AN APPRAISAL OF MITIGATING MEASURES FOR ADDRESSING CLIMATE CHANGE IN NIGERIA

BY

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M.TECH/SSSE/2005/1395

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FEBRUARY 2009

DECLARATION

I hereby declare that this thesis is an effort made by me and has not been submitted in any form for another degree or diploma at any university or institution. Information derived from published and unpublished materials has been duly acknowledged in the text.

AHMED MOHAMMED SANI

2ND July, 2009

DATE

CERTIFICATION

This thesis titled: An Appraisal of Mitigating Measures for Addressing Climate Change in Nigeria, by: Ahmed, Mohammed Sani (M. Tech/SSSE/2005/1395) meets the regulations governing the award of the degree M. Tech of the Federal University of Technology, Minna, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This Research Work is dedicated to the Almighty Allah who gives me the ability and wisdom for the successful completion of this work.

To my late parents, Alhaji Ahmed Aliyu and Hajia Habiba Ahmed for sending me to school and for their guidance and support during their lifetime. May their souls continue to rest in peace, respectively (Amin).

And finally, to my wife, Hajia Aisha Ladidi S. Ahmed and my children Zainab, Habiba, Ahmed and Aminu S. Ahmed for their courage, endurance, moral support and mutual understanding, which made it very possible for me to successfully complete my M. Tech Programme in Environmental Management (Environmental development planning).

May God reward them for their patience as we pray for better days ahead.

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ABSTRACT

This work examined the contribution of Nigerians to the Global House Gas (GHG) emissions, gas flaring and its projections; the effect of climate change on the energy sector including other relevant sectors in Nigeria. This work therefore appraises the mitigating measures for addressing climate change in Nigeria. To reduce climate change is the major objective of this work. Data on renewable energy sources including the introduction of solar energy as instruments to reduce climate change is inadequate in the energy sector in Nigeria. to appraise the activities of the KYOTO Protocol, UNFCCC and other related mechanisms and instruments for the mitigation of climate change in Nigeria to create and appraise public awareness and education among Nigerians on the causes, implications and the impact of climate change and its related problems, so as to find urgent mitigating measures in addressing the problem. Relevant data were sourced through secondary method of data collection for the purpose of this research work. The most attractive mitigating options are CFL lighting, improved kerosene stoves, improved wood stoves and the use of efficient motor including efficient use of solar energy.

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CHAPTER ONE

INTRODUCTION

1.1 General Introduction

It may be noted that although the contribution of Nigeria to the Global Green House Gases, (GHGs) emission is insignificant, the Country is also famous for gas flaring, which accompanies the oil production activities. It is note - worthy that the country is beginning to embark on a vigorous programme of elimination of Gas flaring (LNG processing is one of the measures). This will be significant in relation to mitigating Global warming and climate change. Climate change is a Global phenomenon, which should catch the attention of all countries, whether developed or developing. As such, Nigeria was the first group of developing countries that signed the United Nation Framework Convention on Climate Change. (UNFCCC) and became a party as soon as the convention came into force.

The LNG Protest was based on the realization of the predictable adverse consequences climate change will bring onto our large population and sensitive on environment, which also have serious implications to the Country at large, in terms of socio - economic structure, energy, agriculture, human settlement and health.

1.2 Statement of Research Problems:

Climate change and the problems of sustainability of the environment and management of resources as well as the serious problems in human population and settlement are some major causes of climate change. One of the effects of global warming is melting of polar icecaps, which results in Sea Level Rise (SLR). The emission of Green House Gases (GHGs) and Gas flaring will increase the Green House effect and compound the effects of Sea Level Rise (SLR), which will submerge large proportions of low – lying islands that are already constantly plagued with flood and erosion.

There will be a serious problem on agriculture, livestock production and management, water resources and water resources management, health, biodiversity, loss in forests and freshwater fisheries. Climate change will have significant effect on the energy sector in Nigeria, rising temperature changes in the amount of precipitation and variation in humidity, wind pattern and the number of sunny days per year could be a problem to both consumption and production of energy in Nigeria. All these problems will emanate as a result of Green House Gases (GHGs) emission and other related industrial and human activities. Because of these problems, there is the need to appraise and have in place very strong mechanisms to address climate change in Nigeria.

1.2.1 **Aim**

It is the aim of this study to analyse and appraise all mitigating measures for addressing climate change in Nigeria.

1.2.2 **Objectives**

- To appraise the activities of the Kyoto protocol, UNFCCC and other related mechanisms and instruments for the mitigation of climate change in Nigeria.
- To create and appraise public awareness and education among the Nigerian population on the causes , implications and the impacts of climate change and its related problems so as to find urgent mitigating measures .
- To appraise new technology in reducing Green House effects including the effects of LNG productions, which are the most, alarming factors responsible for climate change, globally.
- Appraise the active support of other nations of the world led by the aggressive posture of the European community.
- To encourage Research in the area of climate change mitigation, its related issues and factors.
- To appraise what is done in the past and what is presently on the ground including what will be done in future for mitigation measures to address climate change in Nigeria.

1.2.3 Justification of The Study

Justification of this research work has to do with the factors responsible for climate change, its impact, challenges and the needs for urgent mitigation measures to address the problem.

The Nigerian economy has changed from natural vegetation of forests and rich grasslands to pockets of forests. Industrial activities has also altered the environment largely posing serious threat to human population, human settlement including loss of biodiversity.

The mitigation of GHG in Nigeria and the issue of gas flaring is very important. The most important source of Cco2 emission in the Nigerian energy system are gas flaring in the industry, diesel and gasoline used in transportation, fossil fuel consumption for electricity and the emission of carbon dioxide from the energy sector are considered.

1.2.4 Significance of The Study

It is significant to understand the problems, causes and their effect to the environment, then offering useful suggestions, recommendations, and getting the solution will become easy. It is important to understand the causes of climate change and their effect on the ecosystem. This will enable us to identify the mitigating measure to be adopted in addressing the problem.

1.2.5 Focus

This research work will only focus on the appraisal of the mitigating measures for addressing climate change in Nigeria. That is to say, emphasis will be on what is being done and future projections in 'timing' the impact of global warming.

1.2.6 Scope

All aspects necessary for mitigation of climate change in Nigeria. Kyoto protocol, United Nations Framework Convention on Climate Change (UNFCCC) including other local, national and international strategies for the mitigation of climate change in Nigeria

1.2.7 Limitation

This has to do with factors that are considered as constraints, such as-

- Mitigating Climate change involves material resources (funds); this is grossly inadequate in Nigeria.
- Green House Gas (GHGs) reduction.
- Unregulated dumping of toxic and comparable waste materials.
- Inappropriate Agricultural practices.
- Uncontrolled logging aggravated by lack of re-planting.
- Bush burning and lack of fuel wood extraction.
- Research in the area of climate change mitigation is lacking.
- Compliance of mitigation measure in Nigeria is very inefficient.
- Enforcement of the laws itself by the regulatory authorities at both the State and National level is not efficient.
- The destruction of water sheds leading to siltation of rivers, soil erosion and loss of watercourses.
- Gas flaring and the resultant problems of ecosystem destabilisation, heat stress, acid rain and their effects on freshwater and aquatic lives.
- Mining without adequate land reclamation.

THE STUDY AREA "NIGERIA"

1.3 Description of The Study Area

This study area will cover all mitigating measures for addressing climate change in Nigeria. It will also look at the contributions of some relevant international organisations, conferences, conventions and protocols adopted locally and internationally to mitigate climate change in Nigeria. The contribution of Non Governmental Organisations (NGOs) both national and international and finally, the role of agencies and the Nigerian government in mitigating climate change.

1.3.1 LOCATION, SIZE AND HISTORICAL BACKGROUND

With an estimated population of about 140 million (2006 population census), the Federal Republic of Nigeria is the most populous country in Africa. Its 923,800 square kilometres occupies about 14% of West Africa.

The country lies between 4°N and 14°N of Equator and between 3°E and 15^0E of Greenwich Meridian. It is bordered on the north, east and west by Niger, Cameroon and Benin Republic respectively. The Atlantic Ocean forms the southern boundary. The total length of the coastline of the country is about 850 kilometres.

Nigeria is a creation of the colonial period, which started during the late nineteenth century. The history of the country as one political unit however dates back to 1914 when the two protectorates of Northern and Southern Nigeria were administered together. The country became independent in 1960 and three years later, adopted a republican constitution but remained a member of the Commonwealth of Nations.

Nigeria is made up of 36 states with a Federal Capital Territory.

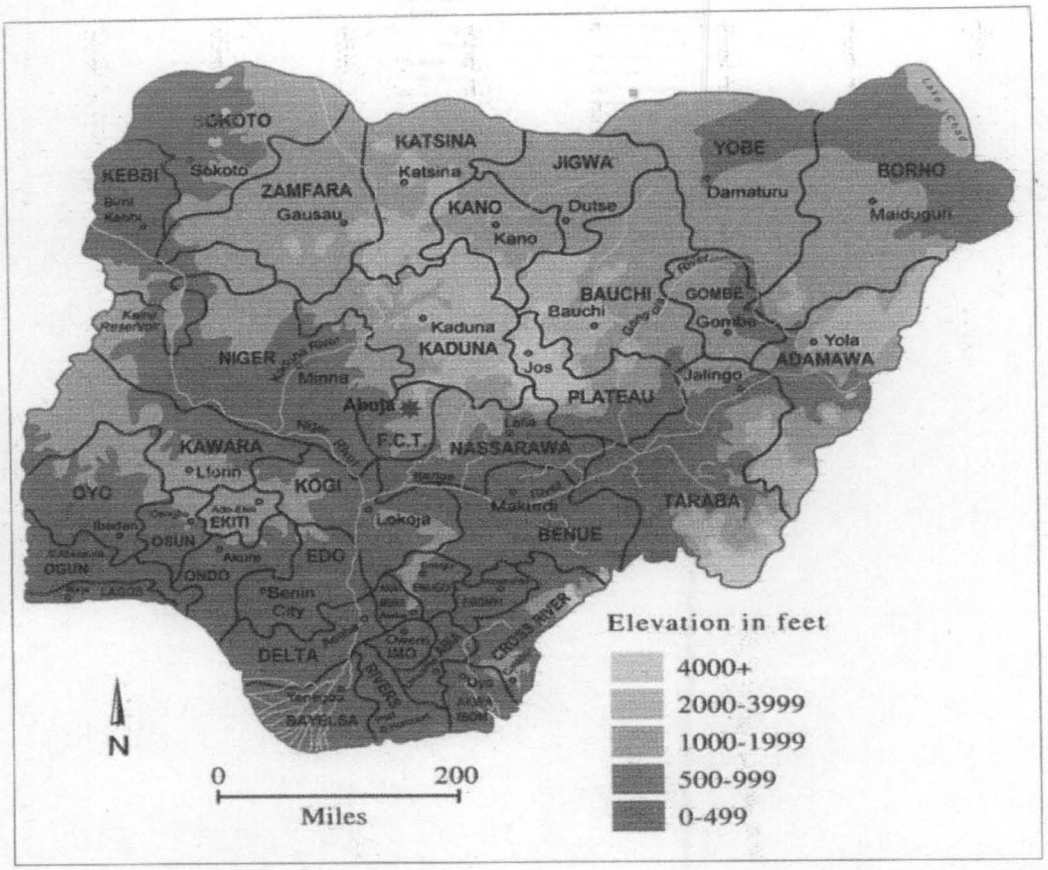

Figure 1: 1 Map of Nigeria showing 36 states and the Federal Capital Territory. (Source, First National Communication)

1.3.2 Geology

Most of Nigerian land comprises of rocks of pre - Cambrian age, but there are also rocks of Eocene times, as well as volcanic rocks. (Figure 1:2)

The pre - Cambrian rocks are mostly composed of granite and metamorphosed rocks and are generally found in the higher part of the country, while sandstones of crustaceous and Eocene times occupy the Benue, Gongola and Middle Niger Basins.

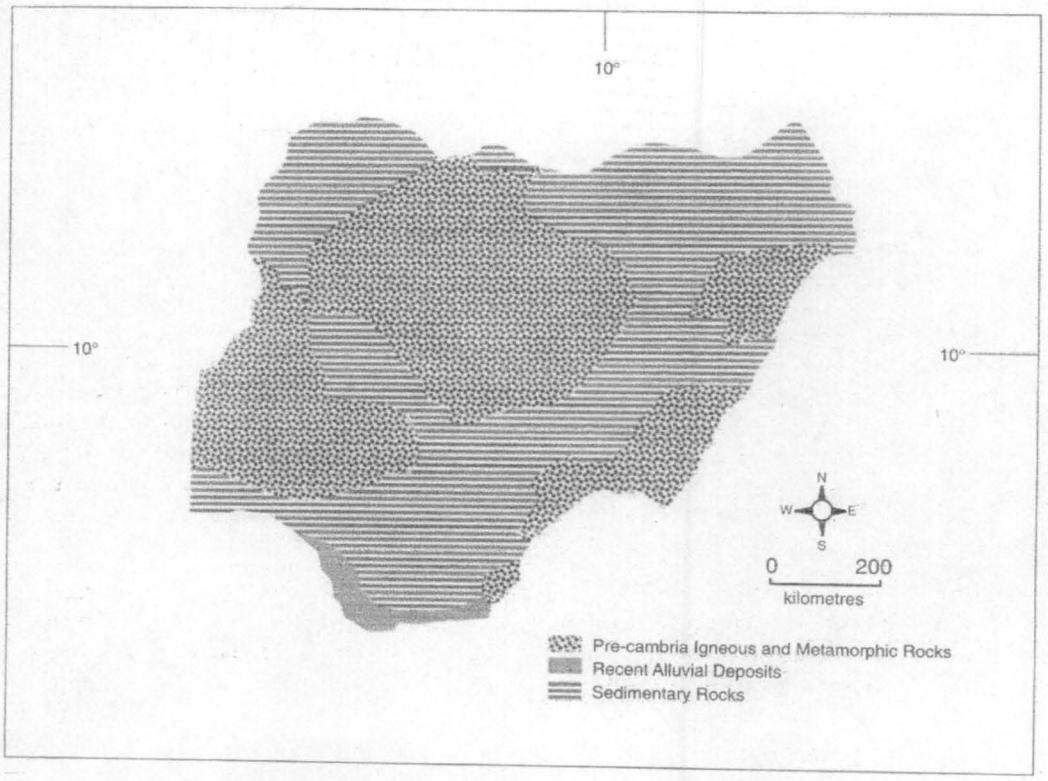

Figure 1.2 Geology of Nigeria (Source, First National Communication)

In general, three types of structures can be identified in Nigeria, namely; areas of uplift, basins of sedimentation and isolated volcanic areas. The areas of uplift are the areas raised enbloc during the pre - Cambrian times. They are the oldest rocks in Nigeria - the basement complex rocks - and are found in four main areas of the Northern block, Western block and Eastern block. The rocks are made up of granite, gneiss and quartzite. The basement complex rocks are most widespread and where they are not found at the surface they underlie relatively younger rocks at great depths.

The basins of sedimentation are the down - warped areas, which were owned by the sea at different times and in which sediments eroded from the areas of up lift were laid down. These are in the Sokoto Basin and the Chad Basin the Niger – Benue Trough and the Lower Niger Basin. The Niger – Benue_Trough is an elongated basin of sedimentation, which occupies the middle Niger and the Benue, separated from Sokoto Basin by the Bussa anticline, but joined to the Chad Basin by the narrow corridor west of the Biu plateau. The lower Niger Basin is a continuation of the Niger - Benue Trough and forms a simple syncline.

1.3.3 Relief

The highest areas are in the east, north and west where land is generally over 1,500 metres, 600 metres, and 300 metres respectively. The low - lying areas, which are generally below 300 metres, lie along the coast and along the valleys of the main rivers.

The Udi plateau, which lies to the east, however attains a height of over 300 metres and this breaks the monotony of the Niger Delta, the coastal areas of the lagoons and the swamps, separated from the open sea by a strip of sandy land, which varies in width from 2 to 16 kilometres. The Lagos entrance is the only major outlet through which the lagoons and creeks drain into the sea.

The section, which lies in the coast of the Niger Delta, consists of creeks and swamps that stretch from Opobo town through the Cross River estuary to the border with the Cameroon.

The Niger Delta is a low-lying region cut up by a complicated system of natural channels through which the River Niger finds its way to the sea. It is made up of three distinct sub–regions. They are:

(a) Freshwater Zone

(b) The mangrove swamps, and

(c) The zone of coastal sand and bench ridges

The freshwater zone, which starts from the apex of the delta, just below the town of Aboh, is essentially an extension of the lower Niger flood plains. The numerous water channels in the zone are bordered by natural levees, which provide the sites for most of the settlements and farmlands in the zone.

The mangrove swamps are sparsely settled. Strips of sandy benches and ridges, which vary from a few metres to 18 kilometres, separate the mangrove swamps from the open sea. In addition to natural levee, ox-bow lakes are common land forms in the Niger delta. The high rainfall in the region, coupled with the abundance of surface water and the flat terrain, create a serious drainage problem and makes road construction very difficult.

The coastal plain is a region of gently undulating landscapes developed on

young sedimentary rocks. It has an average elevation of less than 90 metres above sea level. The portion of the River Niger especially between Jebba and Yelwa is characterised by rapids, which impede navigation. Below Jebba, the Niger is free of rapids.

1.3.4 Drainage

The main drainage systems in Nigeria are:

(a) The Niger - Benue

(b) The Chad, and

(c) The coastal river systems

The main sources of the rivers include the Jos Plateau, the Western Uplands, the Eastern Highlands and the Udi Plateau. While some of these rivers flow into Lake Chad, others are tributaries to the Niger and Benue Rivers.

Some of the rivers, which rise from the Western Highlands, flow northwards into the river Niger and some flow into the Atlantic Ocean. Rivers, which flow from the Eastern Highlands flow mainly into the Benue River, while some of those that rise from the Udi Plateau flow into the Niger. Some of the smaller rivers flow into the Cross River. Most of the coastal areas are poorly drained particularly during the rainy season, which makes the rivers and creeks to overflow their banks.

The longest river in Nigeria is the River Niger, followed by the Benue, which joins the Niger at Lokoja and rises from the Cameroonian Highlands. The Chad, located to the North East of the country is the largest natural lake. It is generally shallow but .extensive in area, covering about 10,000 to 13,000 square kilometres with marked seasonal fluctuations. It has significantly shrunk from its original size.

Lake Kainji on the river Niger is man - made, and at 1,295 square kilometres is one of the largest lakes in Africa.

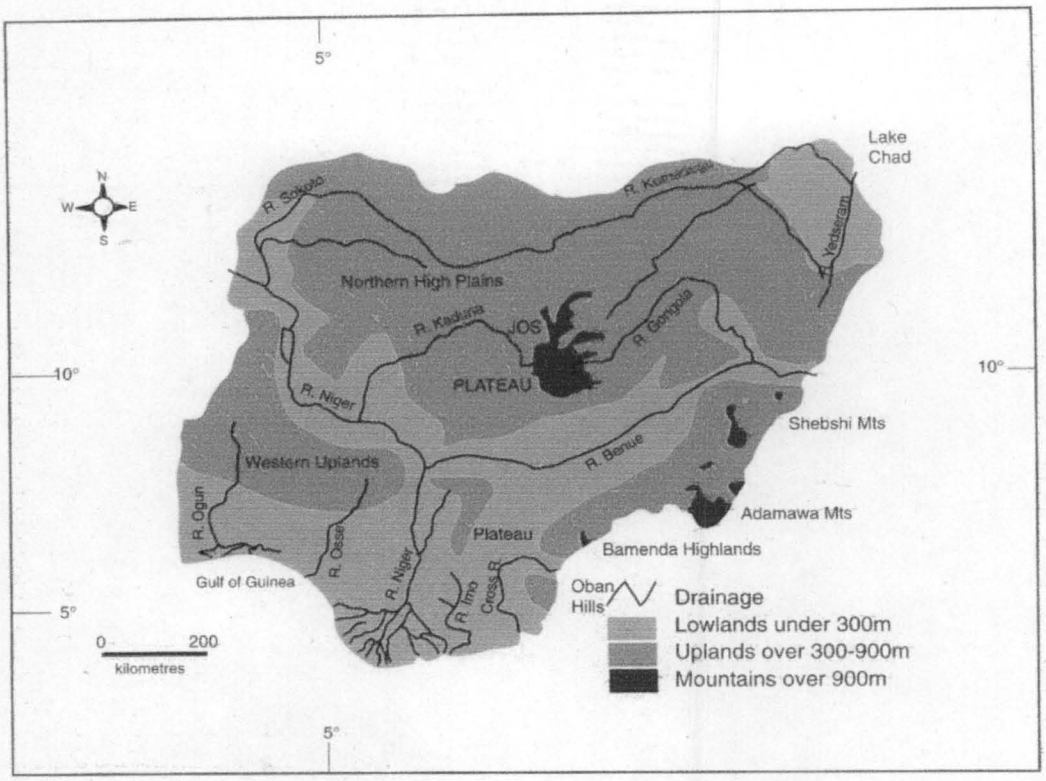

Figure 1.3 Relief and Drainage Systems of Nigeria. (Source, First National Communication)

1.3.5 Climate

Nigeria is located primarily within the lowland humid tropics and is generally characterised by a high temperature regime almost throughout the year. In the far south, mean maximum temperature is 32°C while in the north it is 41°C. However, the mean minimum temperature is 21°C in the south and under 13°C in the north, which has a much higher annual range. The mean temperature for the country is 27°C, in the absence of altitudinal modifications. Over the last few decades, there has been a general increase in temperature throughout Nigeria.

The climate of the country varies from a very wet coastal area with annual rainfall greater than 3,500mm, to the Sahel region in the North west and north eastern parts with annual rainfall less than 500mm. the annual variation of rainfall, particularly in the north eastern parts is large. This often results in climatic hazards, especially floods and droughts, which bring in their wake much suffering with devastating effects on food production and the nation's economy. Recent studies have revealed declining trends in rainfall. Often

enough parts of Nigeria receive less than 75 percent of their annual rainfall and this is particularly worrisome in the north.

There are generally two seasons in the year; the wet and the dry seasons. The length of the rainy season decreases from 9 - 12 months in the south, to only 2 - 3 months in the extreme northeast. The climate is also characterised by double rainfall maxima in the south, with first maximum in June and second maximum in September. There is thus a break the "August break" or short dry season in between.

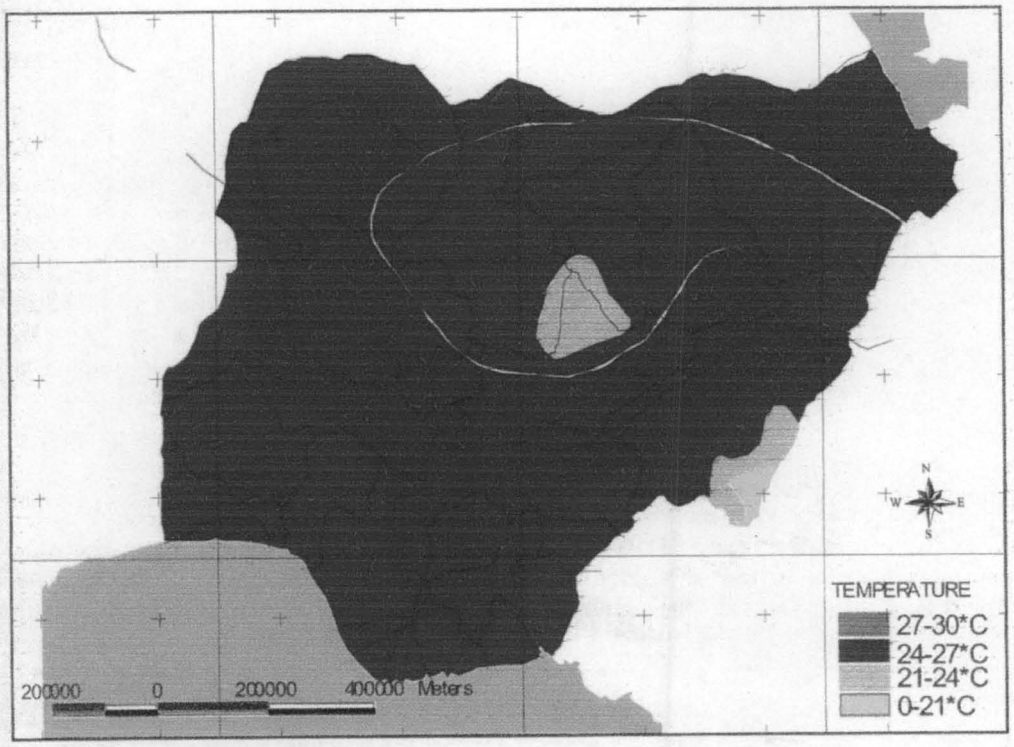

Figure 1:4 Spatial Variation of Mean Annual Temperature in Nigeria. (Source, First National Communication)

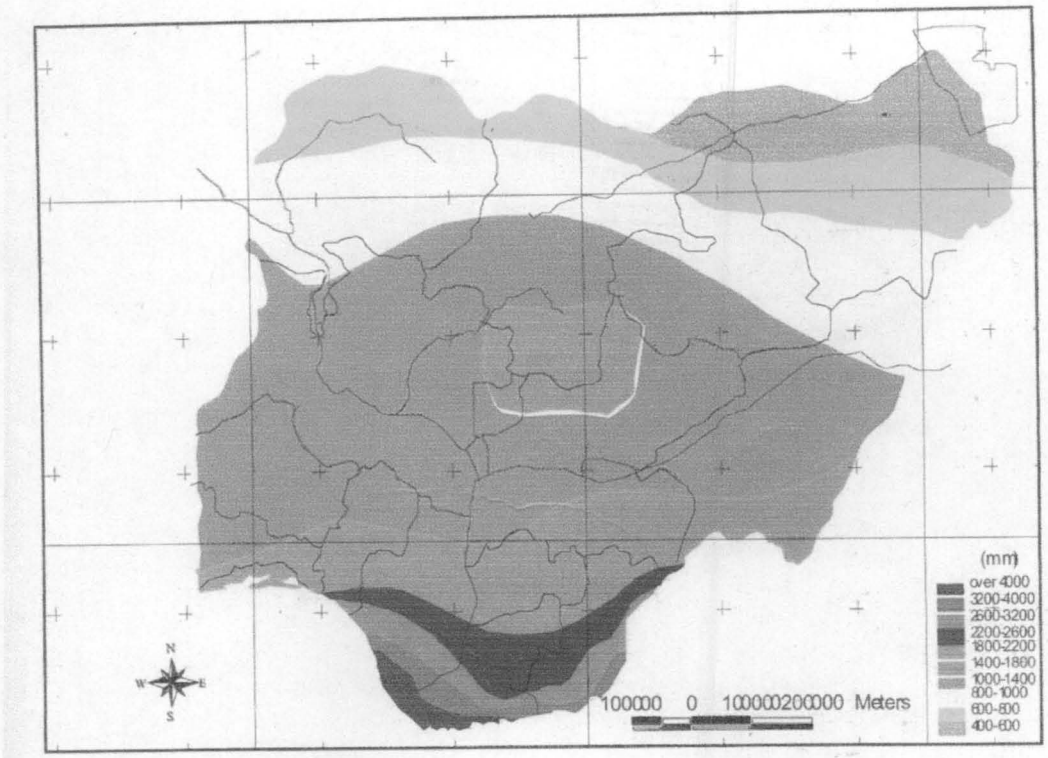

Figure 1.5 Spatial Variation of Annual Rainfall in Nigeria. (Source, First National Communication)

Rainfall is by far the most important element of climate in Nigeria. From a water balance perspective, the country experiences large spatial and temporal variation in rainfall and less variations in evaporation. Consequently, precipitation becomes a very important index for assessing cumulative rain and water resources potential in the country. In general, most of the coastal areas, which receive rainfall throughout the year, have more than required, and numerous rivers and creeks drain often these areas.

The quality of domestic water supply in the northern region is generally poor.

1.3.6 Vegetation

Nigeria has six main vegetation zones; the saltwater and freshwater swamps, tropical lowland, rainforests, Guinea Savannah, Sudan Savannah and Sahel Savannah. (Figure 2:6)

Salt and fresh water swamps are along the coast of Nigeria. The saltwater swamps stretch inland for 1 - 2 km in the Lagos area, to over 30km in the Sapele area, further inland beyond the tidal waters.

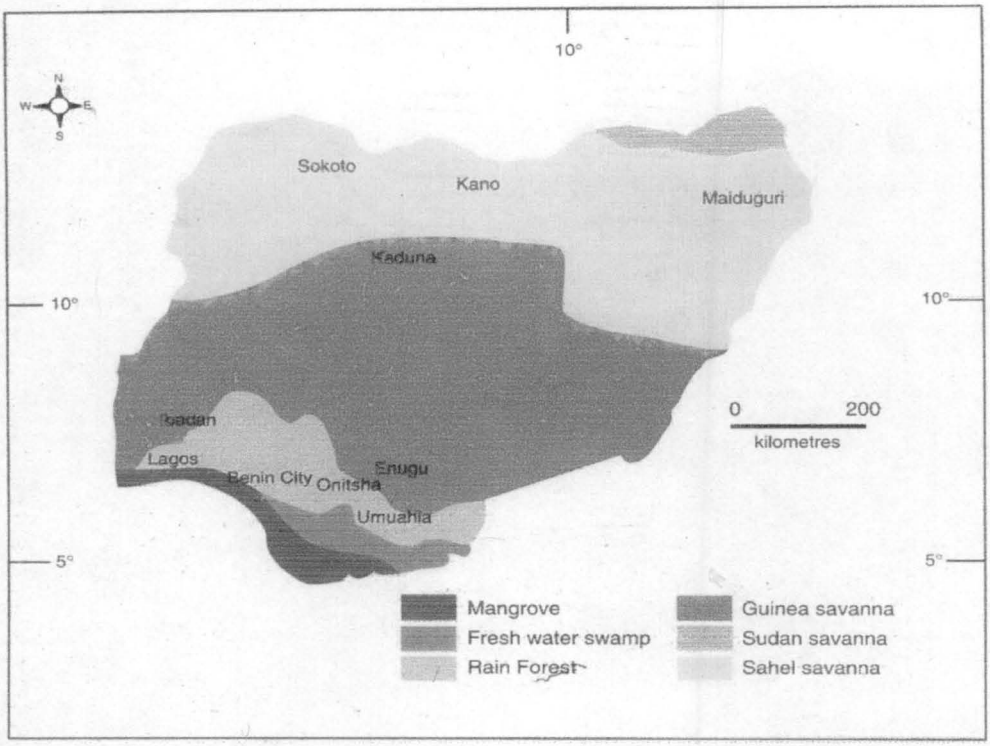

Figure 1.6 Vegetation of Nigeria

The mangrove gives way to freshwater, the most important of which is the raffia palm. Many species of the tropical lowland forest such as *Mitragyna* and *Clastopholic spps* grow in the freshwater swamps.

Along the lagoons, the mangrove gives way to the tropical lowland rainforest, a dense evergreen vegetation of tall trees with undergrowth of small trees, shrubs and herbs. These may become so entangled as to make penetration become so difficult. Three layers of tree groups dominate the forests with the tallest trees being more than 36 metres. Wherever the forest is relatively untouched, the top canopy becomes so closely interlocked as to prevent most of the rays of the sun from reaching the ground. In such cases, the ground remains damp and almost completely void of undergrowth. The total area of the tropical rainforest in Nigeria is less than 10 percent of the country and continues to be threatened by human activities.

The Guinea Savannah is the most extensive vegetation belt in Nigeria. It consists of a mixture of trees and grass, with trees being more numerous in sparsely settled areas. It exists in areas with 1,000 to 1,500mm of annual rainfall and where the wet season lasts for 6 - 8 months. Much of the

Savannah is a by - product of centuries of devastation by man and fire. Along the riverbanks in the Savannah are finger - like extensions of the low forests, known as Gallery Forests.

The Sudan Savannah belt is found in the northern parts of the country. It stretches from the Sokoto plains across to the Chad Basins, covering over a quarter of the country's land area. It is found in places with rainfall of about 600 - 1,000mm and 4 - 6 months of dry season. The vegetation is made of grasses of 1 - 2m high and often stunted trees. Some of the most frequent trees in this environment are acacia, dum palm and the baobab.

The Sahel Savannah, the last of the five vegetation zones, occurs in the extreme northwest and northeast where the annual rainfall is less than 600mm and the length of the dry season exceeds 8 months. The atmosphere is dry except for one or two months in the middle of the brief wet season. The grasses are short and tussocky, 0.5 - 1.0m high, and are interspersed with sand dunes. The acacia is the dominant tree in the zone, although date palms appear here and there. The swampy shores of Lake Chad support tall reeds growing on seasonally flooded flat land.

The distribution of vegetation has been highly affected by land use changes during the last 100 years. This has partly been induced by the high population and high rate of urbanisation on one hand, and desertification on the other.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Global Perception of Climate Change

Climate Change, as defined in the United Nations Framework Convention on Climate Change (UNFCCC), is:

> *"A change of Climate which is attributed directly or indirectly to human activity that alters the composition of global atmosphere and which is, in addition to natural climate variability observed over comparable time periods."*

Climate change has become the most engaging environmental issue since R10 – 92. Indeed, it is the number one. According to Adefolalu, (2006). The environmental problem that could cause global instabilities in the 21 Century and beyond. Severe natural disasters, already being experienced globally have been associated with consequences of global warming resulting from emissions of Green House Gases (GHG) into the atmosphere. Studies have now confirmed that associated with increased GHG are high Sea Surface Temperature (SST) in Tropical/Sub-Tropical latitudes and very high Sea level Rise (SLR) in Coastal belts.

Today, Global Climate Change has become a focal issue of the International Community. This is because over the last three decades there has been a widespread increase in trends of severe weather Event such as El – Nino, Floods, Drought and Desertification, etc. Some of these extreme events have been attributed to increased concentration of carbon dioxide (CO_2) levels. Although this natural GHG effect is what keeps the earth warm enough to sustain life but its amount has doubled within the last 150 years resulting in current wave of catastrophes worldwide.

The increased CO2 concentration started at the time of Industrial Revolution about 200 years ago when human activities resulted in increased emissions above natural levels from the burning of fossil fuels, forest fires and other forms of deforestation, which have altered the composition of the atmosphere and caused an 'enhanced' greenhouse effect. As a result, the earth's temperature has risen between 1^{o} and 2^{o} C and this, in turn, is changing the climate with projections of 2.5 to 6°C by the year 2025 –2050. This will lead to changes in global climate, which will result in severe environmental hazards such as floods, landslides, snowstorms and snow-slide, tropical cyclones, droughts and desertification usually accompanied by losses of properties and lives. Adefolalu, (2006).

2.2 United Nations Framework Convention for Climate Change (UNFCCC)

Climate Change issues became focal topics for discussions and debates within the United Nations (UN) setting. According to Adefolalu, (2006). The World Meteorological Organization (WMO) and the United Nations Environmental Programme (UNEP) were mandated to set up an inter-Governmental Panel on Climate Change (IPCC) to initiate studies on Climate Change. The IPCC, which was established in 1988, issued its First Assessment Report in 1990. This report confirmed that climate change was indeed a threat and called for a treaty to address the problem. Many other bodies echoed the call and the UN General Assembly responded to these calls in December 1990 when it formally launched negotiations on a framework convention in climate change through its resolution 45/212. The Assembly also established an Intergovernmental Negotiating Committee (INC) to conduct the negotiations. On the 9th of May 1992, the INC adopted by consensus the United Nations Framework Convention on Climate Change (UNFCCC).

The Convention was opened for signature at the UN Conference on Environment and Development (UNCED), the "Earth Summit" in Rio de Janeiro, Brazil, on 4th June 1992 and came into force on 21ststst March 1994. About 180 Governmental and the European Community have so far ratified,

accepted, approved, or acceded to the Convention and are as such Parties to the Convention. All the countries of West Africa within the Economic Community of West African States are Parties (COP) to review the implementation of the Convention and continue talks on how best to tackle climate change. All the countries of the West African sub-region has been active participants at the COP meetings, in fact, many West African countries are focal members of the African group at COP meetings.

The Convention sets as its ultimate objectives, the stabilization of atmospheric concentrations of GHGs at safe levels, which must be attained within a time frame sufficient to allow the ecosystem to adapt naturally to climatic change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. In order to achieve these objectives, Parties have a general commitment to address climate change, adapt to its effects, and reports on the actions they are taking to implement the convention. The Convention divided countries into two groups: Annex I parties and non – Annex I Parties. The former are industrialized countries that have historically contributed the most to climate change. Their per capital greenhouse gas (GHG) emissions are higher than those of non-Annex I Countries which are developing nations.

Furthermore, annex I countries have greater financial, technical and institutional capacities to address the problems. The principles of equity and "common but differentiated responsibilities" enshrined in the Convention required the Annex 1 national to take the lead in modifying longer – term trends in emissions. Towards this end, they were committed to adopting national policies and measures with the non-legally bidding aim of returning their GHG emissions to the 1990 levels by the year 2000. The non-Annex I Parties on the other hand have very little historical contributions to GHG concentration in the atmosphere but are expected by the convention to be actively involved in the global action on climate change. However, their low present little or no contribution to GHG emission has conferred on them the status of a group whose contribution to solving the problem are expected to be minimal.

As can be noted from the description above, the UNFCCC did not include binding, quantitative emission reductions for signatories. The first review of the adequacy of developed country commitments was conducted as required at the first session of the Conference of Parties (COP-I), in Berlin in 1995. The parties concluded after extensive deliberations that the commitments of the developed countries as spelt out in the UNFCCC to aim at returning their emissions to 1990 levels by the year 2000 was inadequate for achieving the Convention's long-term objectives of preventing "dangerous anthropogenic (man-made) interference with the climate system" . As a result, they adopted a "Berlin Mandate" which launched a new round of talks on strengthening developed country commitments.

The Ad hoc Group of the Berlin Mandate (AGBM) was set up to draft an agreement. After eight sessions, AGBM forwarded a text of the agreement to the COP meeting that was held in Kyoto, Japan in December 1997 for final negotiations. A consensus decision (1/CP.3) to adopt a Protocol referred to as the Kyoto Protocol was reached. (Adefolalu, 2006).

2.3 Mitigation Measures to Address Climate Change in Nigeria.

The emission of GHG in Nigeria is generally low based on low per capita energy and other resources consumption in the country. According to Nigerian's First National Communication (2003). These are expected to rise in the futures because of the high population growth rate, and corresponding increase in per capital energy and other resource consumption. The assessment of options to reduce future GHG emissions is considered an important contribution to the sustainable development of Nigeria. This is being undertaken in respect of the energy, land use change and forestry (LUCF) sectors, which are the main contributors to carbon emissions.

The primary tools used for the study of Nigeria's future energy system and the options for mitigation are the market Allocation (MARKAL) model, and he Model for analyses of Demand for Energy (MADE). Based on these, the expected current and projected primary energy consumption patters are presented up to 2030.

The identification and ranking of mitigation options for energy, land use change and forestry (LUCF) sectors have been carried out. For the energy sector, results indicated that some of the options could be implemented at a net negative cost to the total energy system cost. Apart from the obvious case of gas-flare reduction in the oil industry, significant CO_2 emission reduction should be achieved in the residential, transport and industrial sectors of the energy system. Based on the incremental costs per ton of CO2 removed, the most promising mitigation options in the Nigerian energy system are the introduction of compact fluorescent light (CFL) bulbs at a negative incremental cost of $58/Ton Co_2, followed by the introduction of kerosene stoves in households, at a cost of $21/Ton of CO2 reduced. Other viable options include fuel-oil to natural gas fuel substitution in the cement industry ($18/Ton), introducing of efficient motors in industry ($15/Ton), and improved electrical appliances ($16/Ton) and wood-stoves ($3/Ton) in the residential sector.

For the land use change and forestry sector, afforestation, agro-forestry and forest protection options have been evaluated. Results for the afforestation have the highest potential for carbon sequestration followed by agro forestry and forest protection options. For the afforestation option, the volume of carbon expected to be sequestered is in excess of the estimated net emission of 427.4 and 580.5 MtC at 1.3% and 2.6% deforestation rates respectively. The average initial cost of establishment is $500/ha or an average unit cost of $13.4/tC. This implies a capital need of $3.8 billion over a period of 40 years (about $94 million /yr). The analysis also shows that the wood product needs of the country would be met over the period is less than that which will be released by 2030. Nigerian's First National Communication (2003).

The emission of GHG in Nigeria is generally low, based on available data. According to Nigerian's First National Communication (2003). This is expected to rise in the future because of the high population growth rate, which is expected to lead to increase in energy consumption. Nigeria is not a member of the Annex I countries and therefore is not committed to any GHG emission reduction under the Kyoto Protocol. In order to assist non-Annex I parties to achieve sustainable development and at the same time assist Annex

I parties to achieve compliance with their emission reduction commitments, article 12 of the Kyoto Protocol established the Clean Development Mechanism (CDM). In this first national communication, mitigation analyses were carried out in two major source sector categories: energy and land-use change/forestry sectors. The analysis was done with a view to identify mitigation measures that could also contribute to sustainable development of the country. The analyses for the two sectors are descried in this chapter.

2.4 The Energy Sector

Energy plays a dominant role in the Nigerian economy. It supports virtually every other sector of the country and its dominance will increase as the population increases and as the industrial sector expands.

The Primary modelling tool employed in studying the future of Nigeria's energy system is the Market Allocation (MARKAL) model. MARKAL is a large-scale linear optimization model based on the concept of the reference energy system (RES). It is capable of capturing the complex interrelationships of an energy system from primary energy resources to energy service demands. Being a dynamic model, MARKAL can be used to explore mid-to long-term responses to different technological futures, emission constraints and policy scenarios. Given a set of energy demand projections, technologies and emission constraints, MARKAL is able to identify the least-cost path within the RES that best satisfies the overall objectives of the energy-environmental system.

MARKAL is demand-driven, and useful energy demand must be estimated exogenously for input into the model. Useful energy demand projections have been computed using the Model for Analysis of Demand for Energy (MADE), a simulation model. Basically, MADE employees a combination of statistical econometric and engineering process techniques in calculating useful energy demand projections.

Useful energy demand projections are made for four economic sectors of the energy system – industrial (including agriculture), transportation, residential, and commercial sectors. In all, the sectors are broken down into 30 demand

categories with a total of 102 demand technologies. (Nigerian's First National Communication, 2003).

2.5 Green House Gases Emission Mitigation in Nigeria

The Nigeria Country study consists of mitigation analysis of the energy and forestry sectors and on economy impact analyses of the green House Gases (GHG) emission reduction policies, according to Adegbulugbe et al (1996)

The MARKAL energy system optimization model and COPATTI AND COMAP cost' benefit analysis models are employed for the energy and forestry sector respectively. The micro economic assessment used the Computable General Equilibrium (CGE) approach in modelling the Nigeria Economy.

The most important source of CO_2 emission in Nigeria energy system are gas flaring in the oil industry, followed by diesel gasoline used in road transportation, fossil fuel consumption for electricity in the residential sector, and the use of oil products for process heat in industry. Reduction of associated gas flaring becomes prominent only under the most stringent CO_2 emission constraints, displeasing fuel oil use in industry, in the transport sector, reduction of diesel and gasoline consumption resource mainly for efficiency improvement in road transport vehicles. The contribution of dual-fuel gasoline /CNG vehicles is minimal. This study also shows that despite immense solar energy potential in the country. Solar electricity generation will only be attractive under severe CO_2 constraints. On the other hand the use of small-scale decentralized hydro power stations is favoured under all scenarios considered. Analyses also indicate that in the residential sector there is a major shift from the use of kerosene for cooking to gas in urban households and solid biomass in rural areas.

The most attractive technological options in the energy sector based on the incremental costs per unit of CO_2 reduced are in other CFL, lighting, new kerosene stoves, new wood stoves, efficient motor , improved air conditional and gasoline/ CNG dual fuel light vehicles .

In the forestry sector, the total carbon stock, uptake and emission were determined using the COPATTI spreadsheet model. In 1990, the net carbon emission from all the forest formation of about 15.6 millions ha was estimated at 9.5 mtc based on the figures, trend analysis up to the year 2050 gave cumulative emission of 427 and 581 mtc at deforestation rates of 1.3 and 2.6 respectively. Using COMAP on end use base approach tied to the wood product requirement of the country was adopted.

Cost benefit evaluation of three mitigation options – forest protection, afforestation and agro forestry was done the results shows that the forestry sector has greater potentials for mitigation carbon emission in the country.

Forest protection has an advantage in overall carbon storage while afforestation in the most attractive in terms of land management, meeting the wood needs and carbon acquestration potentials .

However, it has limitation in terms of biodiversity preservation as only a few species of trees are encouraged. Agro forestry is very cost effective in terms of initial costs of establishment and the derivable benefits, although it requires a considerably larger area of land to meet the wood needs. (Adegbulugbe at el, 1996).

Two possible scenarios for the energy sector are presented in this section. These are the baseline scenario and the greenhouse–gas–abatement scenario (According to the First National Communication, 2003). The baseline scenario follows the concept of the most likely development path in the energy system, whereby inefficiencies in the current system are not necessary carried into the future. In addition to existing social and economic infrastructures, all firm or proposed projects and policies are incorporated into the baseline scenario. The abatement scenario is obtained by the introduction of a number of mitigation options into the baseline scenario. These include-

(a) Efficiency improvement options in the residential, industrial and commercial sectors;

(b) Increased use of renewable resources, consisting of the introduction of small scale hydro plants and solar –electric options;

(c) Supply-side options, especially rehabilitation of some existing oil refineries and power plants, and the introduction of newer technologies,

(d) Options for increased use of natural gas.

The increased gas-use options focus on finding domestic economic uses for the associated natural gas that is currently being flared in the oil fields. The options considered in this category include liquefied petroleum gas and methanol extraction plants, substitution of fuel oil for natural gas in the industry for process heat generation and the introduction of compressed natural gas vehicles in the transport sector. There has been various attempts by the government to reduce gas flaring in the past, including introduction of penalties for the amount of gas flared by the producing companies. These have had only little effects. Recently, however, the major oil producing companies have set targets for the elimination of gas flaring Chevron, Elf and Shell: 2008; Texaco: 2005/6; Agip and Mobil: 2004). Therefore, the abatement scenario assumes that adequate legislation will be introduced to compel the oil companies to eliminate gas flaring by year 2010.

2.6 GHG Emissions Projections

For this analysis, only the emissions of carbon dioxide from the energy sector are considered. In assessing CO_2 emissions, the IPCC Reference approach was used in emission accounting. In this case, only the carbon in fuels, supplied to the economy was accounted for, irrespective of the technologies consuming the fuels or whatever transformations they went through before. In addition the IPCC default CO_2 emission factors adopted.

2.7 Energy Supply

Total primary energy consumption of Nigeria was 1270 PJ in 1995, projected to 1360PJ in year 2000, 1718 PJ in 2010, 2800 PJ in 2020, and 3140PJ in 2030 in the baseline scenario. The total requirements in 1995 oil accounted for 47%, natural gas 14%, solid fuels 32% while hydropower accounted for only 7%. By year 2030 however, the energy –mix would change to 52% oil, 25% natural gas, 16% solid fuels, while the contribution of hydropower remains at 7% hydro. Although the percentage contribution of hydro remains

the same at about 7%, its absolute contribution to the energy supply has increased considerably.

The primary energy intensity in terms of the amount of primary energy consumed per GDP is indicative of the energy required to sustain the projected economic and structural developments. This shows that primary energy intensity decreases with time over the period under investigation, an indication that the GDP is growing faster than primary energy consumption.

2.8 Forestry and Land use Sector

COPATH and COMP model were used in assessing mitigation options in the forestry and land-use sector. While COPATH estimates the amount of carbon stored, released and sequestered in different forest formations in a country, COMP evaluates the costs and benefits of mitigation options. The end-use based approach, which is tied to the wood product requirement of the country, was adopted. In order to determine the extent to which mitigation policies could be pursued, the demand, supply and balances for he major wood products in use in the country were estimated for the base year and projected to year 2030.

2.9 Forest Protection

This is a forestry management strategy that emphasizes protection of the forest. Nigerian's First National Communication (2003).

2.9.1 Inventory of Greenhouse Gases (GHG)

The gross carbon emissions from energy, land use change, industry solvents use, agriculture and waste management in 1994 was 52.5Tg - CO_2 – C, while the net uptake, principally from land use change, was 10.4Tg - CO_2 – C.

Gas flaring, transportation and electricity generation are the most significant energy consumption processes leading to GHG emission. Energy and land use change sectors were the main contributors to CO_2 emissions, while energy, agriculture and waste management are the main contributors to the CH_2 emissions. The energy and land use change sectors are the dominant contributors to CO_2 emission, while agriculture, waste management and energy are the main contributors to CH emissions. Carbon monoxide emissions and other GHG precursors arise mainly from energy and agriculture and to a lesser extent from waste management and industrial processes.

The assessment of the potential for inducing global warming by the three major GHG's has also been undertaken based on the global warming potential (GWP) for CO_2, CH_4 and N_20 projected for the next 100 years.

Total Emission by Sources

2.9.2 Carbon Dioxide Emission

The total CO_2 emission in 1994 was 192Tg - CO_2. The energy sector contributed 115Tg CO_2. This represents 59% of gross national emissions, while land use and land use change and forestry (LULUCF) sector generated 75TG representing 39.2% of gross national emissions into the atmosphere. Less than 1% of gross national CO_2 emissions were emitted from the industrial sector. Gas flaring contributed 58.1 million tonnes or 50.4% of gas emissions from the energy sector. The consumption of liquid and gaseous fuels in the sector led to the emission of 51.3 and 5.4 million tonnes of CO_2 respectively.

2.9.3 Methane Emissions

Methane is the second most important GHG after CO_2 based on its global warming potential. The total methane emission in 1994 was 5.9Tg - CH_4. Out of this, the energy production and consumption sector with a total emission of 1.48Tg - CH4, contributed 25% of gross national emissions, with agriculture and waste management contributing the rest.

In the agricultural sector, livestock contributed to the emission of 1.1 TG - CH_4, representing 19% of gross national emissions, while rice cultivation and other agricultural processes contributed 1.08TG - CH_4 and O.14Tg - CH_4 respectively. Municipal solid wastes (MSW) and wastewater treatment had 32% of gross national emissions. There were significant emissions from industries, solvents and forestry sectors. This indicates that municipal and industrial wastewater treatment is the single most significant source of CH_4 emissions.

2.9.4 Nitrous Oxide Emissions

The gross emission of nitrous oxide in 1994 was 11.95Gg N_2O. The energy sector (principally petroleum refining, small combustion and transport sub – sectors generated 7.47Gg N_2O, representing 63% of gross national emissions for the year. This was closely followed by emissions from Savannah burning (28%), field burning of agricultural wastes (6%) and on–site biomass burning from forest conversion (1 %).

2..9.5 Carbon Monoxide Emissions

The total emission for 1994 was 17.05Tg CO. Out of this, the energy sector generated 13.1 Tg CO with the following major energy sub - group emissions; transport 4.73Tg CO or 28% of the gross national emissions; small combustion sources and gas flaring, each representing about 25% of the gross national emissions. The agricultural sector emitted 3.59Tg CO or 28% of the gross national emissions for 1994, while the other energy sub sectors, waste management and land use change and forestry emitted 33.2Gg CO, 171Gg CO and 162Gg CO respectively. Energy sector sources therefore dominated the CO profile with various sub - sector activities contributing 78% of the gross national emissions.

2.9.6 Oxides of Nitrogen Emissions

Nitrogen oxides are, like CO, mainly emitted from combustion processes, with emissions highly technology dependent. The gross emission for 1994 was 658Gg NO_X. These were derived mainly from energy (502Gg NO_X), and agriculture (148Gg NO_X). Process industries, land use change and forestry, and waste management contribution to NO_X emissions was less than 10Gg NO_X. The profile of process emissions indicates that the transport sector contributed the highest to NO_X emissions.

The sector is responsible for 62% of the total NO_X emissions closely followed by small combustion sub - sector with a contribution of 23%. Other energy sub - sectors contributed 10%, LULUCF and waste management had 1% each, while agriculture contributed 3%.

2.9.7 Non - Methane Volatile Organic Compounds Emissions

The total national emissions of non - methane volatile organic compounds (NMVOC) in 1994 were processes generated 366Gg NMVOC. Of the energy sub - sectors, transportation contributed 42% to gross national emissions while fugitive sources; (including gas flaring) contributed 40%. The other energy sub - sectors together contributed 17Gg NMVOC or 1% of the gross national emissions.

2.9.8 Emissions from Energy

From the TD method, the consumption of solid, liquid and gaseous fuels CO_2 emissions of 105.5 million tonnes (Mt CO_2) or tetra grams (106 grams, Tg) of CO_2 (Table 1:1). Liquid fuels contributed 31% to CO_2 emissions, while natural gas contributed 62.96% with solid fuels (coal) contributing less than 0.04%. based on the consumption of biomass fuels and fugitive processes in the upstream energy sector, the total emissions for non – CO_2 GHG and precursor gases were 1708Gg of CH_4, 3.36Gg of N_2O, 4232Gg of CO, 123Gg of NO_X and 1334Gg NMVOC.

2.9.9 Emission From Process Industries

The preliminary results of emissions estimated from process industries indicated that non-metallic minerals (mainly cement and lime) and inorganic chemicals' production generated about 1760Gg CO_2, CH_4 emissions from ammonia and production and NMVOC emissions from paints production, food and beverage production and textiles. The industrial emissions of CO and NO_X are substantially low in comparison with emissions of CO_2.

2.9.11 Emissions from Solvent and Other Products Use

It is currently estimated that 0.4Gg of NMVOC are emitted from paints applications in Nigeria annually based only on local production of paints. The sector therefore accounts for less than 4% of the gross NMVOC emissions in Nigeria.

2.9.12 Emissions from Agriculture

Current estimates indicate that emissions from a combined livestock population of 509,000 in 1994 led to the emission of 1115Gg CH_4. Similarly, rice production led to the emission of 1090Gg CH_4, while Savannah burning generated 109Gg CH_4, 3.4Gg N_2O, 2870Gg CO and 120Gg NO_X. The field burning of 61.2mt of agricultural crop wastes also led to the emissions of 34Gg of CH_4, 0.7Gg of N2O, 720Gg CO and 26Gg of NO_X.

The sector emitted 2.3Tg CH_4 and 3.6Tg CO into the atmosphere, while N_2O and NO_X emissions where 4.1 and 148Gg respectively.

2..9.13 Emissions from Land Use Change and Forestry

The gross estimates of carbon uptake from forest and non- forest trees growth as well as from abandonment of managed lands are 36.75Tg CO_2 (10.02Tg CO_2 - C). Similarly, the gross emissions of carbon from biomass harvests and conversion of forests and Savannah to agricultural lands is estimated to be 112.23Tg CO_2 (30.61Tg CO_2 - C). This gives a net carbon emission of 75.54Tg CO_2 (20.6Tg CO_2 - C).

Table 1.1 Summary of Emissions from the Energy Sector. (Source: First National Communication 2003)

SECTOR	TOTAL ENERGY CONSUMPTION (PJ)	1994 EMISSIONS (Gg)					
		CO_2	CH4	N_20	CO	NO_X	NMVOC
Public Electricity	100.9	5686.3	0.01	0.20	1.30	5.82	0.00
Auto - generation	9.5	706.7	0.02	0.02	3.34	9.54	0.12
Petroleum Refinery	765.9	6098.9	0.61	2.91	28.34	4.14	12.10
Industry	18.3	1435.9	0.05	0.12	0.30	3.06	0.04
Transport	545.1	38473.4	12.07	0.86	4728.99	322.47	896.19
Small Combustion	738.5	4700.9	445.21	3.36	4139.25	127.87	4.71
Fugitives	5.2	58080.0	1018.23	0.00	4224.00	28.99	951.10
Total	**2183.4**	**115182.1**	**1476.2**	**7.47**	***13114.80***	***501.89***	**1864.26**

2..9.14 Emission from Waste

Estimates of wastewater generation from industries are obtained from gross industrial water consumption and BODs content of industrial wastewater from different sub - sectors. The results of the emission assessment show that WWT accounts for approximately 1.68Tg CH_4, while MSW accounts for 0.2Tg CH_4. The burning of MSW also leads to the emission of 0.25Gg N_2O, 171 Gg CO and 3.3Gg NO_X.

2.9.15 Specific Emissions

The potential per capita sectoral emissions and gross emissions based on emissions per unit of human population represented in the table below is based on gross population of 96.7 million for the year 1994.

This indicates gross per capita CO2 emissions in the energy sector to be highest (0.32tc/cap) compared top gross per capita emission of 5tc/cap non – CO_2 GHG and precursor gases are between 2 to 4 orders of magnitude lower than CO_2 per capita emissions. This data is low when compared to emissions from the United States and the OECD countries. However, this indicates that Nigeria's gross emissions may approach those of these countries if its population continues to grow at the current rate of 2.5% per anum, since per capital emissions are also likely to increase with increasing trends in the economy.

Table 1.2 Per Capita Sectoral and Gross Emissions for 1994. (Source : First National Communication 2003)

SECTOR	1994 SPECIFIC EMISSIONS					
	CO_2	CH_4	NO	CO	NO_X	NMVOC
	(kg C/cap)	(kg C/cap)	(kg C/cap)2	(kg C/cap)	(kg N/cap)	(kg NMVpC/cap)
ENERGY	324.65	11.44	0.05	54.26	1.58	19.27
INDUSTRY	4.96	0.00	0.00	0.00	0.00	3.79
SOLV.USE	0.00	0.00	0.00	0.00	0.00	0.00
AGRIC	0.00	18.17	0.03	14.83	0.47	0.00
LUC	212.92	0.14	0.00	0.67	0.01	0.00
WASTES	0.00	16.21	0.00	0.71	0.01	0.00
TOTAL	**542.54**	**45.97**	**0.08**	**70.46**	**2.07**	**23.06**

2.9.16 Total CO_2 Equivalent Emissions

The appraisal for the potentials for inducing global warming by the three major GHGs has also been undertaken based on the global warming potentials (GWP), for CO_2, CH_4 and N_2O for twenty and one hundred years averaging periods. The results are presented in Table 1:3. (Cummulative Effects of GHG emissions in 1994 to global warming in 20 years and 100 years).

This indicates that the gross CO_2 equivalent emissions are 564Tg CO_2 equivalent respectively. Over a 20 years averaging, methane seems to have the potential to contribute about 44% of the total global warming despite te lower emissions. This indicates that mitigation to reduce methane emissions in short term is important. However, over the long-term period (100 years), CO_2 emissions, contribution to global warming is observed to increase from 55% to 74% (see Figure 1:1.9 above).

Table 1.3 Cumulative Effects of GHG Emissions In 1994 To Global Warming In 20 – Years And 100 – Years Horizon

(Source: First National Communication 2003)

GHG EMISSIONS BY SECTOR	1994 EMISSION (Gg GHG)	GWP		CO_2 EQUIVALENT (Gg – CO_2)		PERCENTAGE CONTRIBUTION TO WARMING	
		20YRS	100YRS	20YRS	100YRS	20YRS	100YRS
CO_2							
ENERGY	115182.1	1	1	115182	115182	20.43	33.72
INDUSTRY	1760.9			1761	1761	0.31	0.52
SOLV. USE	0.0			0	0	0.00	0.00
AGRIC	0.0			0	0	0.00	0.00
LUC	75541.7			75542	75542	13.40	22.11
WASTE	0.0			0	0	0.00	0.00
SUB TOTAL	192484.7			192485	192485	34.15	56.35
CH_4							
ENERGY	1476.2	62	24.5	91525	56167	16.24	10.59
INDUSTRY	0.0			3	1	0.00	0.00
SOLV. USE	0			0	0	0.00	0.00
AGRIC	2344.2			145342	47434	2579	16.18
LUC	18.5			1148	454	0.20	0.13
WASTES	2091.7			129686	51247	23.01	15.00
SUB TOTAL	5930.7			367703	145302	65.24	42.53
N_2O							
ENERGY	7.5	290	320	2167	2391	0.38	0.70
INDUSTRY	0.0			0	0	0.00	0.00
SOLV. USE	0.0			0	0	0.00	0.00
AGRIC	4.1			1188	1311	0.21	0.38
LUC	0.1			37	41	0.01	0.01

WASTES	0.3			74	81	0.01	0.02
SUB TOTAL	11.9			3465	3823	0.61	1.12
TOTAL				**563653**	**341610**	**100.00**	**100.00**

CHAPTER THREE

MATERIALS AND METHODS

This chapter examines the techniques and methods in data collection including the data collection sources. There are basically two major instruments or methods used in research data collection. These are the primary and the secondary data collection methods.

The primary source of data collection includes field surveys, oral interviews and the administration of questionnaires. The secondary source of data collection includes information from existing texts, published and unpublished literature from the departmental library including other libraries, thesis, journals, seminar and workshop papers, newspapers and the internet etc.

For the purpose of this research work, secondary source of data collection method was adopted. Data were collected from the following sources.

3.1 The Federal Ministry of Environment – Abuja

Relevant information/data concerning the energy sector were sourced and collected from the Ministry Special Climate Change Unit Federal Secretariat Abuja

Useful energy projections according to various sectors were collected; information on residential, commercial, industrial and the transport sectors were obtained at this source.

Data on mitigating measures and mitigating assessment were also obtained.

Inventory of Green House Gases (GHGs) and their major sources were collected for appraisal.

Information on modern technologies for mitigating climate change and mitigation options were collected at the Federal Ministry of Environment Abuja.

3.2 National Institute for Fresh Water Fisheries Research New Bussa, Niger State

Relevant information such as the change in harvest technology in terms of time, species and age of fisheries were collected. Data on vulnerability assessments and adaptation measures for fresh water fisheries are expected to be collected. The impact of climate change on fish production and adaptation were collected. Environmental policy of the institute in the area of water conservation and water pollution abatement for sustainable fish production were obtained.

Technology in the protection of water sheds and reservoir sites were obtained. The institute's legislative structure and the maintenance of storage facilities were examined.

3.3 The Federal Ministry of Environment, University Linkage Centre for Climate Change, Federal University of Technology (FUT) Minna

Mitigating measures and options were sourced and collected at the centre. All aspects of relevant meteorological data for Nigeria for the period of two years were obtained at the centre. Information on International response including the responds of Nigeria Government in mitigating climate change were obtained at the centre. Other Data include the response of Private Sectors and NGOs in mitigating climate change.

Information on the nature of adaptation technologies and measures in climate change mitigation in Nigeria were sourced here. Information on green house gases emission mitigation were collected at this centre.

Possible adaptation options for agricultural production and information to improve agricultural productivity, information on whether records, predictions and forecasts were obtained here. This will assist in putting in place strong mitigating measures for climate change. Information on available research and training in the area of climate change were sourced.

It will also serve as data bank for information on renewable energy sources, dedicated systematic observations and weather forecasts, including adaptation options for climate change mitigation.

3.3 The Co- Ordinating Office: Global Environment Facility (GEF) National Park Service, Abuja

Information concerning the beneficiaries from the developing countries, parties to the UNFCCC. This information will help to identify the roles and implementation of Global Environmental Facility (GEF) to Nigeria and the benefit derived from them for mitigating climate change in terms of financial assistance and other contributions to Nigerian Government.

3.4 Nigeria Metrological Agency – Abuja

Relevant meteorological data for Nigeria for the period of two years 2004 to 2006 were obtained from the agency. Data on vulnerability assessment and mitigating measures for addressing climate change in Nigeria were collected.

3.5 Kainji Hydro- Power Station, Power Holding Company of Nigeria (PHCN) Kainji, New Bussa

Relevant hydrological data were sourced and collected. Data on the mitigating and adaptation measures were collected. The effects of hydrological system on the Power Station in respect of power generation on the River Niger at Kainji Dam were collected.

This data/information collected will be used to analyze the effect and consequences of low flow of water for power generation and at the same time appraise the mitigating measures for addressing climate change in Nigeria. These data collected include hydrological data and adaptation measures for addressing change.

The research work is to last for three months. The data were appraised to find the extent of mitigating measures and adaptation of climate change in Nigeria. All relevant sectors were appraised.

3.6 Ministry of Power and Steel, Abuja

This is an important information source, which provides information on modern energy sources and the introduction of small hydro dams for power generation in Nigeria. A great percentage of the total energy from renewable energy sources was obtained. Information on modern technology that will improve the efficiency of, and reduce pollution from the traditional cooking stoves, which will provide access to renewable energy for the people in the rural and urban areas were sourced.

Clean energy for sustainable development and the recent research on clean energy targets adopted to reduce costs and for energy efficiency including renewable energy and targets adopted according to their perspective conditions. Information on small solar home systems were sourced. Clean energy and renewable energy are important factors in mitigating climate change.

3.7 Data Analysis

Based on information/data obtained, analyses of the various data were made while some of the data were represented statistically.

Green house gas emission, which is the major contributor to climate change, will be appraised in terms of the GHG projections; this will then be represented in tables and figures under energy sector projection with the following key sectors, residential, industrial, commercial and transport. Sector and sub – sector NARKAL studies were examined and represented in tables and figures.

Incremental cost of mitigating measures were analysed, this is represented in tables in terms of $/ton. Electricity production by fuel type were presented in figures. Mitigation measures in terms of forestry, afforestation options, woodland and land availability and agro – forestry options were analysed. Fuel use in the transport sector was analysed and represented in figures,

while ranking of abatement options were represented in tables. The contribution of Global Environmental Facility (GEF) was appraised, including the financial commitments to some countries of the world.

CHAPTER FOUR

RESULTS

4. 1. ENERGY SECTOR PROJECTIONS

Table 4.1 is explaining the major energy sector and its projections in Nigeria. The mitigation measures adopted here include: residential, commercial, industrial and transport.

Table 4. 1 **Energy Sector Projections** (Source: First National Communication)

Sector	1995	2010	2030
Residential	***112.58***	***177.02***	***326.06***
Cooking	78.80	119.87	209.76
Lighting	17.27	28.44	55.85
Non-substitutable electricity	16.50	28.72	60.44
Commercial	***6.29***	***13.08***	***34.72***
Cooking	0.47	0.97	2.57
Lighting	4.58	9.51	25.25
Non- substitutable electricity	1.00	0.52	1.38
Street Lighting	0.25	0.25	1.38
Industrial	***81.00***	***114.57***	***134.14***
Feed-stock	14.78	30.38	30.38
Process heat	53.97	70.13	86.88
Motive power	5.61	6.44	7.73
Lighting	1.13	1.30	1.56
Non- substitutable electricity	5.51	6.32	7.59
Transport:			
Passenger Transport (Billion –pass-km/a)	514.27	1090.73	2960.85
Freight Transport (Billion –pass-km/a)	38.86	80.78	214.34
Air Transport	23.48	48.81	129.51
Water Transport	2.31	4.09	9.76

4.2 Sectors and Sub-Sectors Represented in Nigeria Markal Study

Sectors and sub-sectors represented in Nigeria described Agriculture Irrigation and Agric. motive pumps including: Commercial Refrigerators, all aspect of Cooking, and commercial lighting as explained in table 4.2.

Table 4.2 **Sectors and Sub-Sectors Represented in Nigeria Markal Study** (Source, Adegbuligbe et al, 1996)

Sector	***Sub-sector***
Agriculture	Agric. Irrigation Pumps
	Agric. Motive Power
Commercial	Commercial Refrigeration
	Commercial Space Cooling
	Commercial cooking and Warm Water
	Commercial Electrical Appliances
	Commercial Lighting
Industry	Fertilizer Industry Feedstock I
	Fertilizer Industry Feedstock II
	Ajaokuta Steel Industry
	Delta Steel Industry
	Aluminium Industry
	Industrial Electric Motive Power
	Industrial Diesel Motive Power
	Process Heat (Other Industries)
	Industrial Non-Substitutable Electricity
	Industrial Lighting.
Residential	Cement Industry (Fuel Oil Boiler)
	Urban Cooking
	Rural Cooking
	Rural Lighting
	Residential Air Conditioning
	Residential Refrigeration
	Residential Electrical Appliances
Transport	Road Freight
	Road Passenger Transport
	Air Transport
	Water Transport (Ferries and Boats)

	Rail Transport Water Transport (Ships and Vessels.)

4. 3 Increment Costs of Mitigation Options

The Mitigation options described in table 4.3 include: CFL lighting, improve electrical appliances in the residential sector and effective motors in Industry, the introduction of small scale hydro dams.

Table: 4. 3 **Incremental Costs of Mitigation Options**
(Source: Adefolalu 2003)

Mitigation Option	***$/Ton***
CFL Lighting	58
Improved kerosene stove	21.40
Displacement of fuel-oil by gas in Cement Industry	18.42
Improved Electrical Appliances in the residential sector	16.83
Efficient Motors in Industry	15.92
Small –scale Hydro (<10 MW)	10.34
Kainji Hydro Power Plant (Retrofit)	7.02
Improved Woodstove in residential sector	3.92
Large scale Hythos	3.48
Central Solar	1.28
Improved Refrigerators	9.75
Residential Solar PV	12.58
Gas Flare Reduction	49.54
Efficient Gasoline Cars	70.75
Improved air conditioners	141.56
Efficient Diesel Trucks	150.76
Improved Electrical Appliances, Industrial and Commercial sectors	172.20

4.4 **Electricity Products by Fuel Type**

The production of electricity by fuel type is described in figure 4.1 in terms of Oil, Gas and Renewables. This is one of the most effective options because the options involves renewable efforts.

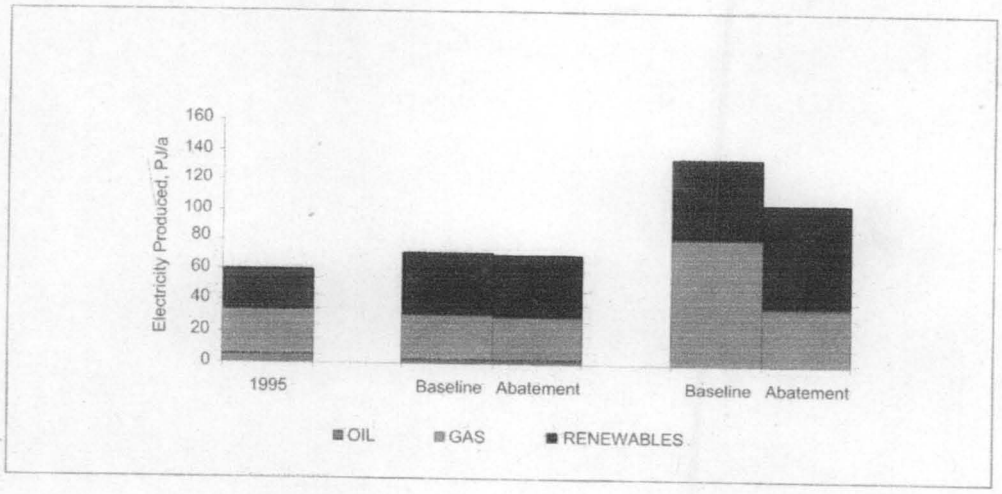

Figure 4.1 ***Electricity Productions by Fuel Type***
(Source, First National Communication)

4.5 Cost Implication of Projects on Nigeria's Sub -- Sectoral Issues

The cost of projects on Nigeria's sub-sectoral issues is too high as indicated in table 4.4.

Implications: Nigeria cannot raise the above sum, which is at least 10 years GNP from its oil dominated resource base

Table 4.4 **Cost Implication of Projects on Nigeria's Sub – Sectoral Issues** (Source: Adefolalu 2004)

S/N	ACTIVITY AREA	SECTOR	COST INDICATION ($N \times 10^6$)	FUNDING SOURCES
1	Averting Coastal Infrastructural Damage, Sea Level Rise Scenarios	Climate Change	4,500	GEF
2	MITIGATION Option Of CO_2 Emission In Nigeria (To Offset 1,628.82 Mtons From All Sectors	Climate Change	10,250,000 (Only Where Incremental Cost Will Pose Threat To Mitigation)	CDM/JI Including GEF
3	Afforestation For Co_2 Sequestation	Climate Change	5,070,000	CDM
4	Agro Forestry	Cliamte Change	360,000	CDM
5	Systematic Analysis And Observation	Climate Change	6,000,000	CDM
		Total	20,380,000,000	
TWENTY TRILLION, THREE HUNDRED AND EIGHTY BILLION NAIRA				

4.6 **Fuel –Use in The Transport Sector**

Fuel use in transport sector as described in figure 4.2 includes: Diesel, Gasoline, Fuel Oil and LNG. These are the major fuel use in the transport sector.

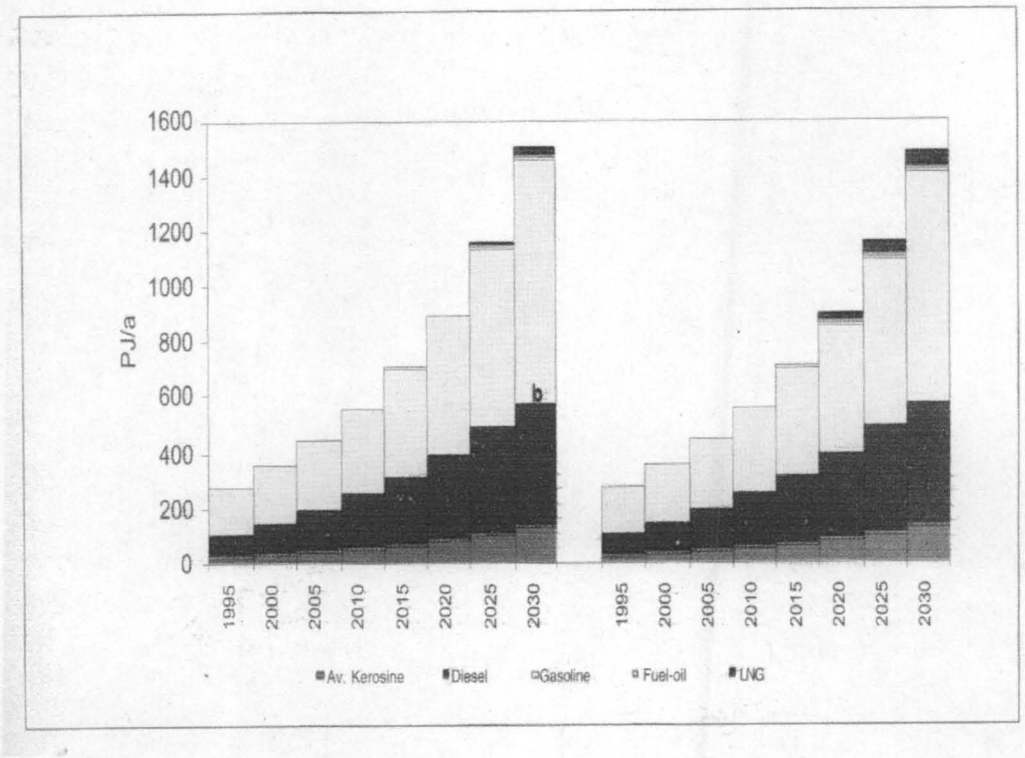

Figure 4.2 ***Fuel –use in the Transport Sector***

(Source, First National Communication)

4.7 Ranking of Abatement Options

The ranking of abatement options described the effectiveness and the incremental reduction in terms of cost and capacity of the options. These options will effectively reduce the effects of climate changes as shown in table 4.5.

Table: 4.5 ***Ranking of Abatement Options*** (Source: Adefolalu 2004)

Mitigation Option	*$/Ton*	*Incremental Cost (US$m)*	*CO_2 Reduction Capacity (Mton)*
CFL Lighting	-299	5.155	58.00
Improved kerosene stove	-131	6.122	21.40
Displacement of fuel – oil by Gas in recent industry	138	7.49	18.42
Improved elec. Appliances in The residential sector	-161	9.566	16.83
Efficient motors in industry	-171	10.738	15.92
Small-scale hydro (<10MW)	-427	41.313	10.34
Kanji Hydro Power Plant (Retrofit)	-351	50.01	7.02
Improved woodstove in Residential sector	-72	18.369	3.92
Large scale hydro	-686	197.353	3.48
Central solar	-24	18.735	1.28
Improved refrigerator	-154	15.793	9.75
Residential solar PV	74	5.883	12.58
Gas flare reduction	45534	919.201	49.54
Efficient gasoline cars	17478	247.05	70.75
Improved air conditioners	218	1.54	141.56
Efficient diesel trucks	9060	60.096	150.76
Improved electrical appliances, Industries and commercial sectors	2485	14.431	172.20

4.8 Some GEF Projects Examples

It is obvious that Nigeria has not benefited from Global Environmental Facility (GEF) projects in terms of Project allocation, financial Assistance and funding in the area of climate change as it is shown in table 4.6. It is only Eritrea in Africa that has once benefited in the area of conservation of Eritrea's coastal marine Arid Island biodiversity.

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

Greenhouse Gases (GHG) emission and its attendant effects are among the most complex environmental problems ever to face humanity. The effects of the accumulation of these gases in the atmosphere are expected to result in climate changes, disruption in agricultural production, ecosystem physio-chemical changes including human and health effects, among others.

Although the bulk of the emissions of GHGs have been traced to fossil fuel consumption in the developed countries, recent studies shows that land use changes in the developing countries like Nigeria also led to significant emissions of GHGs. In addition, the emissions from developing countries such as Nigeria with potentially large economies are bound to increase with economic growth.

Nigeria is endowed with numerous natural resources among which are crude oil, natural gas, coal, and solid minerals. Crude oil currently contributes approximately 90% of the country's total export earnings, with proven reserves estimated at 17.8 billion barrels. Crude oil production grow from 0.017 million barrels per day in 1960 to about 1.8 mbd in (1990). About 18% of this is refined locally. Natural gas, which consists of about 50% associated deposits is also abundant, with proven reserves of about 2.5×10^2 m3 in 1990. More than 75% of the total natural gas produced annually is flared, and current estimates indicate that Nigeria flared about 27% of the total quantity of natural gas produced.

Until the 1960s, the Nigeria economy was largely agrarian. In the early 1960, the economy was transformed into a partially industrialized one due to a combination of oil exports and world oil price increases leading to substantial

growth in the gross domestic product (GDP) and urban population. The consumption of fossil fuels also grew rapidly during this period.

An examination of the historical structure of GDP in Nigeria by sector revealed that in 1960, the agricultural sector contributed more than 60% of the country's GDP whereas oil and mining contributed only 1.2% and manufacturing about 4.8%. By 1980, the share from agriculture had declined to 22.2%, while the contribution from oil and mining had increased to 26.8%.

Within the same period, commercial energy consumption grew from 58 PJ to 540 PJ. Available data on sectors energy consumption show that for public power generation, hydro-electricity contributed approximately 20 to 42% of the total national electricity generation between 1987 and 1992 and that natural gas contributed approximately 93% at all thermally generated electricity in 1990. An estimated average annual growth rate of 12% had been recorded for electricity between 1974 and 1995. The other major exclusive sectors are transport, power generation, industry, household and commerce.

Despite the high consumption of Commercial energy, fuel wood remains the dominant fuel in the domestic's sector. The high population growth/urbanization led to increased demand for forest resources for agriculture and fuel wood, resulting in a very high rate of deforestation of about 200 Kha/sector.

Given the uncertainties surrounding climate change, it has been recognized that a necessary first step is the careful study of various issues involved in Nigeria.

5.2 GHG Emissions Projections

5.2.1 **Energy Sector**: The least cost mitigation analyzes of the Nigerian economic system span 40 years, with 1990 as the base year. The largest single contribution to total CO_2 emission in Nigeria is gas flaring in the oil industry followed by emissions from road transportation and electricity generation.

However, the most attractive mitigation options are CFL lighting, improved kerosene stoves, improved wood stoves and use of efficient motor and efficient use of solar energy.

Nigeria will be able to adapt to climate change of the energy system with the dramatic improvement of hydro dams through deliberate steps to:

I. Ensure adequate flow of water into the hydro dams as shown in table 4.3

II. Control of the high exhaust temperature of turbines during the hot, dusty and dry harmattan

III. Combat forest fires, which destroy power lines during the dry season and

IV. Have steady electricity generation and distribution throughout the year through diversification of energy generation through solar and wind in addition to community – based small hydro dams

5.2.2 CO_2 Emissions

The baseline CO_2 emissions in Nigeria energy system under the three energy growth scenarios are shown in figure 4.1. CO_2 emissions due to electricity generation could be cut by 15.30% in 2030 under the 20% constraint condition, and by 40.54% in the case of a 35% constraint, In the transport sector emission reduction up to 13% is achievable by 2030 in a 20% constraint scheme, or 6 – 21% under the 35% reduction strategy. Note that CO_2 savings in electricity consumption in residential and Industrial sectors from the use of efficiency improvement options are tied to CO_2 avoided in electricity generation. Note that CO_2 savings in electricity consumption in residential and industrial sectors from the use of efficiency improvement options are tied to CO_2 avoided in electricity generation. For this reason the recorded changes in CO_2 emissions in these sectors under constraint conditions may be quite low. Emission due to-gas

flaring in the oil industry could be reduced by 65.96% by 2030 as shown in table 4.2.

Any strategy to drastically reduce CO_2 emission must first tackle the issue of gas flaring in the oil industry, A 20% CO_2reduction from baseline level requires cutting down gas flaring from about 75% in 1990 to less than 25% of total gas production by 2030, or about 4% in the case of 35% CO_2 reduction,. Significant CO_2 reductions can be made by efficiency improvements in end-use devices in the transport, residential and industrial sectors as shown in table 4.1. Based on incremental cost per ton of CO_2 reduced, the most attractive options in the residential sector are the introduction of NFL lighting and improved kerosene stoves. In the industrial sector, there are introduction of efficient motors and the displacement of fuel oil for process heat by natural gas. Analyses shows that despite the immense solar energy potentials available in Nigeria, solar electricity generation will only become attractive under severe CO_2 constraints as shown in table 4.5. On the other hand, as the use of small-scale decentralized hydro generators is favoured under all the constraint conditions. In addition, the marginal cost of a cumulative 20% cumulative CO_2 reduction from baseline level in the Nigerian energy is less than US $ 30.

5.2.3 **Electricity Productions**

Electricity generation in Nigeria is mainly from gas and hydropower. A small amount of diesel and fuel oils is still use in some generation stations, while gasoline and diesel are used for private generation. In 1995, total electricity production was 61PJ. This is projected to about 136 PJ in 2030. Reductions of about 20% from the projected 2030 production estimates are expected. Hydro-electricity has much potential in Nigeria's energy supply. For instance, in the abatement case, the share of the projected hydroelectric generation rises from 44% in 1995 to 64% in 2030.

5.2.4 **Forestry Sector**

The forestry sector had an estimated net release of 9.5 Mtc in 1990. Based on this figure, projections up to the year 2030 give net cumulative emissions of 427.4 and 580.5 Mtc at 1.3% and 2.6% deforestation rates, respectively. The cost-benefit analysis of the mitigation options considered (forest protection, aforestation and agro-forestry). Forest protection and afforestation shows that the first two options are independently capable of absorbing up the carbon released from the forestry/land use sector at a rate of about $1.00/tc forest protection and $13.00/ tc for afforestation.

5.2.5 **Wood Demand and Land Availability**

Under baseline scenario, there is increasing demand for wood products corresponding with increasing population with the expectation of pulped wood, which is expected to be adequate up to 2008; there was a short fall in the supply of other wood products. For instance, the demand for fuel wood has risen from $73.9m^3$ in 1990 and presently to reach $99.0m^1$ in 2030. Supply on the other side will decrease from $82m^3$ in 1990 to 60.0^3 in 2030. There are wide variations from state to state and from forest zones where there is still little shortfall in the supply to the middle belt and northern parts of the country where there is high negative balance of supply.

Thus, under the mitigation scenario, it is considered that fuel wood plantation would be better located within the ecozones where a boost in supply is highly needed. About 4.5 million hectares of fuel wood plantation would have to be established in order to meet the shortfall in supply and requirements of about 0.2 million hectares in 2010 is projected to reach 1.7 million hectares in 2015 and 7.5 million hectares in 2030. In addition to existing forest estates through increased reservation by government and private ownership of forest estates.

5.2.6 **Afforestation Options**

By the year 2030, the total carbon sequestered in the planted forest of about 7.5million hectares will be 638mtc at an annual incremental rate of 16.0mtc, the volume of carbon expected to be sequestered using this option is well in excess of the estimated net emission of 437.4 and 580.5mtc at 1.3% and 2.6% deforestation rates respectively. The average initial cost of establishment is 500 Pounds Sterling/ha or an average unit cost of 13.4 Pounds/ha. This implies a capital net of 3.8 billion Pounds over a period of 40 years (about 94 million pounds/year), assuming that the wood product needs of the country would be met over the 40 years period.

5.2.7 **Agro Forestry Options**

A total of 311mtc will be sequestered by the year 2030 at an annual incremental rate of 7.77mtc. The average initial cost of establishing is 320 pounds while the unit cost of carbon is 17.17 pounds. Thus, the total capital requirement for 40 years period is 2.4 billion pounds or 60.1 million pounds/year. The estimated volume of carbon expected to be stored over the period is less than that which will be released by 2030. This implies that this option alone is incapable of absorbing the released carbon and meeting the wood needs of the country.

5.2.8 **Projection of Response Measures Under The Protocol**

The discussion in this chapter gives insight into possible options and strategies open to Nigeria under both UNFCCC/GEF and the Protocol.

Since the Protocol focuses attention on reducing the effects of anticipated response measures to cut GHG emissions, a summary of elements estimated values at risk or loss that should be void in order to ensure Nigeria's corporate existence without mortgaging her economic resourcefulness is given in Table 4.4

5.3 End-Use Energy Demend

5.3.1 **Resident and Commercial Sub-Sector** The main requirement for energy in the residential sector is for working, lighting and non–substantial electricity. The predominant firewood in the rural and urban areas include, kerosene, and LPG mainly in the urban areas. In 1995, out of the total of 494PJ of energy requirements in the sub-sector, fuel wood consumption amounted to about 75%.

Total energy demand is projects to increase to 550 PJ in 2010, and 1030 PJ on 2030 at an average rate of 2% per annum, demand for electricity (29PJ in 1995) is expected to drop from the baseline projection of 96PJ in 2030 to about 75 PJ in the basement scenario. This is mainly by due to the penetration of compact of fluorescent bulbs into the Nigeria market.

5.3.2 **Industrial and Agricultural Sub-Sector** Energy requirement in the agricultural sector is minimal due to the low mechanization in Nigeria. Fuel requirement is mainly diesel for irrigation and tractor motive power. Energy demand in the industrial sector is broken down to electricity, oil products (principally diesel or fuel oil). Solid fuel consisting of coal, coke and charcoal, and gas. The fuel contributions in 1995 in the baseline scenario are oil products (37%), natural gas (49%) and electricity (11%). The remaining share of 3% is taken up and coal, coke and charcoal put together.

5.3.3 **Transport Sub-Sector** Diesel and Gasoline are the most important fuels used in the transport sector. It is not expected that LNG will take over from these two fuels in the near future.

Gasoline and LNG vehicles rather than dedicated LNG vehicles are expected to be introduced into the road transport sector during the new century and most of these will take the form of the retrofitting existing vehicles fleet. As shown in

figure 4.2 the displacement of gasoline is more pronounced under CO_2 abatement.

5.4 Assessment of Mitigation Options

Some of the results of mitigation assessment are shown in table 4.3.

Ranking of the options have been based on the incremental cost per unit of CO_2 reduced. From the result, it is clear that some of the options can be implemented at net negative cost of the total energy system cost.

5.5 Ranking of Abatement Options

The obvious case of Gas flare reduction in the oil industry, significant CO_2 emission reduction could be achieved in the residential transport and industrial sectors of the energy system. Further more as shown in table 4.5 based on the incremental costs per ton of CO_2 removed, the most promising mitigation options in the Nigerian energy system are the introduction of compact fluorescent light (CFL) bulbs at the negative incremental cost of 58 Ton CO_2 followed by the introductions of improved kerosene stoves in households at a cost of 821 Tons of 821 tons of CO_2 reduced. Other viable options include fuel oil to natural gas fuel substitution in the cement industry (18/Ton) introduction of efficient motors in the industry (15/ Ton) end improved electrical appliances (16/Tons) and wood stoves (3 Ton) in the residential sector.

5.6 The Global Environmental Facility (GEF)

The UNFCCC has put in place a Global Environmental Facility (GEF), which provides for:

- Preparation of Nigeria's first national communications,
- Studies on baseline information to minimise the impact of climate change,

- Projects on eleven operational areas, namely
  - Arid and semi – arid zone ecosystems
  - Coastal marine and freshwater ecosystems
  - Forest ecosystems
  - Mountain ecosystems
  - Removal of barriers to energy efficiency and conservation
  - Promoting the adaptation of renewable energy by removing barriers and reducing implementation costs
  - Reducing the long term costs of low GHG emitting energy technologies
  - Water based operational programmes
  - Integrated and water multiple area operational programmes
  - Contaminant – based operational programmes
  - Promoting environmentally sustainable transport

Regrettably, Nigeria is yet to benefit from any of the operational programmes listed above.

To date, the first national communication project is perhaps the only one that has attracted GEF funding. This must be corrected because other developing countries are beneficiaries of GEF assistance as shown in table 4.6.

5.7 **Technologies for Adaptation to the Adverse Effects of Climate Change**

Recently, in addressing climate change, the international community has devoted increased attention to adaptation to finding better ways to adjust to the impacts

of climate change. Some methods of adaptation will require social or political action but most will also require technology, in many cases people will adapt to climate change by changing their behaviour – by moving, to a different location or by changing their occupation. However, often the people will employ different forms of technology.

Whether hard forms Seawalls, new irrigation system or through resistant seeds of soft technologies such as crop rotation pattern will be introduced. A combination of hard and soft technologies can be used e.g. early warning systems that combine measuring devices with knowledge and skills, rising awareness and stimulating appropriate action.

5.8 **Tried and Tested Technologies**

Technologies for adaptation are not all new. Many have been tried and tested over generations – coping with floods for example, by building houses on sticks or by cultivating floating vegetable plots. Other technologies are much more recent, involving advanced materials science or satellite remote sensing. One of the main challenges for all these technologies is to ensure they serve those in greatest need- the most vulnerable communities in Nigeria particularly those who lives and work in close contact with the Natural environment and who stand to loose most from the impacts of climate change.

Although many adaptation technologies are already available in place, further investigation revealed to make them more effective. E.g. using different materials or modified designs. There are also technologies that have been employed in one location or country or region but could usefully be replicated elsewhere. Therefore the development, diffusion and transfer of technologies for adaptation are essential for increasing capacity of a developing country like Nigeria to cope with the adverse effects of climate change.

5.9 **Transfer of Technology**

Transfer of technologies for mitigation of climate change has typically involved transferring equipment or know how from developed to developing countries like Nigeria. There may then be a temptation to envisage transfer of technologies for adaptation. Following the same pattern, however, technologies for adaptation defer from those of mitigation in a number of important perspectives.

The emergency interpretation of the Clean Development Mechanism (CDM) regime is that since most of the known Annex I recipients are developing nations like Nigeria with low technology development history. Annex I nations are expected to assist in technology transfer and capacity building. Many international initiatives in the area of transfer of technology and capacity building are currently ongoing. One of the most aggressive and perhaps better – proliferated initiatives in this direction is UNIDO'S "capacity building for CDM in African countries", including Nigeria. The initiatives, which started in late 1999 with the pilot phase which started in six African countries including Nigeria has since proliferated in about six additional African countries as well as countries in Asia.

5.9.1 **The Nature of Adaptation**

Unlike mitigation, which is a relatively new task adaptation builds on efforts to reduce vulnerability to current climate variability, for which many technologies are already being applied even in some of the least developed countries. Adaptation rather than being concentrated in one sector such as energy, will essentially dispersed across all socio-economic sectors including coastal zone, agriculture, water, health infrastructure of which presents its own challenges.

Adaptation technologies, with some exceptions, are likely to be capital intensive and more available to small-scale interventions. They should therefore be more flexible and adaptable to local circumstances, which means that in addition to

being socially and legally acceptable, they can be more cost effective. Nevertheless, as with any form of technology, there is always a risk that adaptation technologies and measures will be more accessible to more effluent communities. Clearly technologies will only be component of the response to the impacts of climate change. Vulnerability also depends on prevailing social economic and environmental conditions and existing management practices. Technologies for adaptation should however form a vital part of broader frame works of integrated postal management of integrated water resources management and search for new generation of crop varieties and Vaccines to prevent the transmission of infections diseases that can be exacerbated by climate change.

5.9.2 **Adaptation Options**

In order to minimize the negative impact of climate change on the ecosystems water resources, socio economic domains, a number of adaptation measures are open to Nigeria. They range from education to inform and encourage behaviour rural change to changing location and use, preventing effects, modifying threats, sharing loss or simply bearing it.

Naturally, all multi-cellular organisms are able to sense and response to abiotic factors and have evolve set various mechanisms to track the set of the environmental conditions under which they are able to exist and reproduce. Thus, organisms and the ecosystems can adopt autonomously. However, the ability of the ecosystem to autonomously respond to climate change is inherently limited.

Therefore, in addition to autonomous adaptation, there must also be planned adaptation and adoption of adaptation strategies. These will include, among others"

5.9.3 Physical and Ecological Adaptation

* Diversification and extension of protected areas for the conservation of ecosystems that are most vulnerable to climate change and sea level rise.
* Maintaining ecological structure and process at all levels and reducing existing pressure on natural ecosystems.
* Reducing population and ecosystem vulnerability to climate change and reorientation of their evolution towards higher resistance to the changes.
* Incorporating biodiversity conservation into adaptations strategies in the other sectors of the Nigeria economy.
* Establishment of maintenance of protected area (institute preservation) population outside of protected area, estate management)
* Development and implementation of programmes for restricted areas and buffer zones, resource harvesting on a sustainable basis, ecological restoration , sustainable management and agro ecosystems.
* Monitoring to evaluate species and ecosystems stability from climate change perspective.

5.9.4 Degradation of Soils and Land Resources

- Implementation of agricultural systems adequate to protect the soil from erosion.
- Establishment of mechanical and engineering , structures (e.g. check dams, stone diversion, channels, bench terraces Contour bounds) as well as biological measures (e.g. cover cropping, mulching , contour cultivation, minimum of zero tilling that could reduce soil erosion).
- Efficient use of compost to replenish humus losses from soil.

5.9.5 **Soil and Water Intrusion**

Adoption options would include-

- Construction of dykes, barrages, storm surge barriers and storm diversion channels.
- Relocation and settlement of affected people.
- Realignment of transportation routes and nodes.
- Adoption of new or different livelihoods
- Adaptation of new bulking and other construction technologies.

5.9.6 **Drought and Desertification**

- Restoration or rehabilitation of over grazed and irrigated agricultural land.
- Minimization and management of biomass burning especially in the Sudan-Sahel regions
- Minimization of forest and woodland destruction.
- Restoration of degraded forests and woodlands
- Promoting socio-economic and political sustainable management of the Sudan-Sahel regions
- Resettlement.

5.10 **Agriculture**

The possible adaptation options in agriculture for responding to climate change include:

Crop production:

Adaptation crop choice including:

- Creating, diversification and study of local vegetation resources in order to find new plant species and varieties that would have higher resistance to anticipated temperature increase and reduced rainfall.

- Improving local agricultural crop varieties that are well acclimated as well as drought and pest –resistant.

- Development of varieties and hybrids that would allow separation in time of critical development phase from limiting environmental factors, particularly rainfall, affecting productivity. Adaptation by altering tillage and husbandry through :-

i. Use of minimum or zero tillage and other appropriate, technologies that would replace soil erosion and loss of organic matter and interests but increase soil moisture, availability to plants and reduce weed and pest infestation.

* Development and implementation of appropriate hydro-and agro-technical systems for accumulation and efficient use of rainfall.

- Adaptation by alteration of input.

- Introduction of new irrigation scheme to dry land management to improve water use efficiency and minimize moisture stress for crops, particularly in the Sudan Sahel zone where climate change is expected to result in reduced amount of rainfall for rain fed agriculture.

- Improved use of fertilizer, including varying for amount and timing of application and promoting of organic fertilizer to match application to offered pattern of rainfall, avoid pest, weeding and disease damage.

- Adaptation by promoting policy – enabling environment.

- Adaptation of the natural resources utilization processes in agriculture to sustainable development principles.

- Creation of socio-economic conditions for profitable agricultural activities.

- Implementation of medium – to - long-term development strategy for industries based on sustainable agricultural principles.

- Linking crop production to meteorological focus

- Meteorological Agency to alert farmers on weather.

- Farmers encouraged to use meteorological forecasts.

5.10.1 **Livestock**

Adaptation strategies in the livestock sector would include-

- Reduction in stocking rates of livestock density.
- Adoption of supplementary feeding
- Change in mix of grazers or browsers
- Flexibility in the location of the watering points to promote alteration of animal distribution.
- Restoring degraded areas.
- Increasing rangeland vegetation and /or adopted species.
- Modification of price supports and other government programme to enable cattle farmers to respond quickly to climate change, for example, through stabilization programmes and subsides, tariffs and other trade barriers.
- Development of large –scale water shed projects.
- Encouragement in production in the most efficient area by discouraging the use of marginal lands and protecting areas that are degraded.
- Enhancement of veterinary and extension services and
- Public awareness.

5.10.2 **Fisheries**

- Change in harvest technology
- Stocking marine water and contaminated inland water bodies with salt tolerant or hardier fishes.
- Expansion of aqua - culture production systems.
- Improvement of processing and storage facilities.
- Enforcement of legislation on appropriate and acceptable fishing practices.

5.10.3 **Water Resources**

- Modification of existing physical structure (e.g. changing locations or height of water intakes, using closed conducts instead of open channels, using artificial

recharge to reduce evaporation, raising dam height, adding more turbines, removing sediment from reservations for more storage.

- Increasing water supply capacity through construction of new structures (e.g. reservoir, hydro-plants, delivery system for inter basin transfer).
- Alternative management of new structures (e.g. changes in operating rules) and integration of water supply systems.
- Promoting water recycling and re-use.
- Development of ground water supplies.
- Improving efficiency of sources of water already developed.
- Protection of water sheds and reservoir sites through establishment of intensive vegetation cover to minimize evaporation.
- Monitoring ground water resources
- Improving on rain- harvesting techniques back –up tanks

5.11 **Socio-Economic Sector**

Diversification of the economy:

- Readiness to relocate threatened power generation and transmission facilities.
- Cutting new facilities development in location that are minimally threatened by sea level rise.
- Vigorous and extensive tree planting for fuel wood and other purposes.
- Physically protect highly sensitize energy production facilities (e.g. Oil rigs with physical barriers)
- Develop and enhance utilization of renewable energy resources (e.g. solar energy).

5.12 **Industries**

- Readiness to relocate to more favourable sites.
- Appropriate location for new industries in view of anticipated sea level rise.

- Development of appropriate mining techniques and industries for transiting climate conditions.

5.13 **Transport**

- Use of devices to shield sensitive equipment form excessive dust and humility.
- Drainage construction in and around ports in coaster areas.
- Emplacement of storm surge barriers around airports.
- Appropriate choice of sites for airports and motor parks.
- Careful design of highways and railway lines taking into account expected changes in soil, moisture changes due to climate change.

5.14 **Health**

- Consistent attack on disease vector population.
- Strengthening the health care delivery system.
- Sustained public awareness on health issues.
- Improved public sanitation and immunization coverage.

5.15 **Coastal Areas**

- Among the adaptation strategies that could be applied are technical engineering and structural, biophysical and ecological and non- structural.
- Technical engineering and structural adaptation responses include the use of protection devices (e.g. dykes, levees, flood walls, seawalls, revetment and bulkheads, groynes, detached break waters, flood gates and tidal barriers , salt water intrusion barriers and other soft options such as (beach nourishment beach fill) dune restoration and creation, wet land restoration and creation and aforestation .
- Biophysical and ecological options include modification of land use, changes in planning date, changes in cultivars, application of irrigation and changes in crop. Other include replacing lost resources, developing of attractive habitat areas (e.g. creating wetland and sand dunes), protecting threatened ecosystems,

5.9.6 Ranking of Abatement Options

The obvious case of Gas flare reduction in the oil industry, significant CO_2 emission reduction could be achieved in the residential transport and industrial sectors of the energy system. Further more as shown in table 4.5 based on the incremental costs per ton of CO_2 removed, the most promising mitigation options in the Nigerian energy system are the introduction of compact fluorescent light (CFL) bulbs at the negative incremental cost of 58 Ton CO_2 followed by the introductions of improved kerosene stoves in households at a cost of 821 Tons of 821 tons of CO_2 reduced. Other viable options include fuel oil to natural gas fuel substitution in the cement industry (18/Ton) introduction of efficient motors in the industry (15/ Ton) end improved electrical appliances (16/Tons) and wood stoves (3 Ton) in the residential sector.

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  - Coastal marine and freshwater ecosystems
  - Forest ecosystems
  - Mountain ecosystems
  - Removal of barriers to energy efficiency and conservation
  - Promoting the adaptation of renewable energy by removing barriers and reducing implementation costs

5.16 **Summary**

Climate change has become the most engaging environmental issue since the United Nations Conference on Environment and Development (UNCED), better known as RIO - 92. Indeed, it is the number one environmental problem that could cause social and economic instabilities in the 21st century and beyond.

The appraisal of options to reduce future GHG emissions and various mitigation measures including adaptation to addressing climate change issues in Nigeria. Green House Gas (GHG) emissions in the energy sector and gas flaring reduction, the GHG emission projections, the end use energy demand and the transport sub–sector including other relevant sectors in Nigeria are the machinery of Kyoto protocol.

Electricity production in Nigeria is mainly from gas and hydro power. A small amount of diesel and fuel oil is still used in some generation stations while gasoline and diesel are used for private generation. Hydro electricity has much potential in Nigeria energy supply system. Forest protection and afforestation are both capable of absorbing the carbon released from the forestry/ land use sector. In addressing climate change, the international community has devoted its attention to the adaptation and mitigating options, which will result to finding better ways to reduce the impact and to adjust to climate change.

5.17 **Conclusion**

Climate change is a global issue that is already impacting on the lives of Nigerians and the Nigerian environment. The most serious impact now and in the future include flood/erosion and drought/desertification; sea level rise (SLR), which may wipe out Nigeria's coastal zones characterised by large population, vast natural and fuel minerals and socio - economic activities. Severe weather events like tornado type storms (hitherto alien to Nigeria) due to high sea surface temperature (SST) in the area are very close to this value. Mitigation against such a disaster can only be achieved through transfer of technology for numerical fine-mesh weather prediction models.

The UNFCCC and especially Kyoto protocol are instruments by which nations acting together will slow down emissions, through international, regional .and national activities. Nigeria's ratification of the Kyoto protocol will assist the country to meet the challenges of the impacts of climate change through international cooperation, assistance and partnerships. Not only will the country be assisted with adaptation options to mitigate the impacts of climate change.

Agro forestry under LULUCF, renewable energy resources exploitation and enhancement through LNG gas turbines etc are all win – win situations.

"A healthy nation is a strong nation". Health hazards (among others) are expected to become very critical in the country. The energy sector is left unattached while food shortages persist.

5.18 **Recommendations**

Nigeria must establish a national climate change Bureau or Commission. The Commission should be named as a NATIONAL CLIMATE CHANGE COMMISSION.

It should start operations before the end of 2008 since the country's first national communication has already come up since November 2003.

Representation at future UNFCCC Technical Meetings and Conference of the Parties should follow the format in place when Nigeria was chairman of G - 77 and China. Then, a Core Technical Team (CD) was established with scholars on the climate change, technology etc appointed as Scientific Advisers on merit. Nigeria must find money to ensure active participation of experts at all meetings and COPS.

Nigeria should carry out studies on political, economic and environmental strategies of the USA and other G – 8 ANNEX 1 countries, which proposed the protocol but is currently its foremost "antagonist".

Research and Predictions

Nigeria in the 21st century, the way forward requires urgent need for the more effective coordinated national climate programmes and management policies. In particular for effective support of the world climate programmes and its associated activities, and for effectively carrying out other climate and climate related activities including those related to the promotion of climate services for sustainable development. It is necessary for the country to establish and strengthen national climate programmes and national committees. Such national climate programmes would, for example more easily promote activities related to climate monitoring and observational networks, education and training, capacity building, climate change research and development of models, technology transfer and adaptation of technology, development and implementation of impact assessments, improved climate information service and public awareness of application of climate information. National climate programmes would also facilitate co-

operation, collaboration and coordination at all levels especially with tertiary institutions.

The Nigeria Meteorological Agency, (NIMET) should as a matter of urgency, initiate action to collaborate with the National Space Research and Development Agency (NASRDA) of the Federal Ministry of Science and Technology and National Climate Change Centre - a linkage programme of the Federal Ministry of Environment, which is Nigeria's focal point for all UNFCCC activities. Through these, the much needed collaboration with external (African) climate study centres will be possible.

It is no doubt significant for Nigeria to continue to support the WCP and its four components. It is also significant to support the requirement of the UNFCCC, the implementation of Agenda 21 and the work of IPCC. In addition, it is essential to strengthen the links of climate related activities of other programmes such as IGBP. All these would be better promoted with the establishment of national climate programmes.

Dedication Systematic Observations

As highlighted above, the Nigerian Meteorological Agency, which recently replaced the old Nigeria Meteorological Services, weather charts were data void because though observations were recorded, they were not transmitted to the Central Forecast Office (CFO).

Today, the story is a most encouraging one, but the time to redouble efforts in sustaining such enviable standard is now with NIMET given total authority as an autonomous agency.

To a large extent, the WMO (through UNDP assistance) has been the major source of funds for several National meteorological and Hydrological services (NMHS) in Africa (including Nigeria), to maintain their facilities and introduce new technologies. In view of diminished level of assistance by voluntary donors to the organisation in recent years, a major constraint that would greatly affect the performance and development of the Nigerian Meteorological Agency in coming years would be the lack of external

assistance to supplement national efforts. In this regards, it is necessary for Nigeria to spare no effort in looking into the possibility of improving its traditional low funding for meteorological activities, which is capital intensive In this regard, it is significant for example that Nigerian Meteorological Agency quickly metamorphosed into a virile and autonomous parastatal as obtains in most countries of the world, which to a large extent would be self - supporting financially. For example, the United States spends an average of US$5 billion annually on just climate change research alone since 1999 to date.

Commitment on GHG Emission Reduction

While Nigeria affirms the sovereign right of all nations, it may be difficult to convince the developing countries to undertake any official voluntary commitments towards implementations of the conventions or the protocol, which was neither provided for in the convention nor protocol. There must be leadership by example on the Annex 1 parties to the implementation on both the convention and the protocol will dictate whether the developing country parties will take official commitment or note in the future.

A credible accounting system is to be used for monitoring "carbon credits" in order that real commitment to reduction of GHG emission can not be compromised by Annex I (industrialised) country partners.

From the foregoing, Nigeria owes it a scarce obligation to the citizenry to be a full partner in the climate change process. The convention sets as its optimum objective, the stabilisation of atmospheric concentration of GHG's at safe levels, which must be attained within a time frame sufficient to allow the ecosystem adapt to climate change, ensure that funds production is not threatened and to enable economic development to proceed in a sustainable manner. In order to achieve these objectives, parties have a general commitment to address climate change, adapt to its effects and report on the actions they are taking to implement the convention.

Creation of Programmes for Education and Awareness

Article 6 of the UNFCCC is unequivocal regarding the importance of education, training and awareness creation in the implementation of the convention. The article requires parties to the convention to promote and facilitate the development and implementation of educational and public awareness programmes on climate change and its impacts. This is in recognition of the fact that a larger percentage of people in the developing countries have little or no knowledge about climate change and the magnitude of its impacts. Education, training and awareness raising should constitute an integral part of the implementation of the convention.

In general, the public information and education programmes would;

(a) Promote awareness and knowledge of climate change issues

(b) Provide guidance for positive practices to limit and/ or adopt to climate change.

(c) Encourage wide participation of all population sectors in addressing climate change issues and developing appropriate adaptation strategies.

A number of national and international actions are necessary for dissemination information on climate change. For example, it would be necessary for national committees to collate, develop and disseminate educational materials on climate change issues.

These committees would serve as focal points for information gathering and dissemination. At the tertiary education level, efforts shall be geared towards the inclusion of the subject of climate in the general studies programmes. In this regard, institutions, which already have programmes on climate, shall be encouraged to strengthen such courses by providing for deeper focus on climate change. Topics on climate change shall be included in subjects such as social studies and geography at the secondary school level. At the same time,

secondary schools shall be actively encouraged to form Nature Clubs and Conservation Societies and embark on environmental awareness campaigns. Similarly, in primary schools the syllabus should be expanded to include topics on climate change and impacts. The pupils can also engage in environmental sensitisation activities including excursions.

Among the items to be included for instruction at various educational levels are the following;

(a) Nature of weather and climate

(b) Role of weather and climate in human affairs

(c) Nature of climate change

(d) Hazards and general effects of climate change

(e) Adaptation and adjustment to climate change

For the public at large, seminars, workshops and informal discussions will be organised towards enlightenment and awareness creation. Information, educational and communication (IEC) materials such as posters, leaflets, stickers and face caps shall be developed for education. The Federal Ministry of Environment Abuja, publishes a magazine titled "Environment News". This media needs to be encouraged to focus more on climate change issues. The Daily Trust publishes environment news every Thursday. Other Nigerian newspapers should also be encouraged to provide a page or two for climate change issues. It is necessary also that policy makers shall be adequately sensitised and made knowledgeable about climate change issues in Nigeria.

Taking all the above points into proper perspective, the condition is now right for Nigeria to participate fully in Kyoto protocol on climate change.

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