CLIMATE CHANGE AND CROP VULNERABILITY IN NIGERIA

Kalu B.A. ¹ and Egbe O.M. ²

¹Department of Plant Breeding and Seed Science, University of Agriculture, Makurdi
²Department of Crop Production, University of Agriculture, Makurdi
P.M.B. 2373, Benue State, Nigeria.

ABSTRACT

In Nigeria, food insecurity remains problematic due to dislocations in the agricultural productivity pathways. Food preferences and utilization patterns are skewed in favor of crop-based staples, which availability in quantity and quality, depend on the aggregate crop output. Unfavorable environmental conditions such as caused by climate change would create some level of vulnerability of the crops and thus have implication on food security. Two components of the Agricultural Value Chain, production and storage, appear to be most responsive to changes in environments with production being the most vulnerable since all the activities involved in the process of production occur in the fields and are weather-dependent. Climate change – directed irregularities or deviation from the normal seasonal patterns such as onset and duration of wet and dry periods, short and prolonged dry spells clearly manifest in various levels of crop vulnerability. It would therefore appear that a sustainable crop-based agricultural system can only be achieved where crop vulnerability is considerably minimized. If climate change effects can be incorporated in the design and implementation of national development programs right away, it will help to reduce vulnerability, stabilize food production and better secure livelihoods.

The ecosystem approach with crop rotations, bioorganic fertilizers (e.g., from legumes) and biological pest controls, improves soil health and water retention, increases fertile top soil, reduces soil erosion and maintains productivity over the long term.

Key words: vulnerability, climate change, crop productivity.

INTRODUCTION.

Agriculture and the Value Chain.

Agriculture is understood as all the productive occupation of man that mobilize various forms of resources (natural human and material) to produce or provide food fiber and other forms of raw materials and their transformation into various utilizable or consumable forms. This may be explained in the context of the agricultural value chain which involves the components of production, processing, storage and marketing (Fig.1). The separate or the sequences of combined activities involved in the components generate outputs of value. Production is a critical “take off” base or “kick starter” of the value chain especially in crop agriculture, as its quantum outputs and supplies per unit time determine the quantitative input requirements of the other components. Storage has its peculiar constraints as substantial supplies from the production components could be lost due to biodegradation or pest complexes while in storage before or after processing or marketing.

The two components- production and storage appear to be most responsive to changes in environments with production being the most vulnerable since all the activities involved in the process of production occur in the fields and are weather dependent. It would therefore appear that a sustainable crop-based agricultural system can only be achieved where crop vulnerability is considerably minimized.

Crop Vulnerability and Food Security.

In Nigeria, food insecurity remains problematic due to dislocations in the agricultural productivity pathways. Food preferences and utilization patterns are skewed in favor of crop-based staples, which availability in quantity and quality, depend on the aggregate crop output. Unfavorable environmental conditions such as caused by climate change would create some level of vulnerability of the crops and thus have implication on food security. Good knowledge and understanding of the crop as a system and its responses to the environmental history in relation
to climate change would be of immense help in the
development of strategic options for reducing crop
vulnerability. The objective of this paper therefore
seeks to provide that understanding. The paper
specifically seeks to:
• discuss climate change, its realities and
predictions in Nigeria
• discuss vulnerability of crop agriculture in
Nigeria to climate change and its
implications for food security
• enumerate opportunities available for
development of adaptive capacity of
Nigerian crop agriculture to climate change
to ensure food security.
• point out constraints to development of
adaptive capacity/mitigation mechanisms of
crop agriculture to climate change.
• make recommendations.

METHODOLOGY:
The methodology adopted in this paper is
extensive review of literature on climate change,
its influences on crop agriculture, adaptive/mitigation mechanisms, the authors’
experiences in the field and their reasoned guesses
in this rather novel area of agricultural research in
Nigeria.

Figure 1: Schematic Presentation of Agricultural Value Chain
Fig 2 Schematic presentation of the sequential consequences of deforestation leading to crop failure.
Source: Adapted from Okigbo (1991) and modified from Goodland and Irwin (1975).
Fig. 3 Relationships between vegetation removal by deforestation and burning and crop failure
Source: Adapted from Okigbo (1991) and modified from Goodland and Irwin (1975).
DISCUSSION
Climate Change: realities and predictions.
The shrinking size and water-holding capacity of Lake Chad, ravaging floods in both north and south of the country occasioned by severe storms and erratic rainfall, desertification and prolonged dry season with high temperatures in most parts of Nigeria, may be warning signs of the reality of climate change. Agriculture is highly sensitive to climate variability and weather extremes, such as droughts, floods and severe storms. The forces that shape our climate are also critical to farm productivity. Changes in rainfall can affect soil erosion rates and soil moisture, both of which are important for crop yields. The IPCC (Intergovernmental Panel on Climate Change) predicts that precipitation will increase in high latitudes, and decrease in most subtropical land regions-some as much as about 20 per cent. While regional precipitation will vary, the number of extreme precipitation events is predicted to increase (IPCC, 2007).

At increasing atmospheric concentrations, greenhouse gases are projected to raise the average world temperature, lead to a rise in sea levels and change seasonal and geographic precipitation patterns. These changes are expected to severely impact agriculture, ecosystems, water resources, coastal areas and human health (Santhaye and Ravindranath, 1998). The IPCC’s Fourth Assessment Report summary for Africa describes a trend of warming at a rate faster than the global average, and increasing aridity. Key attributes of the IPCC’s Fourth Assessment Report for Africa, sourced from Christensen et al. (2007) highlighted, among other things, the following:

- Warming is very likely to be larger than the global annual mean warming throughout the continent of Africa and in all seasons, with drier subtropical regions warming more than the moist tropics
- It is unclear how rainfall in the Sahel, Guinea Coast and southern Sahara will evolve

Major contributory factors to climate change in Nigeria
The Tide Online Newspaper of 18th January, 2011 noted that there was massive deforestation going on in Nigeria, and that deforestation was the next thing that came to mind after gas flaring whenever the issue of climate change is mentioned in Nigeria. Deforestation, poses a lot of danger in that, the forest acts as carbon sink so when the forest is destroyed, the carbon in there is released into the atmosphere. The report further stated that deforestation and gas flaring were the major contributors to carbon emission in Nigeria, and regrettably, the laws protecting the forests in Nigeria have weak mechanisms of enforcement.

Climate change: A Global Concern
Climate change is posing undisputed challenges in all sectors of human endeavor. The general consensus is that greenhouse gas (G.H.G) emissions account for the highest percentage variability in climate change, with clearly devastating effect on water supply, agriculture (crops, animals, forestry, fisheries), transport and health with agriculture exhibiting the highest vulnerability.(Grain, 2010; IPCC, 2007; Margulls, 2010). Several countries of the world have peculiarities on the effects of climate change on their diverse sectors of national livelihoods. Most of these countries are developing adaptation and mitigation strategic plans on immediate to short-term to long-term basis.(Agoumi, 2003) Some have attempted to characterize the nature of the effects of climate change for the purpose of identifying the most vulnerable sectors and the patterns of vulnerability for determining the forms of adaptation and mitigation measures (Rudd, 2010).

Climate Change: Some Forms and Consequences
The realities, forms and consequences of climate change remain undisputed. Some of the characteristics of climate change and the associated consequences are highlighted in Table 1.
Table 1: Forms, characteristics and consequences of climate change

| Forms/Characteristics | Consequences |
|-----------------------|--------------|
| 1. Increasing green house gas emissions and global annual temperautre at 2°C above pre-industrial levels in 2050 (Margulls, 2010). |
| Rise in sea levels; changes in seasonal and geographic precipitation patterns, characterized by more intensive rainfall, more frequent floods, droughts and heat waves. |
| 2. Trends of warming in Africa likely at a rate faster than the global average (IPCC, 2007). |
| Ecosystem dislocation with high vulnerability in crop agriculture and water resources (Santhaye and Ravindranath, 1998). |
| High temperature may be beyond the range of tolerance for current crop varieties and cultivars (Adejynwo, 2006). |
| 3. Precipitation increases in high altitudes and decreases in most sub-tropical regions as much as 20% (IPCC, 2007). |
| Erosion is exacerbated. |
| Flooding at low-lying areas become more vulnerable to inundation from sea level. |
| Damages to settlements and infrastructure (Rudd, 2010). |
| Rapid rate of organic matter decomposition. |
| Reduced crop growth (Agoumi, 2003). |
| Reduced crop growth and may lead to crop failures (Kalu, 2008; Odo, 1999). |
| Distorted rainfall pattern. |
| Drying up of streams. |
| Hot and humid environment within the forest eco-systems with high vulnerability exhibited by vegetable crops, spices, root and tuber crops. |
| Loss of genetic diversity. |
| Water logging and salinisation of irrigate lands. |
| More frequent drought, erosion and floods |
| Increased carbon dioxide emission |
| Retarded regeneration and crop failure |
| Accelerated desert encroachment |
| Sequential and cyclic impacts are presented in Figures 1 & 2. |
| Multiple stresses on the biophysical, social and institutional environment underpin crop production. |
| Weakening of economics livelihoods and food security (Smith and Barchiesi, 2009). |
| Secondary stresses leading to pest and disease complexes |
| Increased competition for resources and degeneration of regional and ecotypic biodiversity. |
| High vulnerability in crops |
| Disastrous impacts on artesanal fishing, wildlife species and forest products. |

Climate Change and Nigerian Agriculture

Agro-ecological delineation.

Nigeria is delineated into distinct agro-ecological zones (Kowal and Knabe, 1972). The major zones are the Rain forest in the southern parts, the Guinea savanna in the central and northern parts, and the Sahel in the extreme northern parts. Each zone is characterized by distinct and often overlapping ecological features typified by patterns of vegetation, soil types and land formation, rainfall, temperature, relative humidity, solar radiation which interplay in various forms to determine crop adaptation, biodiversity forms, demographic features and consequently the farming system of the areas.

Seasons and crop vulnerability

Agricultural activities in Nigeria are governed by two distinct seasons of the year, namely the rainy (wet or growing) season and the dry season with ecological variation in the onset and cessation of each. The southern ecologies are generally characterized by long rainy periods of about eight months (March to end of October) and short dry period of about four months (November to February), while the northern ecologies are generally marked by short rainy periods of 5-6 (May/June to October) and longer dry periods of 6-7 months (October/November to April/May/June). Nigerian agriculture is known to be 90% rain-fed. Irrigated agriculture (with vast potential) is scantly and is mainly located in the northern parts of the country, producing mainly vegetable crops. Water supply therefore is a critical factor of the overall crop productivity. Annual crops (for example) must complete their life cycles within the period of the growing season. It would therefore be bad for a plant to flower so late in the season that the fruit and seed development could not be completed before the
onset of the dry season. In the same way, biennial plants need to have sufficiently developed underground storage organs during the wet season to enable them endure the dry periods and continue growth and production in the succeeding year. Similarly, perennial plants possess some mechanisms for timing of their dormant periods and must flower at an appropriate time of the season of the year for fruit and seed development (Bidwell, 1974). Climate change – directed season of the year for fruit and seed development and must flower at an appropriate time of the season of the year for fruit and seed development and must flower at an appropriate time of the season of the year for fruit and seed development and must flower at an appropriate time of the season of the year for fruit and seed development and must flower at an appropriate time of the season of the year for fruit and seed development. The separate or combined effects of these determine the degree of vulnerability of the crop under an eco-typic environment.

Vulnerability Rating of Some Selected Crops
From the fore going, it would appear that the major contributors to crop vulnerability due to changing environment are drought, flooding, erosion, pests and diseases. The vulnerability rating of some selected crops based on these and the possible sources of the response patterns are presented in matrix (Table2)

Table 2: Vulnerability rating of some selected crops on a scale of 1-5 (1-least vulnerable, 5-most vulnerable).

| Crops | Drought Due to extended dry spells during a growing season | Due to early cessation of rain | Flood/water logging | Erosion | Pest and diseases |
|-------|----------------------------------------------------------|-------------------------------|---------------------|---------|------------------|
| Legume: | | | | | |
| 1. Cowpea | Overall vulnerability rating = 3, due to: Low germination per cent under dry soil. Partial to permanent wilting at the vegetative stage. Flower abortion due to high temperature. Most vulnerable at flowering and podding stages. | Overall vulnerability rating = 3 due to: Physiological distortions resulting in poor pod filling. Premature senescence and immature seeds in pods. Cowpeas being relatively drought tolerant low vulnerability may occur if residual moisture can support pod maturity. | Overall vulnerability rating = 4 due to: Submerging of stands. Cowpeas not tolerant to water logging. Desiccation of roots and foliage leading to symptoms similar to drought conditions. | Overall vulnerability rating = 4 due to: Washing away of stands. Exposure of root system to sun and death of stands. Deposits and accumulation of sand and debris Vulnerable during the entire growth period. | Overall vulnerability rating is 5 due to: Extensive defoliation by insect pests. Extensive damage to cowpea flowers and pods. Most vulnerable from flower through podding stages. New insect pest and disease organisms may evolve with changing climate and may even be more devastating. |
| Mitigation /adaptation options | Intensive breeding research to incorporate more drought tolerant genes into existing lines. Use drought –tolerant varieties where available. Development of cropping systems through research to accommodate new genotypes. | Avoid planting in flood prone areas. | Overall vulnerability rating = 4 due to: Submerging of seedlings for more than 48 hours can lead to complete crop loss. Complete defoliation, root rot and death if flood in ≥ 7 days. Vulnerable at all stages of growth. | Overall vulnerability rating = 2, due: Extensive, strong and deep tap root systems. Well developed lateral roots that are ≥ 2m. High leaf litter reduces speed of water. Seeding stage is most vulnerable. | Overall vulnerability rating = 3, due: Susceptibility to Fusarium wilt, Phytophthora and Alternaria blights. Pod damage by Helicoverpa armigera and Maruca testulalis can reduce yield. Cowpea can compensate for leaf and flower damage sufficiently. Most vulnerable stage is podding. |
| 2. Pigeonpea | Overall vulnerability rating = 1 due to: Good germination under low moisture regime. Adaptation to low moisture conditions and resumes vigorous growth as moisture becomes available. Flowers and bears pods even in dry conditions once it has established because of deep root systems. Most vulnerable at seeding stage. | Overall vulnerability rating = 1 due to: High inherent adaptation to moisture stress due to strong tap root system. Produces flowers and pods normally at low moisture regimes Indeterminate varieties are better adapted to grow in water-stressed environments. | | | |
### Table 2 contnd

| Cereals: | | Mitigation/adapation options |
|---|---|---|
| 2. Rice | Overall rating = 4 due to: | - Water shortage resulting in poor germination and establishment - Impaired growth during vegetative stage (most vulnerable) - Poor to zero flowering and panicle formation and grain filling (very vulnerable at this stage). |
| | Overall rating = 4 due to: | - Poor tillering especially for upland rice - Panicle abortion in upland rice when wilting of stands before seeds mature - Most vulnerable are upland rice varieties |
| | Avoid planting in flood prone areas | - Sincere attempts to conserve genetic diversity of indigenous maize varieties - Use of early maturing genotypes in the cropping systems |
| | Overall rating = 3 due to: | - Increasing frequency of over flooding in shallow/swamp rice being cultivated in areas most vulnerable - Impairment of germination - Higher incidence of iron toxicity - Vulnerable at germination, seedling stage, panicle formation, grain filling and maturity. |
| | Avoid planting in flood prone areas | - Plant fruit trees, for example, cashew and Vertiver grass on erosion routes |
| | Overall rating = 2 due to: | - Sheet erosion in upland rice fields, encroachment of sand into both upland and shallow swamps - Most vulnerable from germination to grain filling. |
| | Grow genotypes that are disease resistant and tolerant to insect pests. | - Developed new varieties through breeding (research). |
| | Overall rating = 3 due to: | - Stemborer attacks (most vulnerable from seedling to maturity). - Attack by army worms (most vulnerable from germination to booting stage). - Bird attack (most vulnerable from grain filling to maturity). - Blasts and blights (most vulnerable before flowering). |
| | More entomological research to identify and manage/control emerging insect pests and diseases. | - Developed new production systems to target correct planting dates for specific rice growing areas - Breeding new lines to cope with changes in climate |
| | Developing new production systems to target correct planting dates for specific rice growing areas - Breeding new lines to cope with changes in climate | - Further breeding work on short d. - Populatisq existing short duration lines despite yield compromises - Supplementary irrigation. |
| | Overall rating = 2 due to: | - Non-uniformity in germination of direct-seeded crop. - Delayed establishment of transplants - Reduction in weight and number of seeds per panicle - Relatively high incidences of |
| | Overall rating = 5 due to: | - Submerging of root system. - Physiological capacity of roots for water and nutrient absorption is blocked - Discolouration, wilting and death of the above-ground parts - Zero production where |
| | Overall rating = 3 due to: | - Complete washing away of stands - Root exposure - Lodging - Most vulnerable from |
| | Overall rating = 3 due to: | - High susceptibility to Striga infestation - Stemborer infestation for early planted crops. - Fungal infestation (moulds and smut) at |
Table 2 Contnd

| Mitigation/ adaptation options | Roots and Tubers 6. Yams | Mitigation/ adaptation options | Cassava 7. | Mitigation/ adaptation options |
|--------------------------------|--------------------------|--------------------------------|----------|-------------------------------|
| Breeding of drought-tolerant varieties and systematic adaptation through new production systems | Breeding for drought tolerance and incorporating coping strategies of specific locations in the development of cropping systems through research | - Early planting. Exploiting the crop hardiness to evolve new production systems with oil crops like castor. | Popularize new crop varieties with tolerance/resistance to these pests and diseases for incorporation into farming systems. | Another choice crop for mitigation. - 1st 1-5 weeks of plant life must have access to adequate moisture. - research to develop suitable production systems to cope with climate change. |
Opportunities available for development of adaptive capacity of Nigerian Agriculture to Climate Change to ensure Food Security.

Building adaptive capacity enables communities and nations to mobilize the decisions and resources needed to reduce vulnerability and adapt to climate change (Nelson et al.,2007). Building adaptive capacity means strengthening attributes including the availability of information and skills, access to technologies, access to economic resources and the effectiveness of institutions (Munasinghe and Swart,2005). Coping with the impact of climate change on crop agriculture will require careful management of resources like soil, water and biodiversity (Sahai, 2010). Recommendations from National Conference on Climate Change and Food Security for India organized by Gene Campaign along with ActionAid as recorded by Sahai (2010) unveils opportunities for Nigeria. Making agriculture sustainable is the key and this is possible only through production systems that make the most efficient use of environmental factors of production (soil, water, air, light, etc.) without damaging these assets. If climate change effects can be incorporated in the design and implementation of national development programs right away, it will help to reduce vulnerability, stabilize food production and better secure livelihoods. Developing sustainability in agricultural production systems rather than seeking to maximize crop, aquacultural and livestock outputs, will help farming communities to cope with the uncertainties of climate change. The ecosystem approach with crop rotations, bioorganic fertilizers (e.g., from legumes) and biological pest controls, improves soil health and water retention, increases fertile top soil, reduces soil erosion and maintains productivity over the long term. The more diverse the agro ecosystems, the more efficient the network of insects and microorganisms that control pests and disease. Building resilience in agro ecosystems and farming communities, improving adaptive capacity and mitigating green-house gas emissions are the ways to cope. This can be addressed at local, state, national, regional and global levels:

Local: The real action for both mitigation and adaptation will have to be at the local level. The pursuit of sustainable agricultural development at the local level is integral to climate-change mitigation and combating climate change effects is vital for sustainable agriculture. Location specific technologies will need to be developed at the level of the agro-ecological unit, to make agriculture sustainable and minimize losses to food and nutrition. Universities of Agriculture and Universities with agriculture faculties may be mandated to generate these adaptive technologies with adequate back-up funds for the research programs.

State: Conserving the genetic diversity of crops and its associated knowledge in partnership with local communities must receive the highest priority in each state of the federation. A scientific knowledge-intensive, rather than input-intensive approach should be adopted to develop adaptation strategies. Traditional knowledge about each community’s coping strategies should be documented and used in training programs to help find solutions to address the uncertainties of climate change, build resilience, adapt crop agriculture and reduce emissions in each state.

National: Adaptation strategies have long duration and need to start NOW.

- Appropriate policy and budgetary support for mitigation and adaptation actions is needed.
- Multiple food and livelihood strategies are needed in rural areas to minimize risk. Food inflation must be contained at all costs. It will worsen with climate change as more frequent and unpredictable droughts and floods will result in shortfalls in food production. Just a few flash floods in Sokoto, Kebbi, Jigawa, Benue, Nasarawa States in 2010 may lead to a loss of thousands of tonnes of rice, maize, millet, sorghum and cowpea, causing prices to go through the roof.
- A carefully planned program for strategic research, along with dedicated funding, is needed to develop solutions to cope with the impact of global warming on crops, livestock, fish, soil etc. Renewable energy must be part of our mitigation and adaptation strategy and we should focus on bringing it to scale.

Pro-poor climate change adaptation strategies should be emphasized as a policy at all levels of governance (local, state, or federal). This can be achieved through (i) Enhanced knowledge about agricultural development pathways that lead to better decisions for climate mitigation, poverty alleviation, food security, and environmental health, used by national agencies,(ii) Improved knowledge about incentives and institutional arrangements for mitigation practices by resource-poor smallholders used by farmers (including farmers’ organizations), project developers and policy makers (CIAT,2010).

Regional: Regional strategies for mitigation and adaptation across similar agro-ecologies will help all countries of the West African sub-region to protect their agriculture and food production. The glimpse of a potentially dire future, provided by scientific
observations and predictions, affords African farmers the possibility of collectively responding to new conditions, using traditional knowledge and in-situ methods, supported by agricultural research and extension, to create the seeds and production systems necessary to cope with a rapidly changing environment (ACB, 2009).

Global: Nigeria must negotiate hard to ensure that the emission reduction pledges or commitments are sufficient to ensure at least 50 percent likelihood that the global temperatures rise is capped at 2°C. If this is not done, the impact on agriculture and food security in developing countries will be devastating. Rising temperatures will be beneficial for the agriculture of cold temperate regions since warmer conditions will allow their single crop zones to become two, even three crop zones. Given that agriculture is the linchpin of the developing world and will bear the worst brunt of climate change, Nigeria must insist that developed countries must reduce their own agriculture emissions while at the same time paying for adaptation, especially in the agriculture sector, consistent with the polluter pays principle. Nigeria should be able to tap from the Global Environment Facility (GEF) initiatives on Climate Change Adaptation and Clean Development Mechanism (CDM) of the Kyoto Protocol for carbon trading (UNDP/FME, 2008).

It must also be noted that climate change holds many dangers- and water is at the centre of its impacts (Smith and Barchiesi, 2009). There are numerous options for adapting to climate change impacts on water, and there are variety of enabling mechanisms which need to be developed and coordinated for adaptation to be effectively implemented. Coping with floods, drought, storms and sea-level rise will depend on water storage, flood control and coastal defense. However, providing these functions simply by building infrastructure-such as dams, reservoirs, dikes, and sea walls will not be adequate. By itself such infrastructures can weaken resilience, especially in a changing climate where the historic hydrology is no longer a reliable guide to the future, because of damage caused to livelihood and the environment (Palmer et al., 2008). The environment has a critical role to play. It must be kept intact as much as possible. The environment itself is infrastructure for adaptation- It is ‘natural infrastructure’. According to Nelson et al. (2007), when based on principles of good governance, sound investment strategies and learning from integrated water resources management, integrating natural infrastructure into adaptation builds resilience.

Constraints to development of Adaptive capacity of Nigerian Crop Agriculture to Climate Change.

The constraints/barriers are numerous, but a few are listed here:

1. Although some level of awareness may exist in the urban areas of Nigeria on the effect of climate change on agriculture, there is a near-complete absence of the knowledge of this phenomenon at the local level where more than 90% of crop production takes place. This fact is corroborated by Ziervogel et al. (2008) who reported that while awareness of and reference to climate change are both increasing, much of these are based on media messages, or highly aggregated data from IPCC (DDC) and GCM models. The link between climate change information and adaptation practitioners on the ground remains largely non-existent and many adaptation practitioners in the agricultural sector still rely on generalized assumptions about how the climate change will change or derive very general information about climate change and its impacts from the IPCC reports. Adequate awareness of the negative effects of climate change at the local level could generate pressure on government to tackle climate issues more seriously. A large scale climate literacy program is necessary to prepare farmers, who are today bewildered by the rapid fluctuations in weather conditions that affect their agriculture. Their traditional knowledge does not help them to manage these recent anthropogenic changes.

2. Finance is central to climate change adaptation/mitigation strategies. Nigeria is listed as one of the developing countries that has committed only $0.2 billion out of an estimated $15.93 billion on installing renewable and low-carbon electricity generating technological option to mitigate climate change (GCN, 2010). Even at the international arena, finance is central to negotiations on climate change. The 1992 United Nations Framework Convention on Climate Change (UNFCCC) obliges industrialized countries to help the developing world meet the costs of reducing greenhouse gas emissions. However, no agreement has yet been reached concerning the overall sum of the developing country climate costs or how the finance should be raised and spent (GCN, 2010).

3. Deforestation. Around 80% of agricultural emissions, including deforestation, occur in developing countries (World Bank, 2007). The unabated excessive exploitation of timber from our forests without a commensurate afforestation programs is a great challenge to climate change mitigation strategy, with consequent effect on food security. Although some laws to guide against excessive timber exploitation exist in
the country, implementation and prosecution of offenders is poor, mainly due to corruption.

4. Low-level research on climate change issues that relate to agriculture and food security. Absence of consistent relevant research to tackle identified problems that militate against climate change adaptations and also research to develop appropriate adaptive strategies to ward off the effects of climate change in Nigeria. This problem is also acknowledged by the international community. CIAT (2010) stated that AR4 recognises that, with only a decade of research on climate change adaptation, considerable knowledge gaps remain concerning adaptive capacity of agriculture.

5. Inadequate expertise on climate change adaptation in Nigeria. Although some expertise exists at the national level, located in the Special Climate Change Unit of the Federal Ministry of Environment and also at International Centre for Energy, Environment and Development (CEED), the scenario at the state and local government areas is the complete opposite. There is lack of capacity both in human resources and computational capacity to expand the available database.

6. Lack of reliable meteorological data. One of the main barriers to producing climate change information remains the lack of reliable meteorological data. This is especially true for complex environments where higher concentrations of station data are needed to capture the complexity of the terrain.

7. Ignorance of global weather conditions. Most farmers base their decisions on short-term weather and seasonal climate variability, and stand to gain little from engaging with complex world of climate projections and its difficult-to-apply messages.

8. Poverty. The report of the First National Environment Summit organized by UNDP and the Federal Ministry of Environment, Housing and Urban Development in 2008 in Abuja indicated that poverty was one of the major constraints to the development of capacities to tackle climate change. The report also pointed out that Nigeria, like other African countries had limited capacity to cope with current global warming and its associated challenges.

CONCLUSIONS.

Crop agriculture is the major sector upon which the majority of Nigeria’s rural poor depend. The shrinking size and water-holding capacity of Lake Chad, ravaging floods in both north and south of the country occasioned by severe storms and erratic rainfall, desertification and prolonged dry season with high temperatures in most parts of Nigeria, may be warning signs of the reality of climate change. Crop agriculture is highly sensitive to climate variability and weather extremes, such as droughts, floods and severe storms. The forces that shape our climate are also critical to farm productivity. A Nigerian study applied the EPIC crop model to give projections of crop yield in the 21st century. The study modeled worst case climate change scenarios for maize, sorghum, rice, millet and cassava. Making agriculture sustainable is the key opportunity to climate change adaptation in Nigeria and this is possible only through production systems that make the most efficient use of environmental factors of production (soil, water, air, light, etc.) without damaging these assets. Pro-poor climate change adaptation strategies should be emphasized as a policy at all levels of governance (local, state, or federal). Although several constraints militate against climate change adaptation strategies to provide food security in Nigeria, research efforts should be intensified in this direction with appropriate government and private sector involvement.

RECOMMENDATIONS

National strategic plan for climate change: There is NOW a dear need to have a national strategic plan in place to tackle the ominous consequences of climate change on agriculture and to harness any possible inherent advantage. Such a plan would involve the critical and relevant stakeholders, namely, Interministerial agencies, National Agricultural Research Systems (NARS)-Agricultural Research Institutes, Universities of Agriculture, Faculties of Agriculture in the Universities, Colleges of Agriculture and relevant Polytechnics, Federal Ministry of information and the National Orientation Agency, with the Federal Ministry of Environment co-coordinating Characterization Study: It is needful to carry out an in-depth characterization study on the impact of climate change on Nigerian agriculture with the aim to isolate specific areas of agriculture most prone to the devastating effects of the change and to evolve adaptive and mitigation strategies in the short and long term.

Human capacity building and computational capacity development to expand available database: Greater expertise has to be developed in agricultural climatology and instrumentation to handle the highly sophisticated instruments for computation and accurate predictions of weather/climate and effects on agriculture and agric-related businesses in both the short and long term.

A carefully planned program for strategic research (breeding for resistance/tolerance to drought, new emerging pests and diseases, development of production systems necessary to cope with a rapidly changing environment, etc.) along with dedicated funding, is needed to develop solutions to cope with the impact of global warming on crops, livestock, fish, soil etc.
Conducting a capacity survey of National Agricultural Research Systems: This is for the purpose of identifying the institutions with relatively higher comparative advantage in handling specific components of climate change as they affect agriculture. We recommend that deforestation, reckless land clearing practices, unorthodox and careless use of agricultural chemicals must be curtailed to preserve the natural environment as an adaptive strategy to also halt the effects of climate change. Government at all levels (federal, state, local) must be deliberate about this.

Political will on climate change should take cue from other countries that are infusing a substantial percentage of their annual budget to make for adaptation/mitigation of the adverse effects of climate change. Public enlightenment on climate change: Intensification of public enlightenment on climate change at the local and state levels require urgency.

National Action Committee on Climate Change (NACCC). Climate change could be as devastating as HIV/AIDS, if not more. There is therefore an urgent need for a National Action Committee on Climate Change to be set up to serve as the Technical Committee on climate in Nigeria.

REFERENCES

ACB (2009). African Centre for Biodiversity. Patents, climate change and African agriculture: dire predictions. ACB briefing paper no.10, 2009. African Centre for Biosafety, Melville, South Africa. http://www.biosafetyafrica.net

Adejumon, J.O. (2006). Food production in Nigeria. II. Potential effects of climate change. *Climate Research* 32:229-245.

Agoumi, A. (2003). Vulnerability of North African countries to climate changes: adaptation and implementation strategies for climate change. In Developing Perspectives on climate change: Issues and Analysis from Developing Countries and countries with Economies in Transition. IISD/ Climate Change Knowledge Network, 14pp.

Bidwell, R.G.S. (1974). *Plant Physiology*. Macmillan Publ. Co. Inc., New York.

Christensen, J., Hewitson, B.C., Busuioc, A., Chen, A., Gao, X Jones, R., Kwon, W T. I apprise R., Magana, V., Means, L., Menendez, C., Raisanen J., Rinke, A., Kolli, R.K. and Sarr, A. (2007) Regional climate projections in PCC Fourth Assessment Report Climate Change 2007. The Scientific Basis Cambridge University Press.

CIAT (2010). Centro Internacional de Agricultura Tropical. Proposal for Mega Program 7: Climate Change, Agriculture and Food Security. http://www.ccsfs.cgiar.org/s.tes/default/files/pdf/ccAFS_Report_May_2010.pdf

GCN (2010). Global Climate Network. Investing in clean energy: How to minimize clean energy deployment from international climate investments. Global Climate Change Network discussion paper no. 4. Nov. 2010.

GRAIN (2010). The international food system and the climate change crisis. Commonwealth Ministers Reference Book, 2010, pp. 170–172. Henley Media Group limited in association with Commonwealth Secretariat, UK.

IPCC (2007). Climate Change 2007: The Physical Science Basis. Contribution Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Solomon, S., Qin, D., Manning, Z., Chen, M., Marquis, K.B., Averyt, M.Tignor and H.L. Miller (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kalu, B.A. (2008). Interplay of the components and the valve control mechanisms of productivity pathways in farming systems. Inaugural Lecture Series No. 7. University of Agriculture, Makurdi, 59pp.

Margulls, S. (2010). How should developing countries adapt to climate change and how much will it cost? Commonwealth Ministers Reference Book 2010, pp. 170–172. Henley Media Group limited in association with Commonwealth Secretariat, UK.

Munasinghe, M. and Smart, R. (2005). Primer on climate change and sustainable development. Facts, policy analysis and applications. Cambridge University Press.

Nelson, D.R., Adger, W.N. and Brown, K. (2007). Adaptation to environmental change: contribution of a resilience framework. Annual Review of *Environment and Resources*, 32: 395-419.

Odo, P.E. (1999). Changing global carbon dioxide concentration: Implications on crop yield and survival in the Sudan and Sahel environment. In: Sustainable Agricultural Development: Principles and Case Studies in Nigeria. Undiandeye, C.U., Bila, Y. and Kushwaha, S. (eds.). Faculty of Agriculture, University of Maiduguri, pp. 131-132.

Okigbo, B.N. (1991). Development of sustainable Agricultural Production Systems in Africa. Roles of International Agricultural
Research Centres and National Agricultural Research Systems. First Lecture Series, International Institute of Tropical Agriculture (IITA), Ibadan, 26th April, 1989, 66pp.

Rajasekaran, B. and Warren, D.M. (1994). IK for socioeconomic development and biodiversity conservation: The Kolli Hills. Indigenous knowledge and Development Monitor 2:13-17

Rudd, K. (2010). Climate change in the Pacific: the challenges of our time. Commonwealth Ministers Reference Book 2010, pp164-168. Henley Media Group limited in association with Commonwealth Secretariat, UK.

Sahai, S. (2010). Recommendations from a National Conference on Climate Change and Food Security. Proceedings, presentations and papers on National Conference on ensuring food security in a changing climate. Gene Campaign and ActionAid, New Delhi, India.

Santhaye, J.A. and Ravindranath, N.H. (1998). Climate change mitigation in the energy and forestry sectors of developing countries. Ann. Rev. Energy Environ. 23:387-437.

Smith, D.M. and Barchiesi, S. (2009). Environment as infrastructure: Resilience to climate change impacts on water through investments in nature. Perspectives on water and climate change adaptation. IUCN/IITA/CPWC and World Water Council paper series presented at 5th World Water Forum in Istanbul.

UNDP (2007). United Nations Development Programme. Adaptation Learning Mechanism: learning through sharing experience. http://www.adaptationlearning.net

UNDP/FME (2008). United Nations Development Programme/Federal Ministry of Environment, Housing and Urban Development. Report of the First National Environment Summit, 20th-21st October, 2008, Abuja, Nigeria. pp 12-13.

World Bank (2007). Population issues in the 21st century: the role of the World Bank. Health, Nutrition and population (HNP): Discussion paper. The World Bank, Washington D.C.

Ziervogel, G., Cartwright, A., Tas, A., Adejuwon, J., Zermoglio, F., Shale, M. and Smith, B. (2008). Climate change and adaptation in African Agriculture. Prepared for Rockefeller Foundation. Stockholm Environment Institute (SEI), Stockholm, Switzerland.