



**HEINRICH BÖLL STIFTUNG  
NIGERIA**

# **Adaptation Strategies of Action for Nigeria**

**A working document prepared for the Special Climate Change Unit of the  
Federal Ministry of Environment Housing And Urban Development, Abuja**



## **HEINRICH BÖLL STIFTUNG NIGERIA**

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## PREFACE

Considerable progress has been made in the International Negotiations on Global Climate Change. The purpose of the negotiations is to foster a unified global effort to fight a threatening enemy of our time climate change. One of the results of the efforts which re-echoed in Bali 2007 Conference is the agreement that developing countries like Nigeria begin to focus primarily on adaptation and mitigation policy strategies which this document attempts to look at with a view to facilitate a reduction in the country's vulnerability to climate change. They are expected to consider issues around technological transfer that can be useful tools in this process. For developing countries this means identifying priority interventions that can be engaged in to strengthen their economies.

This document proffers suggestions on useful ideas that can guide Nigeria's government at the three tiers, as they begin to address pertinent adaptation issues arising from recent climate negotiations. The document is a product of a desktop review of climate change impacts in Nigeria and analysis of potential adaptation actions that can be adopted. After the initial preparation, the document was reviewed by a number of experts and presented at a dissemination/stakeholder's workshop in Abuja in December 2008 for further discussions. Heinrich Boll Foundation (HBF) is of the view that this effort could help as a reference material for further research and intervention as the nation prepares a more robust adaptation plan of action. In the meantime, we hope this will serve the purpose of providing some guide or a working document to the federal and all state ministries of Environments across the country as they respond to the growing impacts of climate change in Nigeria.

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Lagos, December 2008  
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Program Manager, Economic and Ecology Literacy  
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## **EXECUTIVE SUMMARY**

This report focused on eleven different sectors in which adaptation will be crucial in Nigeria. They include water resources, agriculture, forest and forestry including deforestation, coastal areas, energy, human health, settlements, tourism, population, industries and transportation. The report also considered gender issues in adaptation. Vulnerability and Impacts of Climate Change were examined in each of the sectors, noting variations from one region to the other. It was shown that vulnerability and impacts of climate change in all the sectors derived from two groups of factors:

- The entrenched poverty in the nation and the weak socio-economic infrastructures which limit coping capacity and resilience i.e. capacity to recover from shocks; and
- Climate change and variability which are already manifesting in false start of the rainy season, increasing frequency of intervening dry spells during the growing season, rising temperatures and other extreme events. Associated with these are rising sea levels causing coastal flooding by ocean water and land bound storms from the Atlantic Ocean.

### **Vulnerability and Impacts**

Specific vulnerabilities and impacts pertaining to climate variability and climate change include declining volume of water in reservoirs and stream flows, crop failures due to frequent dry spells during growing seasons, menace of aquatic weeds, shortage of fodder and increasing conflicts between farmers and herdsmen, deforestation and desertification. The indirect vulnerabilities issues relate to the sprawling of settlements onto rural land, poor energy production, low industrial activities, poorly developed transportation system, challenges relating to human health and gender issues.

### **Adaptation Measures**

Adaptation measures that can be adopted for each of the areas were identified and analyzed in terms of

- relevance for each geopolitical zone in Nigeria,
- adjudged costs of implementing them,
- priority of adopting the options and
- the individuals and organizations who could be responsible for carrying out specific tasks.

The multi-criteria analytic procedure was used to rank the options in each sub-sector. Some of the criteria were the perceived severity of the issues that a particular option is capable of addressing as well as the sensitivity of the system to particular extreme event. In most of the cases considered, sensitivity was generally high as captured in the summary Tables. Variations were observed mostly with respect to the impact that adopting a particular option would have in adapting to extreme events.

### **Sectoral considerations**

Adaptation in water resources sectors would require focusing on small dams to optimize water storage in the various parts of the country. Biodegradable suppressants can also be used to reduce water loss through evaporation in dams as temperatures rise. More boreholes could be drilled to provide additional

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water and to recharge depleted soil water. Water conservation issues are generally more important in the drier north. The options are expensive to implement but of high relevance because they touch on the physical environment and livelihoods. Government, NGOs and communities are the most important implementers.

With respect to agriculture, crop failure can be controlled by expanding irrigation opportunities and planting hardier, high-yielding and early-maturing varieties of crops. However, new irrigation programmes should be well planned to avoid the problems that were encountered with the earlier ones such as the Southern Chad Irrigation Project (SCIP). Wetlands that are threatened in many locations can be restored by increasing artificial flooding wherever possible. Fish production can be enhanced by clearing aquatic plants that inhibit their breeding and harvesting. Challenges relating to decreasing fodder can be addressed by reducing stock through regular culling of animals, enriching rangelands and creating mutual understanding between farmers and cattle herdsman. The options are of very high relevance, can be applied in different parts of the country particularly in the drier north, and their costs can be contained in States' and national budgets.

In coastal zones, abatement of ocean flooding could be pursued. Infrastructures could be raised above the ground to prevent damages from flooding. They should also be strengthened to withstand anticipated stronger storms from the seas; and farmers would shift to planting salt-tolerant and fresh water swamp-tolerant crops. These options are crucial but the costs are very high. They should be handled by government, NGOs and oil companies.

With respect to forest and forestry, afforestation is an important option in virtually every part of the country. It is also useful in developing shelterbelts and in stabilizing sand dunes in the north to combat the southward incursion of the Sahara desert. Natural forest regeneration and protection are also important especially in the preservation of biodiversity. All of the forestry projects are best achieved by erecting fences round forest estates and by rigorous implementation of anti-logging legislation. Forestry options are very useful as they aid biodiversity preservation and have carbon sequestration potentials. Their cost is in the medium range and can be implemented by government and NGOs with the support of local communities.

In the energy sector, gas and oil are the major source of energy consumed. Hydro-electric power (HEP) is responsible for only 8%. Electricity production from hydro plants can be improved by the use of smaller turbines which require lower volume of water. Alternative sources of energy such as wind and solar should be developed to complement supply from HEP. The option can be implemented in suitable sites in the country. Energy efficiency technology should also be invested in. Those to take responsibilities are government and research institutes. The options are generally of high relevance although their costs are also very high.

To strengthen human health that will be more seriously challenged by Climate Change, more sensitization on preventive and curative medicine should be focused upon. Access to both primary and secondary health care services should be improved and health education strengthened in schools. All of these measures should be adopted in every part of the country. The options are of very high priority but their costs are also very high. Government health institutions and NGOs and the community can team up on this.

Settlements are highly vulnerable because they have been poorly developed, and impacts of disasters such as floods on them are potentially severe. They can be improved by insisting on strict compliance with Town Planning Regulations. Green belts should be established to prevent sprawling of settlements into vital rural lands and concreting of surfaces in the urban areas can be prohibited to reduce heat and run-off and enhance ground water recharge. The issues border on effecting pertinent legislations. The option is relevant in many parts of the country.

There are also potential challenges in the tourism sector which climate variability and change would amplify. The vegetation covers in many of the sites are highly susceptible to degradation due to combined effect of forest exploitation by local communities, settlement encroachment and growing number of visitors. For sustainability of the sites in the face of adverse weather conditions, it will be necessary to embark on biodiversity protection and enrichment.

Nigeria's industrial sector is still underdeveloped although large industrial concerns are found in Lagos-Kano-Kaduna-Port Harcourt axis. Some of the challenges of industries are poor power supply and weak control of importation of competitive products. Many of the industries are raw material based and are being threatened by declining supply of the materials. Poor performances in the industry reduce the potential macro-economic benefits of the sector and weaken the adaptive capability of many. Government will have to implement relevant laws on importation and among others, improve power supply to keep the few industries afloat.

The transport sector suffers from many stressors particularly the collapse of the railway system and the dominance of the road transport mode. Rapid break down of roads increases road hazards and cost of maintenance due to climate variability. For effective preparedness for more extreme climatic events, it is important to revamp the railway system, improve the road system and increase safety to air travels.

There are gender differentials in vulnerability and in the ways the impacts of climate variability and change would affect people. Women and children are generally more disadvantaged because of cultural factors. To adapt to climate change, the gender inequality in access to opportunities has to be addressed. Women need to be empowered economically to strengthen their resilience, and intervention programmes should be designed to target men and women equally with adequate attention on the special needs of children.

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Population is a major factor of the vulnerability of Nigeria to climate change. It drives the pressure on natural resources. The growing pressures are responsible for the wide spread degradation of resources in the country. This increases the potential severity of disasters. With the potential of doubling in 20 years, Nigeria's population is an important variable to control to achieve effective climate change adaptation. The National Population Policy which emphasises improved quality of life, should be vigorously pursued by government.

To implement adaptation measures, adaptation to climate change must be made an affirmative statement. Government should develop appropriate policy to create enabling environment for climate change adaptation. Resources must be mobilized from budgetary allocation and the private sector for adaptation activities. Massive sensitization campaigns are needed to provide information to everyone including men and women in the military and paramilitary formations of the potential danger of climate variability and what he/she could do to cope or adjust to the change.

Technology is a strong factor in climate change adaptation. The level of technology transfer required will be determined by the magnitude of climate change in the various parts of the country. If climates change at a very low rate, technology transfer may be little required or out rightly unnecessary. Under a scenario like this, local farmers could adjust overtime, to the new regimes in climate. On the other hand, if the change is rather rapid, the technologies required may be far beyond what is locally available. Transfer of technology will thus be required to help local communities.

As long as information flow is unimpeded and the environment is conducive, technology transfer will always take place. National Office for Technology Acquisition and Promotion (NOTAP) has been playing significant role in technology transfer in the country since it was established in 1979. The expertise of NOTAP will be needed in addressing climate change.

There are a number of barriers which can affect the process of technological transfer. Principal among these are patent and Intellectual Property Rights issues. Even if the technologies can be paid for, those factors may inhibit the transfer particularly from the developed countries. Appropriate international political instruments would need to be employed to cause the transfer of urgently needed technologies to happen. The country must also provide enabling environment for the domestication of the technologies.

To fully implement climate change adaptation programmes, the Climate Change Unit must collaborate with all other relevant ministries such as the Ministries in charge of Agriculture, Transport and Land Resources, and line agencies like NIMET, and NARSDA. A holistic approach to the management of the adaptation activities is thus needed for effectiveness.

## **1. General Background**

### **1.1. Introduction**

The controversies surrounding the possibility that the global climates may be changing and/or exhibiting significant intra- and inter-annual variability have largely been laid to rest. It is now well accepted that climates are changing and that man must of necessity live by it. The occurrences of extreme climatic events particularly flooding, excessive rise in temperatures, frequent dry spells within growing seasons (Adesina *et al.*, 2007; Mark *et al.*, 2007; Unmüßig and Cramer 2008; Nigerian Tribune, March 23, 2005 pg 24), irreversible damages to ecosystems translating, in part, to rapid expansion of the tropical deserts in the drier part of West Africa (Ayoade, 2007) among others, are strong proofs of immensely altered climatic patterns. The international response to the challenges of climate change particularly through the Intergovernmental Panel on Climate Change (IPCC), whose contributions attracted a Nobel Peace Prize in 2007, has been overwhelming. No other issue except perhaps the fight against HIV/AIDS pandemic has attracted as much global concern as climate change in recent times. Responses have included extensive analyses of the changing behaviour of world climates, assessments of the risks and vulnerability of various anthropological and physical systems, modelling of future climate scenarios and advocacies for effective mitigation and adaptation options.

One of the dominant thrusts of agreement and mandates from the various Conventions on climate change particularly the Marrakesh Accords of 2001 and the Buenos Aires Programme of Work on Adaptation and Response Measures (2004) is that developing countries be strengthened to develop and or amplify existent adaptation strategies to reduce their vulnerability to climate change. Feenstra *et al.* (1998) have articulated clauses in the United Nations Framework on Climate Change (UNFCCC) underscoring the significance of adaptation (see Box 1.1).

The emphasis on adaptation is informed by the fact that developing countries are predisposed to suffer greater impacts of climate change due to their fragile economies, exposure to many other stressors and consequently their abysmally low adaptive capacity. These countries also have weak resilience i.e. ability to recover from shocks (such as those that may come from natural disasters), due to deep rooted poverty, degraded environments among other problems (e.g. Thornton *et al.* 2006). They are thus particularly vulnerable as more frequent and severe extreme events that appear inevitable could “tip them over the edge” into more calamitous disasters (Huq and Ayers, 2007).

### **1.2 Nigeria's response to climate change**

Nigeria has been responding in various ways to the requirement of International Conventions on climate change. Such efforts include the production of Nigeria's First National Communication on Climate Change (FMEV, 2003), the on-going effort to produce Nigeria's Second National Communication and the organization of stakeholder workshops to get a “critical mass” of experts that can jump-start a

process of result-oriented response. This report represents a practical step towards an articulation of actions needed to be taken and the degree of urgency that those actions require to effectively reduce the country's vulnerability to climate change. This will also strengthen the process of achieving the Millennium Development Goals (MDGs), pursuing the Seven-Point Agenda of the present administration and realizing of the goals of Vision 2020.

**Box 1.1: Some clauses in the UNFCCC on Adaptation**

The UNFCCC includes five clauses that specifically address adaptation. These include (Feenstra *et al.* 1998):

- a. All parties ...shall formulate, implement, publish and regularly update national and ... regional programmes containing measures to mitigate climate change ... and measures to facilitate adequate adaptation to climate change (Article 4, Section 1 (b)).
- b. The parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects... To achieve this, such policies and measures should take into account different socio-economic contexts, to be comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation (Article 1, Section 3)
- c. All parties... shall incorporate in preparing for adaptation to the impacts of climate change (Article 4 Section).
- d. The developed country Parties and other developed Parties...shall also assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting the costs of those adverse effects (Article 4 Section 4)
- e. All Parties...shall take climate change considerations into account to the extent feasible, their relevant social, economic and environmental policies and actions, and employ appropriate methods. For example impact assessment, formulated and determined nationally, with a view to minimizing adverse effects on the economy on public health, and on quality of the environment of projects or measures undertaken by them to mitigate or adapt to climate change (Article 4 Section 1(f)).

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A recent meeting was the National Stakeholders Workshop on "Climate Change: Challenges and Opportunities for Economic Development in Nigeria" Abuja. 7th - 9th November 2007, organized by Federal Ministry of Environment, Housing and Urban Development, Abuja, in cooperation with the Heinrich Boell Foundation,

### **1.3 Vulnerability and Adaptation**

The literature is replete with analyses and assessments of the concepts of Vulnerability and Adaptation (Adger *et al.*, 2004; IPCC 2001; 2004; 2007; Leary *et al.*, 2008; Nyong *et al.*, 2007; 2008). In the context of guided response to the challenges of climate change, these two concepts are connected. The existence of the first i.e. vulnerability, necessitates the pursuit of the second - adaptation. Whether adaptation is in anticipation, in which it is taken before the impacts become manifest, or in reaction i.e. developed and implemented in response to subsisting impacts, it enables the reduction of vulnerability of systems or people concerned to climate change.

To put these concepts in perspective, vulnerability is the propensity of people or systems to be harmed by hazards or stresses (Leary *et al.*, 2008). It is affected by how exposed the people or systems are to hazards, their sensitivity to the exposures and their capacities to resist, cope with, exploit, recover from (resilience) and adapt to the effects. With specific reference to climate change, vulnerability is the extent to which change in climate may damage or harm a system which may be anthropogenic or physical (IPCC Second Assessment Report). Vulnerability to climate change can be aggravated by the effect of other stressors such as armed conflicts, political instability and weak implementation of socio-economic development programmes.

Adaptation simply means to adjust to a condition on which one has little or no control. In climate change parlance, it means adjustments in natural or socio-cultural/economic systems in response to actual or expected deviation of climatic parameters from established patterns or their effects. This is with the goal of reducing injuries to the system and or exploiting new opportunities (Baer *et al.*, 2007; Feenstra *et al.*, 1998; IPCC 1996).

IPCC Second Assessment Report (SAR) of Working Group II described more than two hundred types of adaptation measures that can be adopted in the various parts of the world. The choice and appropriateness of an option will be dictated by the peculiarity of the environment in which it is going to be implemented. A general understanding is that adaptation options are “win-win” or “no-regrets” pathways because they offer measurable benefits whether or not there is an adverse climate change. For example, supposing a better management system of irrigation water is developed for the semi-arid areas of Nigeria because of a prevailing water stress, its benefits would remain even if the stressor i.e. inadequate raw water become weakened by increase in rainfall in the region. Also, accelerated economic growth and improved social services would douse the vulnerability of social systems that had been incapacitated by poverty to many impacts of climate change. Delaying action or creating ill-focused adaptation agenda will only result in increased costs from climate change impacts and greater risk to humanity (Rosenberg, 1986).

The concept of Mitigation is often discussed along with adaptation. It is about actions geared towards decreasing the extent of global warming through the reduction and possibly stabilization of greenhouse gases (GHGs) in the atmosphere (UNFCCC, 1992). However, even if stabilization was achieved, sea

level rise and global warming would continue to increase over a long time to come because of the inertia of the earth systems (e.g. Nyong *et al.*, 2007), particularly, the atmosphere and the oceans. For instance, the thermal inertia of the coupled climate system rests in the upper ocean, which has a relatively slow response, while the atmosphere provides the GHGs considerable residency period. Consequently, adaptation which is about actions to minimize the vulnerability to the negative impacts of climate change has been emphasized particularly for the developing countries. However, adaptation and mitigation are sometimes interlinked. For instance, planting forests can be an adaptation strategy to assist in meeting the wood needs of communities and also serve as windbreaks. Nevertheless, trees cultivated for timber in particular, grow for upward of forty years. They are therefore an important stop gap for storing away carbon (Adesina *et al.*, 1999; Adesina, 2001) in the various ecosystems.

For the purpose of this paper, adaptation is conceptualized from three perspectives which are distilled from the literature:

- A prognosis into past or traditional practices/responses to climatic extremes;
- Contemporary practices that help to smother subsisting adverse conditions; and
- An identification of deficiencies in contemporary practices which can be rectified to make vulnerable or impacted systems to cope better with similar or exacerbated stresses in the future.

This conceptualization has the advantage that what is already known is being exploited to more effectively handle contemporary future adaptation issues.

#### **1.4. Objectives of the Study**

The overall objectives of this paper are to explore the vulnerability of Nigeria to climate change and articulate or identify strategies that can be adopted to reduce or remove outrightly, the vulnerability.

##### **1.4.1 Specific Objectives**

- i. Develop a document that can help decision makers to understand Nigeria's vulnerabilities to climate change and the need for preparedness for the impacts;
- ii. Identify relevant adaptation measures for effective climate change adaptation preparedness;
- iii. Specify the significance and potential financial implications of implementing options to facilitate prioritization of the individual adaptation strategies;
- iv. Evaluate critical issues relating to technology transfer; and
- v. Identify appropriate agent(s) that would be responsible for the implementation of the identified strategies

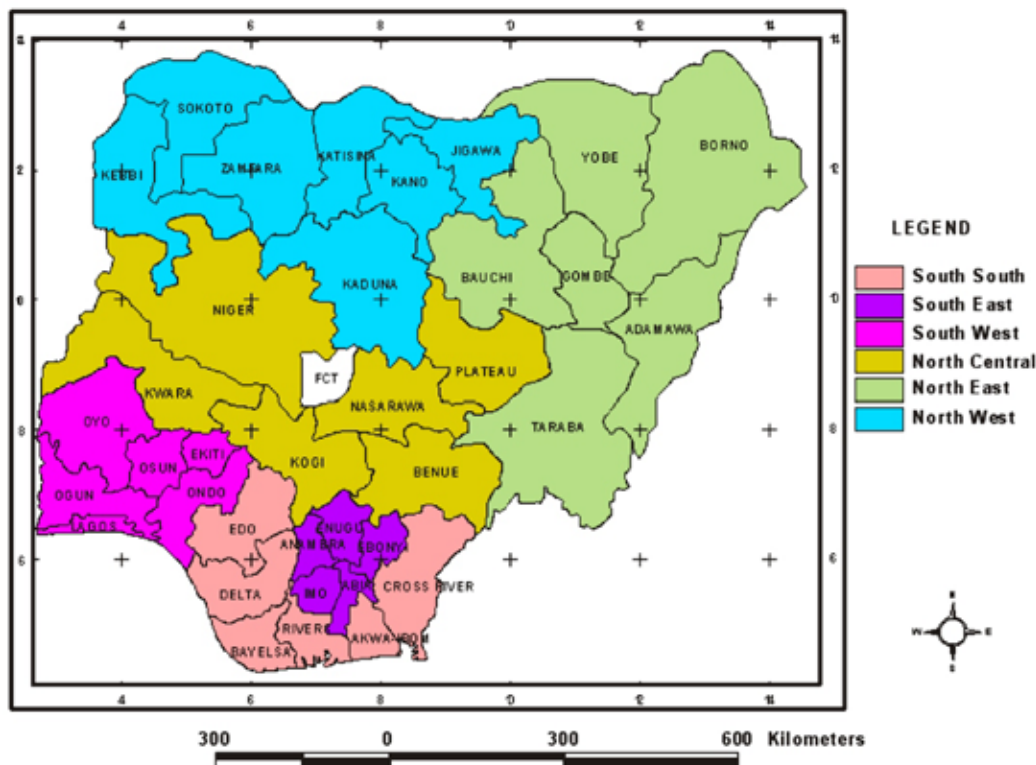
The methodology adopted involved a review and analysis of the works in the literature that deal with vulnerability and adaptation in different parts of the country. In some cases, site visits were made to confirm what was on ground.

## 2 The Nigerian Environment

### 2.1. Location and political structure

Nigeria is a key nation in West Africa. It lies approximately between latitudes 4° and 14°N and longitudes 3° and 15°E and covers a land mass of about 923,768 km<sup>2</sup>. Nigeria shares borders with the Republics of Niger and Chad in the north, the Republic of Cameroon in the east, the Atlantic Ocean in the south and the Republic of Benin in the west. By 2006, its population stood at about 140 million (NPC 2006) and ranks 151 out of 177 countries on the United Nations Human Development Index. The country is administered under a Federal system of government with a strong central government and 36 States together with a Federal Capital Territory (FCT). The states and FCT are further sub-divided into 774 Local Government Areas/Area Councils for grassroots administration. The 36 states are also grouped into six geopolitical zones mainly for political purposes. These are shown in Figure 2.1.

**Figure 2.1: Nigeria's Geopolitical Zones**



### 2.2 Climate

As in the other parts of West Africa, the climate of Nigeria is dominated by the influence of three major atmospheric phenomena, namely: the tropical maritime (mT) air mass, the tropical continental (cT) air mass and the equatorial easterlies (Ojo, 1977; Iloje, 1981). The mT air mass originates from the southern high-pressure belt located off the coast of Namibia, and in its trajectory, picks up moisture from over the Atlantic Ocean, crosses the Equator, and enters Nigeria from south-western direction. The cT

air mass originates from the high-pressure belt north of the Tropic of Cancer. It picks up little moisture en-route and is thus dry. It enters Nigeria from north-eastern direction. The two air masses meet along a slanting surface called the Intertropical Discontinuity (ITD). The equatorial easterlies are rather erratic and cool air masses which come from the east and flow in the upper atmosphere along the ITD. Occasionally however, the air mass dives, undercuts the mT or cT air mass and gives rise to line squalls or dust devils (Iloeje, 1981). Land and sea breezes are another set of air masses found in Nigeria, but because they are limited and confined to the coastal zones alone, they assume a relatively minor role in the climate of the country.

The latitudinal position of the ITD is a function of the season although there are also considerable short period fluctuations. Generally however, it is situated well to the north in July and August thereby allowing the country to be totally under the influence of mT air mass. It is located along the coastal part during January, with the effect that most of the country is covered by the cT air mass during this period. As a result, the country is subject to marked wet and dry seasons associated with the moist and dry air currents, respectively. The amount of rainfall received generally decreases from the coast inland from an annual average of more than 3000 mm in Warri on the coast to less than 500 mm in Nguru in the Sahel region of the north-east (Ojo *et al.*, 2001). However, except along the coastal region, rains are seasonal - 9 to 10 months in the south and 2 to 3 months in the north. In the southern part of the country, the wet season extends from March to October, while it is June to September in the northern part (Ojo, 1977; Iloeje, 1981). The southern two-thirds of the country is characterised by double maxima rainfall regime, while the remaining northern third is characterised by a single maximum rainfall regime. An important feature of Nigeria's rainfall that is becoming more prominent is its high intra-annual variability (Odekunle and Adejuwon 2007). This comes with hazards such as long dry spells during the growing seasons causing crop failures, and floods.

Temperatures are high through out the year except in one or two months when the dry cold north-easterly wind dominates the wind system. Temperate-like weather is experienced in the high ranges such as Obudu, Mambilla and Jos Plateaux. The monthly temperature for most locations in the south ranges between 22°C and 32°C but could be from 18°C to over 40°C in the north. As temperature is generally high and fairly uniform, rainfall amount and spread largely define the climatic zones.

### **2.3 Relief and Drainage**

Nigeria can be divided into two main relief regions: the high plateaux ranging between 300 and more than 900 metres above the sea level, and the Lowlands which are generally less than 300 metres (see Figures 2.2a & 2.2b after Iloeje, 1981). The high plateaux include the north central plateau, the eastern and north eastern highlands and the western uplands. The Lowlands comprise the Sokoto plains, the Niger-Benue trough, the Chad Basin, the interior coastal lowlands of western Nigeria, the lowlands and scarplands of south eastern Nigeria and Coastlands (Iloeje 1981). Most of the rivers that drain the country take their sources from four main hydrological centres: the north central plateau (Sokoto-Rima,

Hadejia, Gongola, and Kaduna rivers etc), the western uplands (Moshi, Awun, Ogun, Osun, Osse rivers etc), the eastern Highlands (Katsina-Ala, Donga rivers, etc.) and the Udi Plateau (Anambra, Imo and Cross rivers etc.). These drainage and relief features of the country have far reaching effects on water resources and land use potentials of the country particularly for agriculture.

## **2.4 Vegetation**

The distribution of vegetation in Nigeria follows closely that of the rainfall. This is understandable from the fact that temperatures are fairly uniform and what distinguishes one region from the other in the most part, is the amount of rainfall received. Nigeria's vegetation can be broadly grouped into two belts: forests and savannas. The forest subtypes include: Mangroves, Fresh-water swamps and High forests. The savanna subtypes are: Guinea savanna, Sudan savanna and Sahel savanna. It is important to note that relief also have some effect on the country's vegetation. A subtype distinctively associated with this feature is 'montane' vegetation.

The mangrove vegetation is restricted to the coastal strips diurnally inundated by salt water. Its soils are swampy and waterlogged. The vegetation is dominated by mangroves species especially those of *Rhizophora* some of which yield good wood for pit-props. As a result of human activities, the vegetations have now been replaced by a number of anthropic derivatives. The fresh-water swamp is found further inland where the land is free from the sea water intrusion. Although the belt is also waterlogged, the mangrove vegetation is replaced by fresh-water plant species such as raffia palm, oil palm trees (*Eleais guineensis*) and trees like *Melicia excelsa*. The high forest vegetation belt is relatively extensive, stretching from the western boundary of the country through Ibadan and Benin, across the Niger to the Oban Hills. The vegetation is made up of trees arranged in three distinct storeys - ground, middle and top storeys. The lower storey is made up of herbs and shrubs dense undergrowths 3 to 6 metres in height. The middle storey consists of heavily branched tall trees ranging between 18 to 24m in heights and having robust branches and heavy dark green foliage. The branches of the trees intertwine to form an almost continuous layer of leaves, which prevents sunlight from reaching the ground storey. The top storey is dominated by emergent trees with small crowns of pointed leaves resting on a few branches. The branches are carried by tall stems about 30 to 60 metres high. Most of these high forests have been interfered with by man, producing anthropic derivatives such as oil palm bush, banana bush and 'derived' savanna.

The Guinea Savanna belt is the single largest vegetation belt in the country, covering about half of the total land area (Iloeje, 1981). It is found largely in the middle part. This broad vegetation belt can be classified into two subtypes, namely: typical parkland savanna and derived savanna. The typical parkland savanna refers to the area of the guinea savanna where the vegetation is made up of a combination of tall grasses and some trees, which gives it its characteristic park appearance. The commonest trees here are the locust bean, shea butter, oil bean and *Isobertina*. The gallery forest is a finger-like extension of low forest into the savanna vegetation belt along river courses. 'Derived'

savanna is found on the northern fringes of the high forest belt. It is made up of tall grasses and smaller trees which are relics of the original high forest plant species. The Sudan savanna stretches from the Sokoto plains through the northern section of the high plains of the Hausaland, to the Chad Basin. The vegetation here is made up of short grasses (about 1.5 to 2 metres high) and stunted trees such as the acacia, the date palm, the silk cotton and the Baobab. The Sahel savanna vegetation belt is the northernmost vegetation belt. It is found mainly in the north-eastern corner of the country where the mean annual rainfall is about 500mm. The vegetation is made up of short and tussocky grasses (about 0.5 to 1 metre high) and tree plants such as acacia and date palms.

Montane vegetations are found on the peaks of high hills and plateaux in the country.

In general, human activities and changing climatic conditions have had profound effects on the flora as well as the physiognomy of the country's vegetation (Fonseca, 2002; Zhengyun *et al.*, 2003). An overwhelming proportion of the 4,614 vascular plants described by Hutchinson (1958) and Hepper (1965) are known to have disappeared or are at the verge of extinction. Deforestation rates in the country are some of the highest in the world with a high likelihood that all of the remaining forests may disappear in the near future (Adesina and Adejuwon 1997).

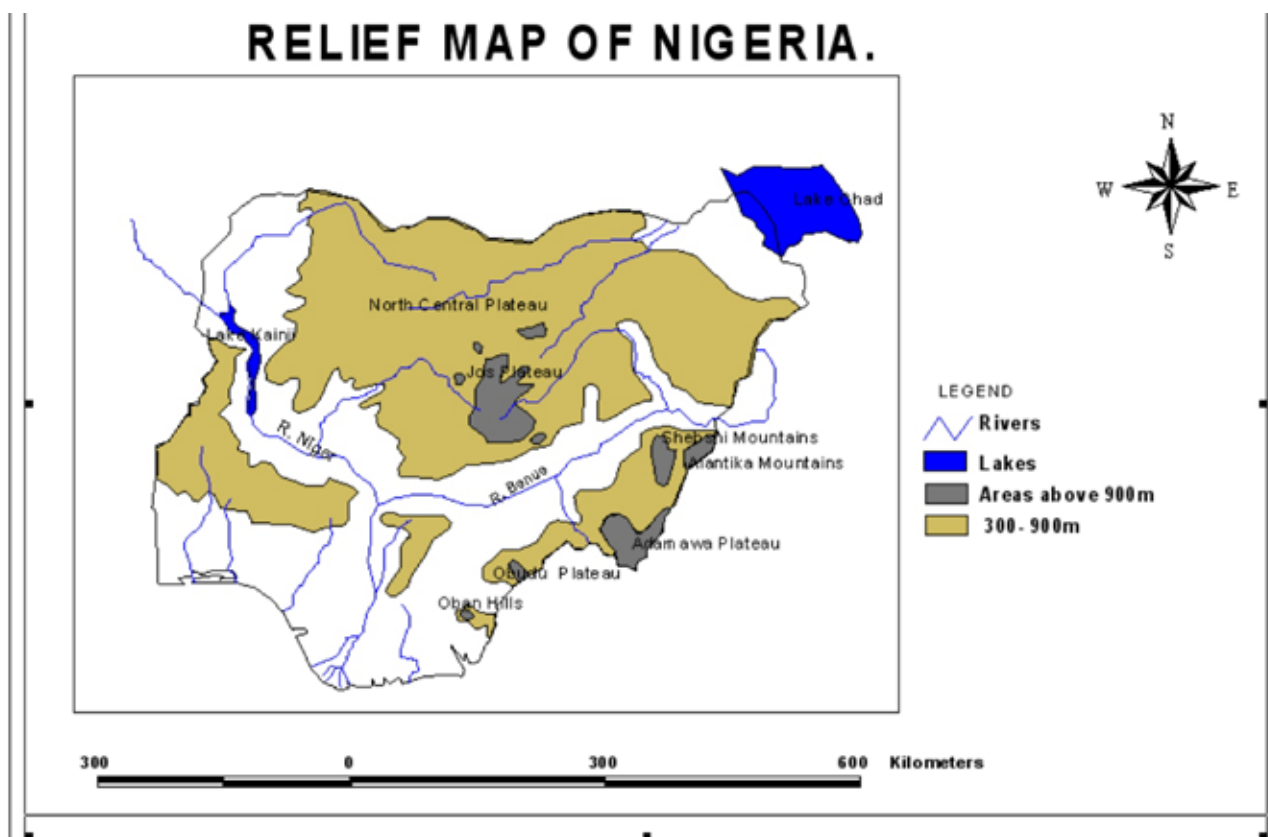


Figure 2.2a: Relief Map of Nigeria

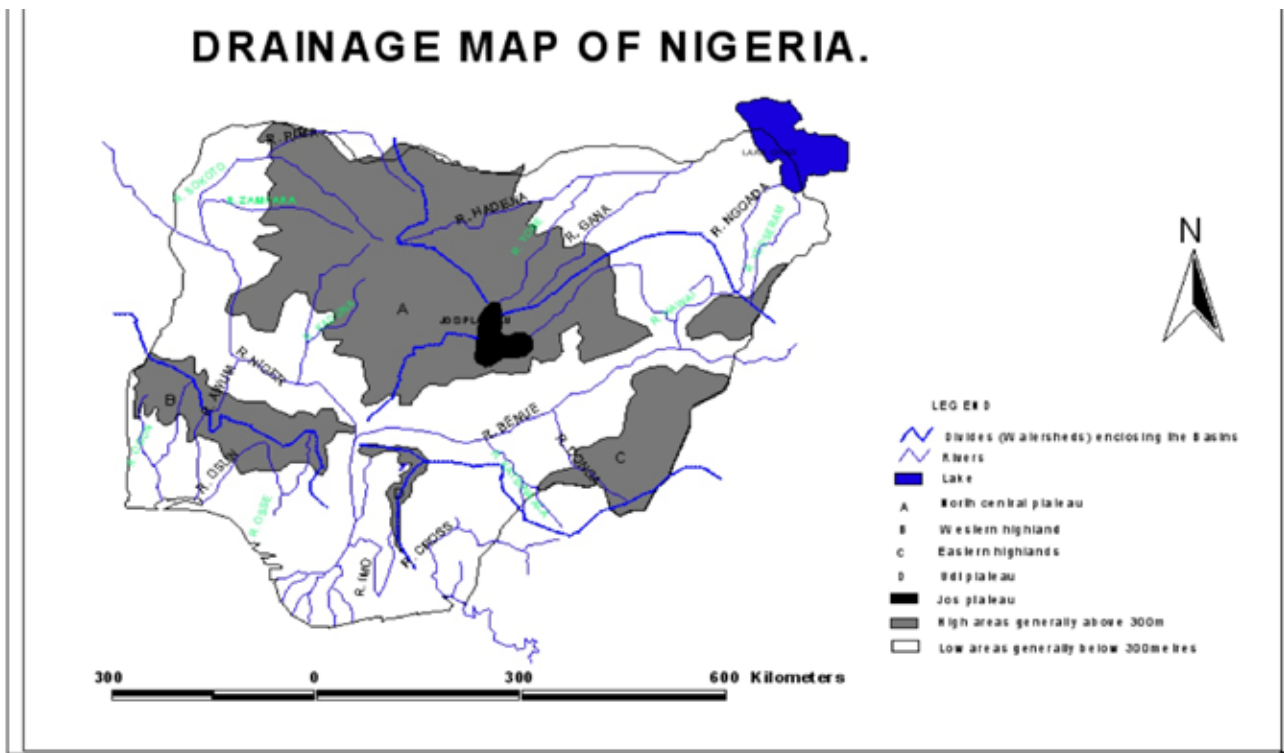


Figure 2.2b: Drainage map of Nigeria.

## 2.5 The Soil

The soil pattern in the country is determined mainly by its geology, relief and drainage as well as the climate. Four main soil groups occur in a zonal pattern from the coast inland. These are the hydromorphic and organic soils, ferrallitic soils, ferruginous tropical soils and the arid and semi-arid soils. The hydromorphic and organic soils are found in the coastal zones and azonally along the major rivers in the country. The ferrallitic soils occur in the rainforest environment mainly on sedimentary rocks. They are predominantly clayey in texture with largely undifferentiated horizons. The ferruginous tropical soils are found at the drier margins of the forest zone and more extensively in the Savanna. The soils are red or reddish in colour, rich in iron and are often low in organic matter. They are more often less permeable and more susceptible to erosion. The arid and semi-arid soils are typical of the northernmost regions with low rainfall. They developed on drift and continental sedimentary deposits and are mainly found in the Lake Chad Basin area.

## 2.6 The Economy

The Nigerian economy is dominated by the oil sector which fetches more than 90% of the country's foreign exchange but with little real impacts on the vast majority of the people. The agricultural sector which once occupied a dominant position has been forced to a poor second position and Nigeria now imports a substantial proportion of its food. As there is little or no feedback of the oil sector on the population, most people are poor. Linkages between various sectors of the economy are weak and unemployment is high. For example the poor development of the nations' energy sector is keeping huge industrial establishments in the Lagos, Kaduna and Kano industrial axes out of business. Although the private sector is not so visible, it plays a dominant role in the nation's economy in terms of employment generation.

### **3. Sectoral and Regional Vulnerability and Adaptation Response**

#### **3.1 Introduction**

This Chapter explores the vulnerability issues from one sector to the other as they affect the nation in general and the different parts of the country in specific terms. It also discusses the adaptation responses that are relevant, prioritizes, identifies who should be responsible and describes the financial implication of adopting a particular option. A summary of these discussions for ease of reference are presented in Tables 3.4 to 3.9. The criteria for prioritizing are the perceived severity of the issue that a particular option is capable of addressing as well as the sensitivity of the system to the particular extreme event. In most of the cases considered, sensitivity was generally high as captured in the summary Tables. Variations are observed mostly with respect to the impact that adopting a particular option would have in adapting to extreme events. Priority of a measure is scaled as low, high or very high depending on how much contribution that option could make to socio-economic well-being of the people. The rating of financial implication is based on our understanding from previous experiences, of how much the implementation of a particular option may require rather than on some set of calculations.

#### **3.2 Water Resources**

##### **3.2.1 Vulnerability and Impact factor**

Despite her vast fresh water resources which is in excess of 20 million hectares i.e. with associated floodplains for rivers (see Table 3.1), Nigeria is highly vulnerable in the area of water supply for domestic and agricultural purposes as well as biodiversity maintenance in all its regions. The vulnerability is associated with four different factors.

- a. Poor water redistribution infrastructure which impedes the use of large volumes of water held back in reservoirs in the country for irrigation. There are vast areas of farmlands which are currently being underutilized due to poor access to water.
- b. Pollution of fresh water sources through dumping of industrial and domestic effluents into them. Pollution also comes from oil spillages due to ruptured pipes and accidental tipping by fuel tankers. Industrial effluents which end up in drainage systems in areas such as Lagos, Onitsha, Port Harcourt and Kaduna, also cause significant water pollution. The isolated industries in different parts of the country are not excluded. For instance, many breweries, in order to avoid the cost of treating effluents, release their effluents into the local drainage systems. Effluents also come from domestic sources and many communities in the Niger Delta have suffered from oil spillages at one time or the other.

Pollution impacts water availability heavily. It degrades water quality thereby increasing the cost of purifying water for consumption. It also destroys many aquatic plants and animals and makes the fish and shrimps harvested from the water body unsafe for consumption.

- c. This relates to climate variability and change. With respect to these, there are three features of critical concern:
- i. Increasing high rate of water loss via evaporation from water surfaces as temperature increases. High evaporation rates not only reduces available water but also increases the toxicity of the water that can be accessed;
  - ii. Diminishing in-flow of water into dams due to lengthening of dry seasons particularly in the northern part of the country (Mark *et al.*, 2007; Nyong *et al.*, 2008); Low flows into the dams are amplified by water diversion for rudimentary irrigation activities.

**Table 3.1: Surface Area of major water bodies in Nigeria**

<u>Lakes</u>	<u>Surface Area (ha)</u>
Lake Chad (Nigerian sector)	550000.00
Kainji Lake	127000.00
Total Lake	677000.00
<u>Rivers (and Flood plains)</u>	
Anambra River	1401000.00
Benue River	129 000.00
(Flood plain)	(181 000.00)
Cross river	3900000.00
Imo River	910 000.00
(Flood Plain)	(27000.00)
Kwa Iboe River	500200.00
(Flood Plain)	(7000.00)
Niger River (less Kainji & Jebba Lakes)	169 810.18
(Flood plain)	(300,000.00)
Ogun river	2 237 00.00
Osun River	1 565 00.00
Total Rivers	10812410.18
Total Flood plains	515,000.00
<u>Ponds</u>	
Fish Ponds	5 476.06
Flood Ponds	1650.00
Cattle Ponds	638.50
Total Ponds	7 764.56
Misc. stagnant pools of seasonal rivers	200,000.00
Misc. reservoirs	275 534.91
Burrow pits	2.00
Mining paddocks	106.00
<u>Grand Total</u>	20,086,792.39

- iii. More frequent flooding around major dams particularly in Kano, Niger, Kwara, Kogi and Kebbi States (e.g. Aminu-Kano, 1996). Flooding around small dams has also become common in the various parts of the country e.g. Ojirami in Edo state (Ogbeide, 2003) and Eko Inde in Osun State. The spate of flooding is due to heavy (though scattered) rains which generate large amount of runoff beyond what most dams are equipped to hold.

d. The fourth factor is the prevalence of aquatic weeds particularly water hyacinth (*Eichhornia crassipes*), lettuce (*Pistia stratiodes*) and typha (*Typha latifolia*) among others, on drainage channels and lakes. The weeds contribute to water loss through transpiration, inhibit fish breeding and harvest as well as boat navigation.

The poor state of the water resources sector has had serious impacts on human health, and socio-economic activities. These could get worse if the current climatic variability become more pronounced without appropriate preparedness in place. In many parts of Northern Nigeria, fresh water fish production has been on the decline as known fishing sites become less favourable for fish growth and development (Welcomme, 2003). Hydro-electric power (HEP) generation across the nation often suffer from low flow of water into the dams. The production of HEP from Kainji, Shiroro and Guarara which are major dams in the country developed for that purpose, has frequently fallen below desirable levels. This is traceable in part, to reduced flows into the dams. Water transportation along inland channels has also been negatively impacted by climate-related factors. Low flows stall movements of boats and can be very bad in the dry season when some channels dry up completely.

### **3.2.2 Adaptation strategies**

To contain the challenges in the water sector, a number of adaptation options can be adopted. These are presented with explanations below

3.2.2.1 At the national and regional levels, attention should focus on small to medium sized reservoirs to reduce water loss due to evaporation.

Evaporation is a significant factor of water balance and is strongly influenced by many climatic parameters particularly temperature. In general, the higher the temperature, the greater the evaporation rate (Ojo *et al.*, 2001). Evaporation rates are also directly affected by the surface area over which they take place (Sellers, 1965). Larger surfaces support dis-proportionally larger volume of evaporation.

Water loss can also be controlled by guided future choices of dam sizes. The strategy focuses on the development of small to medium sized dams with limited surface areas. Examples of such dams in Jigawa State are Dambo, Ayuba, Warwade, Birnin Kudu and Kafin Gana dams. Many of the notable water schemes are supported by large dams such as Kainji, Chalawa, Tiga and Bakolori (World Commission on Dams Report, 2000) which are losing large volumes of water daily due to evaporation.

The financial demand of implementing small to medium sized dams is in the medium range but the measure is less relevant except in areas where new water schemes are on the drawing board. It is for example of low priority in the North West and North central zones which have some of the largest water dams in the country. Of course, there is a concern that the regimes of more than 60% of the world's rivers have been badly impacted by dams built on them (WCD, 2000), well managed water schemes can still deliver high productivity and a good measure of sustainable development.

#### **3.2.2.2. Use of suppressants**

Evaporation can be suppressed by using biodegradable suppressants such as hexadecanal (Adeniji, 2007; Craig *et al.*, 2005) which when applied, spreads like a thin film over the water surface. This approach is capable of reducing evaporation by up to 40%. The use of the method is not expensive but most applicable where the water surface is not too large as suppressants solidify relatively quickly when applied. It has been very well used in paddy rice farming in the Philippines and can be used in paddy rice in the various parts of the country as well as on threatened relatively small dams. It is of high priority in the Sahel.

#### **3.2.2.3. Replacement of furrow irrigation with Drip irrigation**

Many irrigation schemes in the country supply water to crop fields in open channels i.e. furrow irrigation. While this is cheap and quite flexible at the level of field operations, it is a cause of large water losses to the soil through infiltration and more significantly to the atmosphere through evaporation. Adapting to new levels of water availability will require that such water losses are controlled through some more effective irrigation methods such as drip irrigation. If properly designed, drip irrigation causes practically no water losses to runoff, percolation, or evaporation. It also lessens water contact with the above-ground parts of the crop, thus making conditions less favorable for the onset of diseases. Irrigation scheduling can also be managed to meet crop demands, thus obtaining higher yield and quality (Shock, 2006). Of course, drip irrigation requires more capital outlay but provides correspondingly high yield per unit of land.



Plate 3:1 Characteristic open channel irrigation in dry lands of Nigeria.

This option is useful everywhere but particularly in the drier north. Its financial implication is in the high range but is of very high priority.

#### **3.2.2.4 Enhancement of water storage in dams and protection of land areas around them.**

Reservoirs and natural lakes can be made more efficient in terms of the volume of water they hold. For instance Oguta Lake in Imo State is known to be degrading because of deforestation of the catchment and gully erosion that is depositing silting materials into the lake. Similarly, the banks of the small dam in Onitsha, Anambra State, are ravaged by gully erosion.

Three issues would need to be addressed in adopting this option: protection of areas drained by streams or rivulets that empty into the lakes; raising and or reinforcing the banks of reservoirs; and de-siltation of the reservoirs. The synergy of the three will increase the volume of water held in the lakes. Bank enhancement may involve physical elevation of the banks; de-siltation, dredging and basin protection through re-vegetation and control of farming activities in critical areas.

The option is applicable in the different parts of the country. For example, it will be needed in the coastal areas especially in the Niger Delta where intrusion of salt water may threaten pockets of fresh small water treatment sites and fish ponds located in the area. It will also be useful in the north where excess rains frequently cause areas around the dams to experience floods. The costs of executing these projects vary depending on location and size of dams/ water treatment sites in terms of technological

requirements and loss of aquatic organisms especially fish and shrimps during de-siltation. The priorities of the measures also vary across the country.

#### **3.2.2.5 Drilling of boreholes and wells**

Boreholes and deep wells facilitate access to subterranean water deposits for use in many areas where there will otherwise be water stress. Although the sizes of aquifers are not well known, it is believed that large deposit of water exists underground that can be tapped in most parts of the country except in parts of south-eastern Nigeria where the weathered mantle is thick and very poor in water retention. As a climate change adaptation project, the drilling of boreholes and deep wells will provide additional sources of clean and safe water for multi-purposes. Although boreholes are expensive to drill, they are dependable even in periods of extreme droughts when they are located on rich aquifers. The option is relevant in many parts of the country where the requisite conditions are favourable and the areas poorly served by reservoirs or where surface water has been highly polluted.

#### **3.2.2.6 Protection of water Bodies from pollutants**

One of the challenges of water availability in urban and industrial areas is pollution. Appropriate authorities particularly the State Environmental Protection Agency (SEPA), and the local communities need to ensure that industries dispose their effluents safely (with evidences). There must also be more attention on to sanitation in order to minimize or prevent disposal of household wastes into water sources that may be consumed. Oil prospecting companies must also revise their procedures and protocols to minimize accidental spillages of oil into water bodies. The measure is applicable in all parts of the country. Its cost is low but of high priority in industrialized areas. It requires implementing existing legislation on the environment.

#### **3.2.2.7 Cropping of improved breeds of fish and removal of threatening aquatic weeds.**

Cropping hardier varieties of fish is inevitable if fishery is to be made more efficient in the face of progressively drier conditions. This will require input from fish breeders in research institutes. It will also demand a survey of existing hardier species from which selections can be made to improve fish production.

#### **3.2.2.8 Clearing of water weeds**

Fish production is also constrained by the menace of water weeds particularly water hyacinth, lettuce and typha. Regular clearing of these weeds is important to enhance fish breeding and harvest. The weeds can be removed by manual, mechanical, chemical, or biological methods. Biological control with insects and the use of mycoherbicides (de Jong and de Voogd, 2003) has great prospects. However, mechanical controls are preferred because they produce less damage to the environment compared with chemical control methods. The cost implication is in the medium range and the adaptation option is relevant along river channels and lakes as well as the lagoons. The responsibility of doing this is with Government and the various communities.