure (e.g., sea walls, dykes, and embankments) and soft flood defenses (e.g., wetlands, coastal salt marshes)
  - monitoring of both sea-level rise and salinity intrusion at the local level to inform decision-making on the extent of the problem and what is required
  - monitoring, over time, wetland and livelihood gains from alternative responses to climate change threats.
- planning and managing effective responses to drought and desertification in the vulnerable north, including:
  - the establishment of soft infrastructure, such as "green wall" for ecological rehabilitation of degraded areas
  - mainstreaming aridity and desertification hazard maps into development planning
  - continuous monitoring of changes in ecological and livelihood conditions of rehabilitated areas.
- Improving resettlement processes for vulnerable households and communities to include consideration of paying compensation, continuing access over the short-term to previously used livelihood resources, support in exploring new livelihood options, improving access of vulnerable households to productive assets, and providing appropriate skills training prior to resettlement.
- Building adaptive strategies for climate change-induced migrants to include:
  - better education and job-related vocational training and re-skilling to strengthen the capacity of migrants to remit money
  - provision of incentives to encourage successful temporary migrants to invest in local enterprises generating employment
  - ensuring better labour protection for migrant workers.

**Table 7** Hazard-Impacts-Vulnerability-Adaptation Options Matrix for Cross-Sectoral Issues:  
**Urban and Rural Settlements**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
<b>Ecozone: SAHEL and SAVANNA</b>			
<ul style="list-style-type: none"> <li>■ Decreased rainfall (late onset, early cessation, increased drought incidences, irregular/ changes in the distribution of rain days, increased intense rainfall events)</li> <li>■ Increased temperature</li> <li>■ Extreme weather events (storms, floods, wind storms, heat waves)</li> </ul>	<ul style="list-style-type: none"> <li>■ Drying up and changes in depth &amp; sizes of rivers/streams/ dams/ponds, increasing water scarcity</li> <li>■ Siltation of rivers</li> <li>■ Land degradation</li> <li>■ Biodiversity loss</li> <li>■ Increased water scarcity</li> <li>■ Overgrazing</li> <li>■ Cultivation of marginal lands</li> <li>■ Loss of pasture &amp; arable lands</li> <li>■ Poor performance of livestock</li> <li>■ Reduced crop yields</li> </ul>	<ul style="list-style-type: none"> <li>■ High poverty levels</li> <li>■ Low level of technology</li> <li>■ Low level of education</li> <li>■ Low level of awareness· Gender</li> <li>■ High level of deforestation</li> </ul>	<ul style="list-style-type: none"> <li>■ Adapt agricultural crops &amp; practices to the changing conditions</li> <li>■ Diversify livelihoods</li> <li>■ Provide water to alleviate water scarcity problems by drilling boreholes &amp; small earthen dams</li> <li>■ Migration (coping mechanism)</li> <li>■ Improve enabling environment for SME growth &amp; enhance access to product assets (e.g., micro credits)</li> <li>■ Provision of post-harvest storage &amp; value-adding facilities for agricultural produce</li> </ul>
<b>Ecozone: COASTAL/RAINFOREST</b>			
<ul style="list-style-type: none"> <li>■ Increased rainfall and changes in the rainfall distribution (unpredictable onset of the rains)</li> <li>■ Increased temperature· Extreme weather events (storms, floods, wind storms, heat waves)</li> <li>■ Sea-level rise</li> </ul>	<ul style="list-style-type: none"> <li>■ Inundation of coastal areas and low-lying areas with salt water</li> <li>■ Ocean surges cause salt water intrusions</li> <li>■ Delay in the onset of the harmattan</li> <li>■ Increased frequency of flooding</li> <li>■ Soil erosion, resulting in reduced soil fertility, landslide &amp; gulley erosion, increase in incidences of crop pests &amp; diseases, loss of natural resources, increased conflicts over resources</li> </ul>	<ul style="list-style-type: none"> <li>■ High poverty levels</li> <li>■ Low level of technology</li> <li>■ Low level of education</li> <li>■ Low level of awareness</li> <li>■ Gender</li> </ul>	<ul style="list-style-type: none"> <li>■ Adapt agricultural crops &amp; practices to changing conditions</li> <li>■ Diversification of livelihoods</li> <li>■ Provision of water to alleviate water scarcity problems by drilling boreholes and small earthen dams</li> <li>■ Migration (coping strategy)</li> <li>■ Improve enabling environment for SME growth and enhance access to product assets (e.g., micro credits)</li> <li>■ Provision of post-harvest storage &amp; value-adding facilities for agricultural produce</li> <li>■ Develop &amp; use infrastructure to prevent coastline erosion</li> </ul>

SME = small- and medium-sized enterprises.

**Table 8** Policies, Programmes, Adaptation Options Addressed, Implementing Agency, and Cost for Cross-Sectoral Issues: **Rural and Urban Settlements Sub-sector**

Proposed CCA Policies	Proposed CCA Programmes	Ecozone Addressed	CCA Options Addressed by Proposed Policies and Programmes	Implementation Agency (s)	Estimated Costs
<b>Immediate Needs</b>					
<ul style="list-style-type: none"> <li>■ Vulnerability and assessment of climate change (across communities in ecozones)</li> <li>■ Assessment of awareness of climate change vulnerability across regions</li> <li>■ Assessment of impacts of the adaptation strategies</li> <li>■ Assessment of adoption of adaptation strategies</li> <li>■ Identification of indigenous knowledge in various communities in the ecozones &amp; impacts of indigenous knowledge of climate change</li> <li>■ Development of early warning systems at state &amp; local government levels by creating a climate change mandate in state capitals &amp; LGA headquarters</li> </ul>	<ul style="list-style-type: none"> <li>■ Vulnerability assessment results will be used to improve the policies on agriculture, industry, health, and settlements under climate change</li> <li>■ Capacity building</li> </ul>	All ecozones	<ul style="list-style-type: none"> <li>■ Diversification of livelihoods</li> <li>■ Provision of water to alleviate water scarcity problems by drilling boreholes and small earthen dams</li> <li>■ Migrations</li> <li>■ Improve enabling environment for SME growth and enhance access to product assets (e.g., micro credits)</li> <li>■ Provision of post-harvest storage and "value-added" facilities for agricultural produce</li> </ul>	<ul style="list-style-type: none"> <li>■ Pilot projects by universities, research institutes, NGOs, CBOs and enterprising individuals</li> <li>■ Ministry of Education and NUC to include in the course curriculum in the primary schools, universities, colleges of education, and polytechnics, and</li> <li>■ Federal government</li> <li>■ State governments</li> <li>■ Local governments</li> </ul>	Low to high
<b>Long-Term Needs</b>					
<ul style="list-style-type: none"> <li>■ Implementation of programmes that will enhance the resilience of livelihoods under climate change</li> <li>■ Development of climate change desk in state capitals and LGA headquarters</li> </ul>					Medium to high

CBO = community-based organization; CCA = climate change adaptation; LGA = Local Government Area; NGO = non-governmental organization; NUC = National Universities Commission; SME = small- and medium-sized enterprises.

**Table 9** Evaluation of Proposed Policies for Cross-Sectoral Issues: **Urban and Rural Settlements Sub-sector**

Proposed CCA Policies	Criteria to Evaluate Effectiveness of Policy Implementation	Implications if Policy IS Implemented (individuals, communities, private sector)		Implications if Policy NOT Implemented (individuals, communities, private sector)	
		Positive Impacts	Negative Impacts	Positive Impacts	Negative Impacts
<b>Immediate Needs</b>					
<ul style="list-style-type: none"> <li>■ Continuous assessment of vulnerability &amp; impact</li> <li>■ Assessment of impacts of the adaptation strategies</li> <li>■ Assessment of awareness of climate change vulnerability &amp; impact by different communities</li> <li>■ Assessment of adoption of adaptation strategies</li> <li>■ Identification of IK in various communities &amp; impacts of using IK</li> </ul>	<ul style="list-style-type: none"> <li>■ Assessment of the outcomes of the strategies on urban and rural livelihoods (e.g., is there an increase in the quality of life; is there an increased awareness of climate change hazards &amp; impacts; are the impacts of climate change reducing or intensifying &amp; increasing?)</li> </ul>	<ul style="list-style-type: none"> <li>■ The vulnerability of people to climate change impacts will be reduced</li> <li>■ Sustainable livelihoods that reduce both the environmental predicament &amp; vulnerability of urban &amp; rural people will emerge</li> <li>■ Natural resource degradation &amp; biodiversity loss will be reduced</li> <li>■ Migrations will be reduced</li> <li>■ People will live healthier, longer, and fulfilled lives</li> <li>■ Diseases will be reduced</li> </ul>		<ul style="list-style-type: none"> <li>■ Hardly any positive impact will result</li> </ul>	<ul style="list-style-type: none"> <li>■ Increased loss of natural resources &amp; biodiversity</li> <li>■ The vulnerabilities of both urban &amp; rural people will increase</li> <li>■ Disasters will increase</li> <li>■ Conflicts &amp; insecurity will increase in magnitude and frequency</li> <li>■ Loss of lives &amp; property</li> <li>■ People will remain ignorant, convinced the calamities are punishment from the gods, thus encouraging the "business as usual" way of life (politicians will thrive)</li> <li>■ Increase in diseases in humans, livestock, &amp; crops</li> <li>■ Increased migration</li> <li>■ Agricultural productivity slump</li> <li>■ Increased poverty &amp; social ills</li> <li>■ Acute water scarcity</li> <li>■ All the aforementioned will increase the vulnerability of urban &amp; rural people</li> </ul>
<b>Long Term Needs</b>					
<ul style="list-style-type: none"> <li>■ Assessment of adaptation programmes</li> <li>■ Assessment of acceptability of adaptation programmes</li> <li>■ Development of climate change desk in state capitals and LGA headquarters</li> </ul>					

CCA = climate change adaptation; IK = indigenous knowledge; LGA = Local Government Area.

## Issue 5: Vulnerable Groups (gender, youths)

### Current Trends

Scientific evidence suggests that the world's climate is changing and no one will be immune from the overall impacts. But negative impacts of climate change will not affect everyone equally. For example, climate change will have a disproportionate effect on the lives of poor people in developing countries, where poverty increases people's vulnerability to its harmful effects. In general, the consensus is that climate change tends to exacerbate differences among various groups in their vulnerability and ability to cope with the effects. The vulnerable and socially marginalized groups – such as the poor, children, women, the elderly, and indigenous peoples – tend to bear the brunt of environmental change (UNFPA, 2009).

General evidence in the literature indicates that, because of their increased likelihood of living in poverty and their gendered social roles, women are more likely than men to (Brody *et al.*, 2008; UNDP, 2009; UNECA, 2009; Haigh & Vallely, 2010; Olawaoye *et al.*, 2010):

- die in climate change-related disasters and suffer from increased workload, loss of income, health problems, and violence and harassment in the aftermath of such events;
- be displaced or encounter problems when other (usually male) family members migrate for economic reasons;
- experience increased burden of water and fuel collection and resulting health problems, due to increased incidence of drought or other changes in climate;
- feel the effects of rising food prices most acutely and be the first to suffer during climate change-induced food shortages;
- suffer exacerbated health inequalities;
- suffer from violence, including sexual violence, in resource conflicts;
- be expected to, and need to, adapt to the effects of climate change, increasing their workload;
- suffer as a result of intended solutions to the problem of climate change, such as forestry projects and biofuel production.

In the specific context of Nigeria, women are more vulnerable to the effects of climate change than men – primarily as they constitute the majority of the country's poor and are more dependent for their livelihood on natural resources that are threatened by climate change. Those charged with the responsibility of securing water, food, and fuel for cooking and heating, particularly in the rural areas, face the greatest challenges in the face of increasingly variable climatic conditions. Furthermore, they face social, economic and political barriers that limit their coping capacity. When coupled with unequal access to resources and to decision-making processes, limited mobility places women in rural areas in a position where they are disproportionately affected by climate change. It is thus important to identify gender-sensitive strategies to respond to the environmental and humanitarian crises caused by climate change.

### Existing Governance, Policies and Programmes

Women and youth are often perceived primarily as victims and not as positive agents of change. However, women, in particular, can be key agents of adaptation to climate change. Their responsibilities in households, communities, and as stewards of natural resources position them well to develop strategies for adapting to changing environmental realities. For example, as reported variously in WEDO (2007), communities fare better during natural disasters when women play a leadership role in early warning systems and reconstruction. Women tend to share information related to community well-being, choose less polluting energy sources, and adapt more easily to environmental changes when their family's survival is at stake.

In the same vein, youths can be positive agents of change if their talents and exuberant energies are properly channeled. They need to be provided with scientifically accurate and culturally sensitive information on how to ensure environmental sustainability in the face of increasing changes in the climate.

Despite this common knowledge, current policies and mechanisms for women's (and youth's) participation in Nigeria's national development process are inadequate. Nigerian women suffer from pervasive poverty and social and cultural restrictions that prevent their being fully mainstreamed into the national development process. Moreover, there is inadequate information on gender issues related to climate change; neither are many women in relevant professions and positions of authority that can allow them play an active role in decision-making or to influence policy (UNDP, 2009; Olawaoye *et al.*, 2010). Although the Federal Government of Nigeria has many ministries and agencies that have mandates and carry out activities related to climate change and national development, particularly in climate change-sensitive sectors such as agriculture, energy, environment, and water resources, there is no specific focus on their relationships to the gender aspects of climate change impacts. Thus, the current policies, including the National Policy on Women, and mechanisms for gender-sensitive climate change adaptation remain inadequate.

## Recommended Adaptation Actions

In developing appropriate gender-sensitive adaptation actions to reduce the impact of climate change on the vulnerable sectors of Nigerian society, it is important to take into consideration the fact that women and youth are not only vulnerable to climate change, but they are also effective actors or agents of change in relation to both mitigation and adaptation. Women often have a strong body of knowledge and expertise that can be used in climate change mitigation, disaster reduction and adaptation strategies. Furthermore, women's responsibilities in households and communities, as stewards of natural and household resources, positions them well to contribute to livelihood strategies adapted to changing environmental realities. The same applies to the youth and other vulnerable groups.

In natural resource-dependent communities, men and women have distinct roles and responsibilities, which give rise to differences in vulnerability and ability to adapt to climate change. Some of the ways gender roles are linked to climate change adaptation are:

- Due to a gender-based division of labour, men and women perform different jobs/tasks. Climate change will alter what they can do, exposing men and women to different risks and opportunities. Men may migrate for work, while women may spend more time collecting fuel and water, for example.
- Men and women have different access to resources, including physical resources like land, social resources like networks, and financial resources like income-generating work and credit. In times of change, they will have different options and safety nets for coping with and ultimately adapting to climate change.
- Based on their distinct roles, women, men, youth, and the physically challenged have different sets of knowledge and skills, such as knowing which seeds to plant during a dry spell and what management practices to apply. Recognizing their contributions will result in a wider range of options for preparing for and adapting to climate change.
- Participation in decision-making and politics and access to decision-makers is not always equal for men, women, youth, and the physically challenged. This may affect their participation and the representation of their ideas in short- and long-term decision-making on climate change adaptation.

It is important to find initiatives that deal with climate change and at the same time address the injustice of the current system so that climate change policies and adaptation strategies will not reinforce and exacerbate existing inequalities. To achieve climate change adaptation justice, it is imperative to change existing structures and mechanisms so that the capacity of women and vulnerable groups (e.g., youth) can be enhanced to allow their equal participation in decision-making for effective solutions to the challenges of climate change.

On the basis of the aforementioned, the following adaptation actions are recommended:

- Ensure that the proposed National Climate Change Policy and Response Strategy have gender-specific adaptation strategies to redress the current exclusion of women from processes and decisions relating to the impact of climate change on national development.

- A National Gender and Climate Change Action Network should be established as an advocacy platform at the national and international levels to drive gender and climate change concerns.
- The issue of gender and climate change should be given far greater visibility by allowing it to be driven at the highest level, in this case the Presidency.
- National institutions should be strengthened so as to enable them to develop and disseminate gender disaggregated climate data to facilitate more strategic national planning.
- The future national delegations to strategic regional and international meetings should reflect gender balance and comprise well-informed, broadly based, all-encompassing stakeholders to properly articulate the national position.
- Build and implement environmentally friendly and gender-sensitive adaptation policies and programmes.
- Rural dwellers should be empowered with skills and knowledge on environmental conservation, through community demand-driven projects.
- Form civil society coalitions working on environmental issues that address climate change at a local level.
- Use participatory approaches at the local and community levels to involve all members of the community in planning; local gender roles should be understood, including different vulnerabilities.
- Ministries of Youth and Social Development at all levels of government should create a climate change desk where issues of climate change will be given adequate attention.
- The Federal Ministry of Education should liaise with other stakeholders to design a climate change curriculum for primary, secondary, and tertiary institutions in Nigeria.
- The federal government should make the teaching of climate change courses compulsory at all level of education in Nigeria.
- Youth representation on issues that affect climate change and environmental degradation should be strengthened in relevant ministries, departments, and agencies.
- Undertake a gender analysis of national or local climate change policies, programmes, and/or budgets (e.g., examine how national adaptation or other climate change plans include or exclude gender equality).
- Ensure that women participate in decisions related to climate change and have access to capacity building (e.g., enhance opportunities for the participation, education, and training of women).
- Develop gender-sensitive indicators for governments to use in national reports to the UNFCCC, the Kyoto Protocol, and the CDM.
- Create practical tools that allow gender equality to be incorporated in climate change initiatives. (e.g., develop a mechanism for the CDM to fund projects that make renewable energy technologies more available to women).
- Increase female participation in all areas of decision-making relating to adaptation to climate change.
- Ensure emergency provision takes into account women's vulnerabilities, including ensuring that warning systems reach all members of the community, and shelters take into account the needs of women.
- Address the health and nutritional inequalities which make women most vulnerable to the effects of climate change. These developmental goals should not be neglected with the focus on climate change.
- Recognize women's knowledge of the environment and natural resources, and incorporate this knowledge into adaptation strategies.
- Provide aid and financing for climate change adaptation projects that include women in their design and planning, and consider and seek to eliminate any additional burden on women.
- Make provision for appropriate technology transfer in ways that benefit, rather than increase, workloads for women, and include gender targets for "green-collar" jobs.
- Ensure that women have equal access to up-to-date information about climate change and adaptation strategies, recognizing their generally lower literacy rate and other barriers to accessing information.

## Current and Future Trends

### Issue 6: Education

Education is concerned with the development of an individual's ability to think, reason, and create. It is a dynamic process, encompassing all activities that make individuals socially responsible and knowledgeable of the world around them. Education is the process of acquiring and applying knowledge and skills that enhances an individual's personality and provides her or him with confidence to engage with the world (Jackson, 2008). Education involves imparting knowledge and developing the skills for self-realization (Ogueri, 2004). It liberates humans from the "shackles of darkness," making life more meaningful and worth living. Basic education also provides the foundation for developing sound and sustainable means of interacting with the natural environment, and on how its resources are to be used (Universal Basic Education, 2004).

There has been a lot of emphasis, particularly in recent times, for universal access to basic education. This is also in recognition of the declaration of the World Conference on Education for All (WCEFA) made in Jomtien, Thailand in 1990. The declaration clearly states the goals to be attained by the year 2015. These goals include ensuring that the learning needs of all young people are met through:

- equitable access to appropriate learning and life skills programmes;
- improving all aspects of the quality of education; and
- ensuring excellence for all, so that recognized and reasonable learning outcomes are achieved; especially in literacy, numeracy, environmental ethics, and essential life skills.

Although climate change is predicted to have a wide range of adverse effects, public concern is largely directed toward the natural sciences. Researchers in the social sciences and those engaged in educational research have played a comparatively small role, have shown relatively less interest, and are only recently becoming engaged. It is known, however, that poverty, which plays a big role in how well people are able to adapt to climate change, may not be sustainably addressed if the education of the public is not mainstreamed into the climate change discussions.

Specific challenges facing Nigeria in relation to climate change adaptation include high illiteracy rates and low awareness of the issue of climate change (UNDP, 2008). Therefore, those in the education sector are faced with the responsibility of determining how to make the public become more aware of the issues, both through formal and informal education. Researchers, policy-makers, and the general public lack adequate climate change knowledge and information. Increasing public awareness is a novel challenge that should be tackled by Nigeria's policy-makers. To do this, policy-makers require accurate data about climate change that can be used to trigger action.

## Current and Predicted Hazards, Impacts, Vulnerabilities, and Adaptation Options

The Intergovernmental Panel on Climate Change (IPCC) concluded in their fourth assessment report (IPCC AR4) that the warming of the earth's climate is our new reality (IPCC, 2007). The report indicates that the global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005. This is manifested in rising temperatures, rising sea level, and shifts in climatic zones because of higher temperatures and altered precipitation patterns (AERC, 2008; Biello, 2008).

The IPCC predicts an increase in extreme climate events such as unusual storms, floods, changing patterns of rainfall, strong winds, droughts, and tidal waves, all of which are the main threats to Africa, arising from climate change. The adverse effects of climate change are already evident, natural disasters are more frequent and more devastating, and developing countries are the most vulnerable.

Adaptation to climate change is an adjustment in natural or human systems, in response to actual or expected climate stimuli or their effects that moderates harm or exploits

beneficial opportunities (IPCC, 2007). Adaptation is about the future, and the children, youth, men, and women have important responsibilities towards meeting the challenges of the future.

Vulnerability to climate change is the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change (IPCC, 2001).

The level of public awareness on issues related to climate change in Nigeria is considered extremely low except within a few national and private sector agencies, where technical personnel relate closely to the subject (UNDP, 2008). Apart from the key professionals and NGOs whose activities directly involve the assessment of the potential impact of climate change, there is great need to improve the current level of public awareness.

It has become necessary for stakeholders in the education system (such as academics, researchers, teachers, students, and policy-makers) to begin to engage in national programmes and campaigns to inform the public and to improve the perception of climate change. Government at every level, together with the private sector and civil servants, should also be involved in these programmes and campaigns.

Many current environmental problems are due to a lack of knowledge of basic ecology. To counteract this problem, well-funded, scientifically accurate, and carefully designed educational courses in schools, colleges, and communities must ensure that upcoming generations will understand the value and importance of climate change, its impacts and its adaptation strategies.

### **Climate change impacts on education**

The increased frequency and magnitude of extreme weather events in Nigeria is likely to pose threats to school activities, including school closures, learning capacities, and overall performance in academic work. Schools in many parts of Nigeria are often designed with poor ventilation and are too small for the number of pupils or students who attend. The increase in temperatures will only add to the discomfort felt by students in the classrooms, and may contribute to heat stress and adversely affect the mental capacity of both the teacher and the students. With increasing population growth and higher enrolment levels, these impacts will only get worse. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2007), the annual population growth rate is estimated to be 3.3%. Five million Nigerian children, aged six- to 11-years-old, do not have access to basic education (National School Census, 2006). The majority of those who are "lucky" to enter schools are given sub-standard education (Dike, 2002).

The frequency of severe weather events such as rainfall, droughts, and storms that are predicted to increase (WMO, 1997) will have tremendous impact on school buildings. Most schools in Nigeria, especially those in rural areas, are already dilapidated and are likely to be affected by wind and rain storms. It is estimated that about 80% of the primary and secondary schools are located in the rural areas (UNESCO, 2007). Because of classroom shortages, classes are often offered outside and are thus subjected to increased extreme weather, leading to class cancellations and lack of quality instruction.

Although Nigeria's educational institutions in general are in need of upgrading, the most troubled is the primary education sector. Recent statistics on primary education show that there are approximately 2,015 primary schools in Nigeria, with no buildings of any type. In these "schools," classes are held outside, under trees. The quality of lectures conducted under such conditions is very poor and will only get worse with increased temperatures, rain, and extreme weather events. The trees, which provide shade, playgrounds, and sometimes the learning environment will be impacted by these weather events. By implication, school attendance, and what the students are able to achieve, are severely threatened.

Extreme weather events have both short-term and long-term socio-economic and health effects on students, pupils, teachers, and the public. Increased spread of endemic water- and vector-borne diseases and shortages of water and food, are additional threats posed by climate change. Children are the most vulnerable to health hazards. With increased risk of disease, there will be more deaths of schoolchildren and reduced attendance. Drop-out rates will also increase (Summer, 2008). Schoolchildren are likely to suffer from malnutrition as a result of famine and may not be able to learn in school.

## Climate change impacts on public awareness

Humans tend to over-exploit their environment: They cut trees, over-graze, burn, and kill wildlife and fish to the extent that forest cover and biodiversity is very low in Nigeria. People generally do not recognize that their impacts on local ecosystems make the impacts of climate change even worse. When the environment deteriorates as a result of human impact, poverty levels increase, as does the overall standard of living. Resilience and the capacity to adapt to climate change decreases when there is an unhealthy natural environment.

Other issues which demand a change of values and attitudes of both north and south, young and old, and rural and urban inhabitants, are global challenges – resource use, energy utilization and environmental degradation, pollution, demographics (more people, more "everything"), all of which exacerbate climate change impacts. Considering all of this, there is a great need to create an environmental consciousness and awareness of human impact on the environment. This new consciousness requires new values and attitudes about the sustainable use of resources.

According to a UNESCO (2009) report, over 776 million adults worldwide are still illiterate. Two-thirds of these are women, while approximately 75 million school-age children are not attending school. High illiteracy rates reflect the most disadvantaged and marginalized populations, which include a high percentage of women and girls, indigenous peoples, linguistic minorities, rural dwellers, and the disabled. The knowledge vacuum in the understanding of the economic as well as the social impacts of climate change on Africa's development prospects is large.

Education affects social and economic development including poverty, wealth creation, employment, and social security and protection. Nigeria has adopted Article 6 of the United Nations Framework Convention on Climate Change (UNFCCC), which indicates that there is the need to improve the public perception of climate change. This would enable a greater number of stakeholders responsible for managing projects related to climate change mitigation, vulnerability, and adaptation to be made aware of the role such projects or activities may have on climate change.

Information on climate change impacts should be provided to every Nigerian citizen, along with needed adaptation and mitigation measures. It is the task of trained and experienced experts in environmental studies to work with governments, educators, and NGOs to help create awareness in both the country's rural and urban communities. A major concern in Nigeria is the lack of adequate information on climate change. However, there is adequate information on sustainable environmental management, which, if practiced, will help people adapt to climate change.

The need and importance of environmental education, at any level, cannot be over-emphasized. The ignorance and awareness, lack of knowledge and skills, and inadequate environmental ethics among students and the public can only be remedied through such education. With education comes the motivation to become involved and to participate in decision-making, community action, or problem-solving on environmental issues such as climate change. This approach is one step forward in dealing with future sustainable development.

Programmes on environmental issues, including climate change, are essential in order to develop a healthy, sustainable society. Many of our current environmental problems are due to widespread ignorance of the basic ecological facts of life. Well-funded and well-designed courses in schools and colleges can go a long way to raise the overall awareness of the public to counteract these problems.

**Table 10** Hazards-Impacts-Vulnerability-Adaptation Options Matrix for Cross-Sectoral Issues: **Education**

Climate Change Hazards	Climate Change Impacts	Determinants of Vulnerability	Adaptation Options
Increased rainfall intensity leading to flooding	<ul style="list-style-type: none"> <li>■ Collapse of dilapidated school buildings</li> <li>■ Trees and plants will be uprooted</li> <li>■ Flooding on roads to schools will impact long-distance trekking to school</li> </ul>	<ul style="list-style-type: none"> <li>■ Poorly built and dilapidated buildings</li> <li>■ Lack of building regulations leads to poorly built and dilapidated buildings</li> <li>■ School environment not conducive to learning</li> <li>■ Low attendance in schools</li> <li>■ Poor academic performance due to poor or lack of school buildings</li> </ul>	<ul style="list-style-type: none"> <li>■ Solid and better-built schools</li> <li>■ Preservation of old trees and planting of new ones</li> <li>■ Grasses and plants should be planted in school compounds</li> <li>■ Creating awareness through environmental education and management to students at all levels</li> </ul>
High temperatures	<ul style="list-style-type: none"> <li>■ Excessive heat in classrooms</li> <li>■ Discomfort in the classroom as a result of overcrowding, sweating, and heat stress</li> <li>■ Weakness</li> <li>■ Reduced mental capacity as shown in poor readiness to learn, and inability to understand and comprehend concepts</li> <li>■ Teaching and class management becomes difficult for the teacher</li> </ul>	<ul style="list-style-type: none"> <li>■ High poverty levels</li> <li>■ Poor nutrition, especially at certain times of the year before harvest</li> <li>■ Lack of income to provide needed school supplies to assist learning</li> <li>■ Much labour required in the home takes time away from studying and attending school</li> </ul>	<ul style="list-style-type: none"> <li>■ Change in classroom design to ensure better ventilation</li> <li>■ Reduce the number of students in the classroom</li> <li>■ Increase in class streams to accommodate more children</li> <li>■ Change teaching and learning periods to early hours of the day and evenings</li> <li>■ Students should learn by observation, discovery, and inquiry about seasons, weather events and other climate change-related issues</li> </ul>

## Review of Existing Governance, Policies and Programs

Existing policies in Education include:

### 1. The education laws of 1999 to 2004

The Constitution of the Federal Republic of Nigeria (Promulgation) Decree 1999, Chapter 11, Section 18, restates the objectives of education in Nigeria as contained in the 1979 constitution. The third edition of the National Policy on Education (FRN, 1998) states the following as the objectives of Nigerian education:

- (a) the inculcation of national consciousness and unity;
- (b) the inculcation of the right type of values and attitudes for the survival of the individual and the Nigerian society;
- (c) the training of the mind in the understanding of the world around; and
- (d) the acquisition of appropriate skills and the development of mental, physical, and social abilities and competencies as equipment for the individual to live in and contribute to the development of his (or her) society.

The National Policy on Education, 1981 (revised 2004) prescribes that the teacher-pupil ratio should be 1:40. Classrooms are currently overcrowded and, in some instances, schools have operated with teacher-pupil ratios of 1:76. The national teacher-pupil ratio reported in 1995 was 1:41. A program for classroom building to support the implementation of a scheme for universal primary education was either never developed or, if it was, not successfully implemented.

### 2. The Compulsory, Free, Universal Basic Education Act, 2004, and Other Related Matters

The major objectives of the programme conceived in 1999 are:

- to develop in the entire citizenry a strong consciousness for education and strong commitment to its vigorous promotion;
- the provision of free, universal basic education for every Nigerian child of school age;
- to reduce the incidence of dropouts from the formal school system, through improved relevance, quality, and efficiency of education;

- catering to the learning needs of young people, who for one reason or another have had to interrupt their schooling, through appropriate forms of complementary approaches to the promotion of basic education; and
- ensuring the acquisition of the appropriate levels of literacy, numeracy, communication, and life skills, as well as ethical, moral, and civic values needed for laying a solid foundation for lifelong learning.

The re-launch of Nigeria's Universal Basic Education (UBE) programme in 1999 was aimed at providing free UBE for all. It was aimed at enabling all citizens to acquire appropriate levels of literacy and numeracy; and communicative, manipulative, and life skills. The intention was to provide nine years of compulsory education that would span primary and secondary levels. Access to basic education as a national priority included literacy and adult education, science, and vocational training.

A review of the national policy on education and curriculum indicates that climate change and related issues are not taught in schools at every level. Environmental education, where such issues are discussed, should therefore be integrated in the existing school curriculum and be included in future education policies in Nigeria.

## Recommended Climate Change Adaptation Actions

**Public awareness programmes.** There is need for increased public awareness programmes and educational workshops throughout Nigeria. The focus of the awareness programme will be on climate change. This could be done through educational and informational tools, which include the Internet and mass media (television, radio programmes, newspapers). Drama and music are also forums in which to disseminate climate change information.

**Environmental education.** Any form of environmental education must regard human beings as part of larger ecosystems and aim to show the complexity of environmental problems, especially by pointing to the relations between human activities and climate change (Ogueri, 2004). The World Conservation Union (WCU) describes environmental education as that which focuses on the relationship between humans and their environment. The idea is to promote knowledge, skills, attitudes, and commitments on issues concerning the total environment and its associated problems, and how to prevent or solve such problems.

**Community action.** Environmental education calls for empowerment, which implies that the school is expected to expose students on how to take effective community action in matters of environment, either now or in the future. At the primary, secondary, and tertiary levels, schooling should focus on improving student skills in decision-making, problem-solving, and community action. Developing and disseminating information on climate change in the language of the community will encourage student participation in adaptation and mitigation programs.

**School curricula.** It is essential that schools in Nigeria do not avoid subjects dealing with climate issues, perceiving them as being contentious or too difficult or even optional. These subjects should be taught at all levels and should be made compulsory. Children usually appreciate nature and are in tune with the world and its natural interconnections. Environmental subjects and related issues which describe seasons, the flora and fauna, biodiversity, water and nutrient cycles, weather events, etc., should also be taught. The ability to observe, describe, and understand natural phenomena are important skills to develop from an early age, and will help create awareness of the frequency in changes in the environment and the adverse effects on human life.

**Teaching methods.** It is the task of trained and experienced teachers in environmental studies to expose children to environmental issues at all levels. Teaching through observation and experience is important for learning about the natural environment. The education system in Nigeria is faced with the responsibility of training and providing qualified teachers in environmental studies who will expose children to climate changes and related issues.

There is a need to change teaching and learning hours to early hours of the day. Teaching methods should employ more inquiry and discovery so that students will be given the opportunity to search for information and transform it into meaningful knowledge. This reduces the number of hours spent in the classroom, as well as enhances learning.

There is also the need to reduce the number of students in a classroom to 35 students per class, with comfortable furniture. By implication, the number of streams will have to be increased to accommodate the students.

Building solid buildings and creating a physical environment conducive for school curricula and extra-curricular activities will also sensitize students to the environment. There should be abundant trees and other plants around the schools, giving the students an appreciation of their natural surroundings.

Several of the challenges confronting climate change are attitudinal, and arise from the socialization process. For example, how people have been cultured to live, use energy, generate heat, transport and communicate, all have to be modified. The best time to inculcate that is as part of the training process through school curricula and with appropriate teaching techniques and methods. The public should be educated on appropriate lifestyle and behaviours. Environmental skills, knowledge, and attitudes should be developed in children, youths, and adults so that they can be inspired to become lifelong environmental advocates.

Nigerians should be taught to understand that simple changes in their everyday lives can reduce the impacts of climate change. They should be instructed on how to make their homes energy- efficient, such as by reducing heating and electricity use, and by correct disposal of trash and organic waste. Advocates of education reforms should encourage that environmental studies be made a core subject. This will help educate the youth on the need for environmental conservation. There should be training of teachers on environmental and climate issues. Curriculum experts should work with those in the mainstream of environmental issues in order to articulate concepts and contents across ages or class levels. Future educational research should focus on the issues raised in this paper to provide ample and convincing evidence for policy decision-making.

## Cross-Sectoral Issues References

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## Abbreviations

AF	Adaptation Fund
AFB	Adaptation Fund Board
AU	African Union
CCA	climate change adaptation
CDM	Clean Development Mechanism
CER	certified emission reduction
CPDMP	Comprehensive Participatory Disaster Management Programme
DAC	Development Co-operation Directorate
ECOWAS	Economic Community Of West African States
GEF	Global Environment Facility
GHG	greenhouse gas emissions
LDCF	Least Developed Country Fund
LGA	Local Government Area
MDG	Millennium Development Goals
MDTF	Millennium Development Trust Fund
NEMA	National Emergency Management Agency
NERA	National Emergency Relief Agency
NSCCTF	National Strategic Climate Change Trust Fund
NEEDS	Nigeria's National Economic Empowerment and Development Strategy
NPC	National Planning Commission
ODA	Official Development Assistance
PES	Payment for Environmental (or ecosystem) Services
REDD	Reducing Emissions from Deforestation and Forest Degradation
SCCF	Special Climate Change Fund
SEMA	State Emergency Management Agency
SPA	Strategic Priority on Adaptation
SSCU	Special Climate Change Unit
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNTACC	United Nations Territorial Approach to Climate Change
WB	World Bank

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