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Les enjeux de l'adaptation agricole au changement climatique au Nigéria : synthèse de la littérature

Retos de la adaptación agrícola al cambio climático en Nigeria: una síntesis de la literatura

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Challenges of Agricultural Adaptation to Climate Change in Nigeria: a Synthesis from the Literature[1]

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Abstract. Climate change is perhaps the most serious environmental threat to the fight against hunger, malnutrition, disease and poverty in Africa, mainly through its impact on agricultural productivity. This paper discusses the challenges of agricultural adaptation to climate change in Nigeria under the categories[2] – Hunger and Poverty; Agricultural funding for research and technology development; Traditional agricultural practices; Trade Liberalization and Market Development; Policies, Institutions and Public Goods; and Information and Human Capital. The rural population, who produce more than 70% of the food eaten in Nigeria, are disproportionately poor and face malnutrition and disease. Both government and the private sector, which should drive the sector through consistent policies, robust funding and infrastructure development, have failed to accord this problem the priority it deserves. Moreover, the anticipated benefit from trade liberalization has failed to trickle down to the African farmer, coupled with the inefficient local marketing systems. In addition, the farmers are slow in changing their farming practices such as bush burning, deforestation and rain-fed agriculture and they lack the requisite education, information and training necessary to adapt to climate change. It is recommended that the government should not only decentralize its programs on poverty/HIV-AIDS and agricultural research (funding and activities), but should make them participatory. In addition, there should be an explicit national agricultural policy framework, adequate provision for irrigation, drainage, weather forecasting and other agricultural technology infrastructure, an incentive for training in agriculture, participatory and on-going capacity building for farmers, drought resistant and short duration high yielding crops development, integration of indigenous and modern knowledge on climate change adaptation, strengthening of the extension services, and encouragement for the formation of farmer groups.

Keywords. Agriculture, climate change, poverty, development, AIDS, hunger, malnutrition, Nigeria.

1 Introduction

Climate change is one of the most serious environmental threats facing mankind worldwide. It affects agriculture in several ways, including its direct impact on food production. Climate change, which is attributable to the natural climate cycle and human activities, has adversely affected agricultural productivity in Africa (Ziervogel *et al.* 2006). Available evidence shows that climate change is global, likewise its impacts; but the most adverse effects will be felt mainly by developing countries, especially those in Africa, due to their low level of coping capabilities (Nwafor 2007; Jagtap 2007). Nigeria is one of these developing countries (Odjugo, 2010). As the planet warms, rainfall patterns shift, and extreme events such as droughts, floods, and forest fires become more frequent (Zoellick 2009), which results in poor and unpredictable yields, thereby making farmers more vulnerable, particularly in Africa (UNFCCC, 2007). Farmers (who constitute the bulk of the poor in Africa), face prospects of tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases (Zoellick 2009). It is projected that crop yield in Africa may fall by 10-20% by 2050 or even up to 50% due to climate change (Jones and Thornton, 2003), particularly because African agriculture is predominantly rain-fed and hence fundamentally dependent on the vagaries of weather. As the people of Africa strive to overcome poverty and advance economic growth, this phenomenon threatens to deepen vulnerabilities, erode hard-won gains and seriously undermine prospects for development (WBGU 2004, Zoellick 2009). There is therefore the need for concerted efforts toward tackling this menace.

Much of climate change agricultural research has tended to concentrate on assessing the sensitivity of various attributes of crop systems (e.g. crop/livestock yields, pest, diseases, weeds etc) – the biophysical aspects of food production, with little or no regard to the socioeconomic aspects. These partial

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[2] Adapted from FAO (2001)

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assessments most often consider climate change effects in isolation, providing little insight into how and what the farmers are doing to cope with climate change. To better address the food security concerns that are central to economic and sustainable development agendas, it is desirable to also address these aspects of climate change and agriculture. Wisner et al (2004) reports that the vulnerability of agriculture is not determined by the nature and magnitude of environmental stress like climate change per se, but by the combination of the societal capacity to cope with and/or recover from environmental change. While the coping capacity and degree of exposure is related to environmental changes, they are both also related to changes in societal aspects such as land use and cultural practices. This paper discusses the challenges to agricultural adaptation to climate in Nigeria. This is important because climate change is expected to present a heightened risk, new combinations of risks and potentially grave consequences, particularly in Africa due to its direct dependence on rain-fed agriculture as noted above. Accordingly there is the need for an emphasis on "anticipatory adaptation" (UNDP, 2007), that is the proactive rather than the reactive management of climate change risk. This can only be feasible if the potential problems/challenges to adaptation are preemptively analyzed. Most studies on climate change and agriculture in Africa have tended to concentrate on actual and projected impacts as well as farmers' coping/adaptation strategies (Adejuwon, 2006, FAO 2007, BNRC 2008, Apata *et al.* 2010 SEI 2008, Ajetomobi *et al.* 2010 Mendelsohn *et al.*, 2000 Stige *et al.*, 2006 Agoumi, 2003 Thornton *et al.*, 2006). There has been little or no work in the area of challenges of adaptation. This paper will therefore attempt, through a survey of the literature, to fill this gap.

We begin by looking at hunger and poverty. This is because agriculture in Nigeria is predominantly in the hands of rural smallholder farmers, who have been generally described as poor and hungry. Moreover, since the discovery of oil in Nigeria, the attention of the government has been diverted away from agriculture to petroleum resource development. We shall next consider government funding for agricultural science and technology as a challenge to climate change adaptation. Further, there are traditional farming practices that the typical Nigerian farmer is accustomed to, which he/she may find it difficult to modify or change, even though these may pose serious challenges to climate change adaptation. The next challenge we shall discuss is therefore traditional agricultural practices. The issue of globalization and accompanying trade liberalization and how this may pose a challenge is discussed next. Poor infrastructure, weak institutions and bad governance are believed to be the general features of most African countries. This will be discussed under Policies, Institutions and Public goods. Finally, the paper will discuss information and human capital as a challenge to agricultural adaptation to climate change, essentially, because, the two have been widely described as poor, in most African countries. The paper will end with two sections – recommendations and then conclusions. However, in order to place the problem in context, we shall first of all take a look at the patterns of climate change impact on agriculture, which will provide a background for the discussion.

2 Background

The Intergovernmental Panel on Climate Change, IPCC's Fourth Assessment Report summary for Africa describes a trend of warming at a rate faster than the global average, and increasing aridity in many countries. Climate change exerts multiple stresses on the biophysical as well as the social and institutional environments that underpin agricultural production (IPCC, 2007). That is, socio-economic factors, international competition, technological development as well as policy choices will determine the pattern and impact that agro-climatic changes will have on agriculture (Brussel, 2009). In all, Khanal (2009) classified the patterns of impact of climate change on agriculture into biophysical and socio-economic impact. The biophysical impacts include; physiological effects on crop and livestock, change in land, soil and water resources, increased weed and pest challenges, shifts in spatial and temporal distribution of impacts, sea level rise and changes to ocean salinity and sea temperature rise causing fish to inhabit in different ranges. The socio-economic impacts result in decline in yield and production, reduced marginal GDP from agriculture, fluctuation in world market price, changes in geographical distribution of trade regime, increased number of people at risk of hunger and food insecurity, migration and civil unrest. According to Khanal (2009), the patterns of the effects of climatic change are however dependent on latitude, altitude, type of crop grown and livestock reared. Mark *et al.* (2008) highlighted some of the direct impacts of climate change on agricultural system as: (a) seasonal changes in rainfall and temperature, which could impact agro-climatic conditions, altering growing seasons, planting and harvesting calendars, water availability, pest, weed and disease populations; (b) alteration in evapotranspiration, photosynthesis and biomass production; and (c) alteration in land suitability for agricultural production. Some of the induced changes are expected to be abrupt, while others involve gradual shifts in temperature, vegetation cover and species distributions. However, when looking critically on plant production, the pattern of climate change has both positive and negative impacts. Rises in temperature for example helps to grow crops in high altitude areas and towards the poles. In these areas, increases in temperature extend the length of the potential growing season, allowing earlier planting, early harvesting and opening the possibility of completing two crop cycles in the same season (Khanal, 2009). The warmer conditions support the process of natural decomposition of organic matter and contribute to the nutrient uptake mechanisms. The process of nitrogen fixation, associated with greater root development is also predicted to increase in warmer conditions and with higher CO_2, if soil moisture is not limiting (FAO, 2007). The increased CO_2 levels lead to a positive growth response for a number of staples under controlled conditions also known as the carbon fertilizations effect (Mark *et al.* 2008).

But when temperatures exceed the optimal level for biological processes, crops often respond negatively with a steep drop in net growth and yield. Khanal (2009) stated that heat stress might affect the whole physiological development, maturation and finally reduces the yield of cultivated crop.

The negative effects on agricultural yields will be exacerbated by more frequent weather events. For example, Brussel (2009) stated that rising atmospheric CO_2 concentration, higher temperatures, changes in annual and seasonal precipitation patterns and in the frequency of extreme events will affect the volume, quality, quantity, stability of food production and the natural environment in which agriculture takes place. Climatic variations will have consequences for the availability of water resources, frequency of pest and diseases, and soil quality, leading to significant changes in the conditions for agriculture and livestock production. In extreme cases, according to Brussel (2009), the degradation of agricultural ecosystems could mean desertification, resulting in a total loss of the productive capacity of the land in question. This is likely to increase the dependence on food importation and the number of people at risk of famine.

The developing world already contends with chronic poverty and food crisis. The estimate for Africa is that 25-42% of species habitat could be lost, affecting both food and non-food crops (Khanal 2009). Habitat change is already underway in some areas, leading to species range shifts and changes in plant biodiversity which include indigenous foods and plant-based medicines. FAO (2007) reported that up to 11% of arable land could be highly affected by climate change in the developing world. There will be a reduction of cereal production in 65 countries and retardation of about 16% of agricultural GDP. A decrease of up to 30% in world food production due to effects of climate change on agriculture is generally predicted (IPCC 2007).

In Africa, climate change is expected to, and in some parts, it has already begun to, alter the dynamics of drought, rainfall and heat waves, and trigger secondary stresses such as the spread of pests, increased competition for resources, and attendant biodiversity losses. Predicting the impact of climate change on complex biophysical and socio-economic systems that constitute agricultural sectors is difficult. In many parts of Africa it seems that warmer climates and changes in precipitation will destabilize agricultural production.

This is expected to undermine the systems that provide food security (Gregory *et al.*, 2005). Whilst farmers in some regions may benefit from longer growing seasons and higher yields, the general consequences for Africa, as reported in Text Box below, are expected to be adverse, and particularly adverse for the poor and the marginalized, who do not have the means to withstand drastic changes. Evidence from the IPCC suggests that areas of the Sahara are likely to emerge as the most vulnerable to climate change by 2100, with likely agricultural losses of between 2 and 7% of affected countries' GDP. Western and Central Africa are expected to have losses ranging from 2 to 4% and Northern and Southern Africa are expected to have losses of 0.4 to 1.3% (Mendelsohn *et al.*, 2000). Maize production is expected to decrease under possible increased El Nino-Southern Oscillation (ENSO) conditions which are expected in southern Africa (Stige *et al.*, 2006).

A South African study focusing at the provincial level found a significant correlation between higher historical temperatures and reduced dry-land staple production, and forecast a fall in net-crop revenues by as much as 90% by 2100. The study found small-scale farmers to be worst affected by the decrease.

A Nigerian study applied the Erosion Productivity Impact Calculator (EPIC) crop model to give projections of crop yield during the 21st century. The study modeled worst case climate change scenarios for maize, sorghum, rice, millet and cassava (Adejuwon, 2006). The indications from the projections are that, in general, there will be increases in crop yield across all low land ecological zones as the climate changes during the early parts of the 21st century. However, towards the end of the century, the rate of increase will tend to slow down. This could result in lower yields in the last quarter than in the third quarter of the century. The decreases in yield could be explained in terms of the very high temperatures which lie beyond the range of tolerance for the current crop varieties and cultivars. An Egyptian study compared crop production under current climate conditions with those projected for 2050, and forecast a decrease in national production of many crops, ranging from –11% for rice to –28% for soybeans (Eid *et al.*, 2006). Other potential impacts linked to agriculture include erosion that could be exacerbated by expected increased intensity of rainfall and the crop growth period that is expected to be reduced in some areas (Agoumi, 2003). Changes are also expected in the onset of the rainy season and the variability of dry spells (Reason *et al.*, 2005). Thornton *et al.* (2006) mapped climate vulnerability with a focus on the livestock sector. The areas they identified as being particularly prone to climate change impacts included arid-semiarid rangeland and the drier mixed agro-ecological zones across the continent, particularly in Southern Africa and the Sahel, and coastal systems in East Africa. An important point they raise is that macro-level analyses can hide local variability around often complex responses to climate change.

3 Hunger and poverty

The population of Nigeria is projected to increase by more than 50 percent in the coming two decades (FAO 2001). During this 20 year period, the rural population is projected to increase by more than 25 percent, and the agricultural component is expected to grow by a slightly lower proportion, moderated by climate change and undercapitalization of the smallholder farmers. For instance Davidson *et al.* (2003) noted that the food security threat posed by climate change is greatest for Africa, where agricultural yields and per capita food production have been steadily declining, and where population growth will double the demand for food, water and forage in the next 30 years.

In the previous four decades, FAO (2001) reported that the number of undernourished people in Sub-Saharan Africa increased substantially, to an estimated 180 million people in 1995-1997. During this period, the average daily Sub-Saharan African diet contained 2188 kcal/person/day compared with 2626 in developing countries as a whole. It is estimated that 33 percent of the regional population was undernourished at this time, with a higher incidence of undernourishment found in rural areas, where agriculture is the predominant practice. This reason for this level of malnutrition is generally traced

to poverty. For example, Nigeria fares very poorly in all development indices. The average annual percentage growth of GDP in Nigeria from 1990-2000 was 2.4. Statistics show that the incidence of poverty using the rate of US $1 per day increased from 28.1 percent in 1980 to 46.3 percent in 1985 and declined to 42.7 percent in 1992 but increased again to 65.6 percent in 1996. The incidence increased to 69.2 percent in 1997 (Otive, 2006). According to the Nigerian Federal Office of Statistics, in 1960 about 15% of the population was poor, but by 1980 this percentage had risen to 28%. By 1996, the incidence of poverty in Nigeria was 66% or 76.6 million people.

Currently, there are no reasons to suggest any positive change regarding the above information, especially in Nigeria. On the contrary, poverty in Nigeria has continued to increase. Between 1993 and 2003, the share of the population living in extreme poverty (US$1/day income) rose from 59 to 71 percent, and the share living in moderate poverty (US$2/day income) rose from 85 to 92 percent (World Bank, 2007).

Africa has a higher proportion of people living in poverty than any other region of the world. Across the whole region, rural poverty still accounts for 90 percent of total poverty and approximately 80 percent of the poor still depend on agriculture or farm labour for their livelihood. Of even more concern, the total number of poor people is increasing (Otive, 2006). For instance, the UN human poverty index in 1999 placed Nigeria amongst the 25 poorest nations in the world (United Nations, 2005). Presently, it is estimated that two thirds of the 120 million or 80 million Nigerians are poor (Garba, 2006). Poverty results in shortened lifespan. For instance, given an estimated average global life expectancy of 65.82 years for both sexes, Nigeria's overall life expectancy at birth is 44.3 years. In other words, Nigerians are about 30% below the average world life expectancy. The severity of poverty in Nigeria's rural areas is particularly heart-rending. This is further aggravated by the country's extremely low per capita income of US$1,158 – based on 2007 estimates; that is, approximately US$3.00 per day (Oluba, 2010).

In addition, there is the problem of HIV/AIDS, which is adversely affecting government staff and private agricultural service providers. The HIV/AIDS pandemic is a major cause for concern in many African countries. Besides placing a great strain on the health infrastructure, results from several studies across Africa show that there are strong links between HIV/AIDS and heightened vulnerabilities in various sectors, including agriculture. Maize production, for example, on communal farms in Zimbabwe fell by 54% between 1992 and 1997 largely because of AIDS related illness and death. The negative impacts of HIV on agricultural outputs and sales have also been tracked in Uganda and Malawi (Nyong, 2005). This scenario is not so different in Nigeria. Staff turnover is so high that much of the investment in human capacity building by agricultural projects, including overseas training, may have been wasted.

The foregoing is expected to have dire consequences for the farmers' capacity to adapt to climate change. Deressa (2008) reports that most of the problems (or constraints) encountered by farmers in adaptation to climate change are associated with poverty. This is because poor and hungry farmers would naturally divert their limited farm income towards the basic necessities like feeding and medication rather than ploughing them into climate change adaptation measures. Enete and Achike (2008) reported, in southeast Nigeria, that undercapitalized urban farmers did not adopt more efficient inputs in the right quantity and were generally not innovative in their farming practices essentially because of poverty.

4 Agricultural Funding for Research and Technology Development

Technical change in agriculture has played a major role as a leading engine of growth and poverty reduction in many developing countries over the past four decades. Agricultural research has been shown to be one of the most effective forms of public investment (Hazell and Haddad 2001; Fan 2000; Fan and Rao, 2003). In Nigeria, compared to the recommendations that agricultural research spending should not be less than 2% of agricultural GDP, Nigerian government's funding of agricultural research has been well below the average for Africa as a whole (0.85 percent of GDP). Allocations for agricultural research as a percentage of the total budget for agriculture for the periods 1996-1998, 1998-2000, and 1999-2001 were 13.41 percent, 14.82 percent, and 12.42 percent, respectively, which are considered inadequate as reported by Nigeria's House Committee on Agriculture, 2005) and therefore hampers the ability of the research institutes to respond to poor farmers' needs. The National Bureau of Statistics for instance estimates that 70 per cent of fruits and vegetables produced in the country are wasted, basically due to poor infrastructure and inadequate research efforts in preservation techniques (Atser, 2007). Private-sector activity in agricultural research in Nigeria is also negligible, as is the case throughout most of Sub-Saharan Africa (Mogues, *et al.* 2008).

The Department of Agricultural Sciences (DAS) of the Federal Ministry of Agriculture is responsible for all aspects of agricultural research in Nigeria. DAS oversees the funding and management of 15 national agricultural research institutes located throughout the country. Those institutes are tasked with generating improved agricultural technologies for use by farmers and agro-allied industries. However, DAS funding of agricultural science research and technology have been generally sluggish as governments and even the private sector are yet to accord it the needed priority attention. Bientema and Ayoola (2004) assessed agricultural research capacity in Nigeria and found that it is highly dispersed such that the country currently does not have a well-defined national agricultural research strategy. In addition, the funding of agricultural research from the federal government budget, which is always the main and now virtually the sole source of funds, has been in regression since the collapse of oil prices in the early 1980s (Agbamu, 2000; FAO 1996 and Nigeria House Committee on Agriculture, 2005).

African leaders met in Maputo in 2003 and made a commitment to allocate at least 10 percent of public expenditure to agriculture. Although the 10 percent target endorsed in

Table 1. Federal Budget and Actual Expenditure on Agriculture (Billion).

Fiscal year	Budget	Actual Expenditure
2001	17,575	15,916
2002	16,509	9,521
2003	14,908	8,917
2004	12,725	10,768
2005	11,516	11,847
Average	**1.78%**	**1.67%**

Source: Mogues, et al (2008).

Maputo may not be appropriate for every country since the importance of agriculture in the overall economy varies between countries, it serves as a reminder that public resource allocation to agriculture in Nigeria is very low when judged against the most widely cited international benchmark (Mogues, *et al.* 2008). While some African countries such as Ghana, Uganda and Malawi have stabilized their budget expenditures on agriculture around 10%, Nigeria, has consistently spent less than 5% of its annual budget on agriculture. Malaysia, on the other hand, has achieved accelerated agricultural development through sustained annual expenditure of between 20-25% of its budget on agriculture in the last three decades (Youngstars Foundation, 2010).

The standard approach for assessing the adequacy of agricultural spending relative to the size of the sector is to express public spending in agriculture as a share of agricultural Gross Domestic Product (GDP). Between 2001 and 2005, the aggregate federal spending budget averaged 824 billion naira per year. Of that amount, the agriculture sector budget constituted a very small share, averaging only 14.7 billion naira per year, or slightly less than 1.8 percent of the total budget (Table 1). The share of actual expenditure that went to agriculture was similar to the share budgeted. Between 2001 and 2005, actual federal spending averaged 681 billion naira per year, of which 11.4 billion naira went to agriculture.

In a similar vein, the report of Nigeria House Committee on Agriculture (2005) shows that currently, the agriculture share of Nigeria capital budget of about 1.5% falls short of the target set by the National Economic Empowerment and Development Strategy (NEEDS). Such a funding pattern clearly does not befit the sector that is acknowledged to be a prime driver of growth and poverty reduction in the country. Over the past 25 years, the level of public spending in agriculture in Nigeria relative to the size of the country's agricultural sector has seen dramatic swings (Figure 1) (Mogues, *et al.* 2008).

As a result of the foregoing, almost all the National Agricultural Research Systems (NARS) have been under budget pressure, especially as macro-economic reforms are being implemented by governments. In contrast, agricultural research in industrialized countries has been relatively well funded with some of the work being led by the private sector and more connections to the grassroots. For instance in Japan, there are 13 national research institutes that have networks with 255 prefectural research institutes and experiment stations through six national agricultural experiment stations. Japan operates at the prefecture (state) level bottom-top management system in which decisions on research and linkage activities are taken at prefecture level without the direct involvement of national officers. In Mexico, each of the 32 States has an agricultural research station under the State Secretariat of the Agriculture Department (SEDAGRO). The research stations have more direct links with farmers at the local level. In some African countries like Tanzania, coordination of the three national research institutes fall under the authority of the Division of Research and Training and have substations in the 47 provinces. The Farming Systems Research – Extension Programme – also under the Division of Research and Training – is managed by zonal directors and implemented at provincial level through Liaison Offices (Agbamu, 2000).

In the case of Nigeria, all the agricultural research institutes are owned and managed by the federal government; the State and Local governments, which are closer to the rural farmers, have no research institutes. This means that all decisions on the funding, direction and implementation of research activities are taken from Abuja (Agbamu, 2000). The consequence of this is not only over-centralization of agricultural administration, but also that those involved are hardly in touch with the reality on ground. As a result, a much greater range of new technologies is available for production systems and crops of interest to developed countries than for smallholder production systems in Nigeria. This could pose serious challenge for agricultural adaptation to climate change. For instance, the farmers interviewed during the DelPHE 326 research indicated that soil fertility has been on the decline for the past ten years. However, a FAO (2001) report shows that inorganic fertilizer consumption in sub-Saharan Africa is very low despite the declining soil fertility. Total regional consumption is only 1.3 million tons – equivalent to an average of only 8 kg/ha within the region compared with 107 kg/ha in all developing countries. Recently, the study of Atser (2007) revealed that fertilizer application in Nigeria is about eight kilograms per hectare, which is far less than the 200kg/ha world average. In addition, this can also hamper the development of new agricultural technologies like new crop and animal varieties for climate change adaptation.

5 Traditional Agricultural Practices

In Nigeria, the traditional and predominant method of clearing farm land is through bush burning. In addition, the use of firewood as cooking energy source has recently gained prominence, because of the high cost and non-availability of other cleaner sources such as natural gas. These activities increase the concentrations of greenhouse gases (GHGs) in the atmosphere trapping heat and causing global warming, climate change and sea level rise (Medugu, 2009).

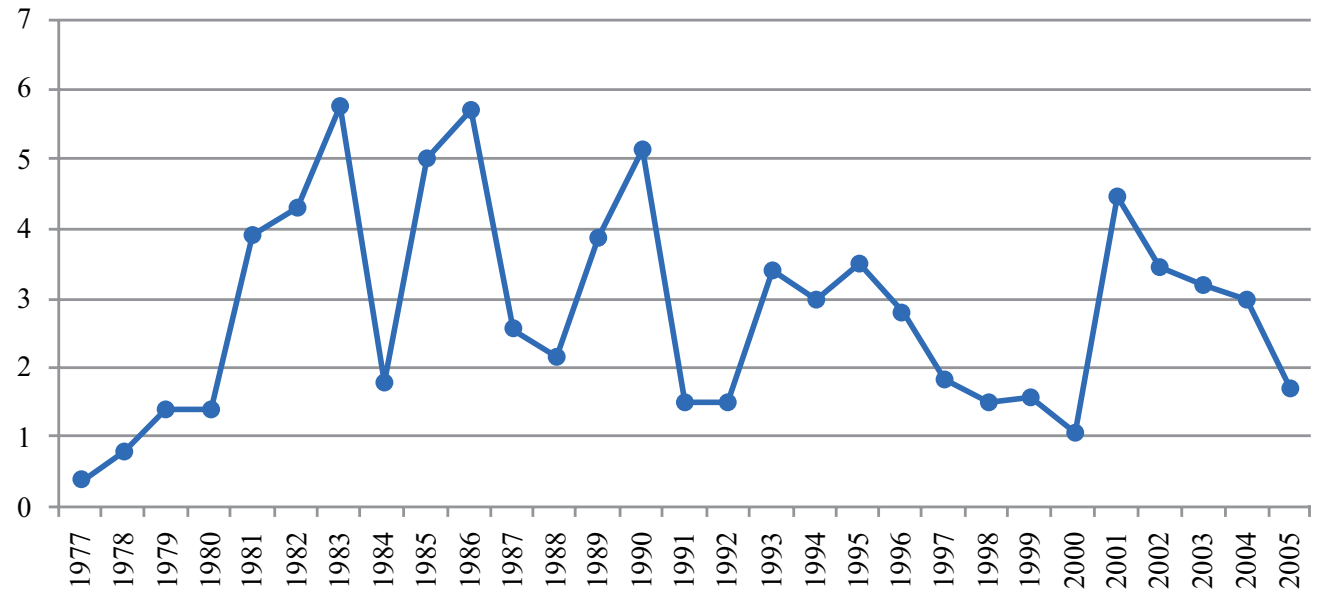

Figure 1. Share of the Agricultural Sector in Federal Capital Budget (%) 1977-2005.
Source: Nigeria House Committee on Agriculture Report (2005)

Further, there is the problem of deforestation. Currently, forest covers approximately 400 million ha (almost 17 percent of land area). The current annual deforestation rate is, however, 0.7 percent and the decline in forest area is expected to continue. Garba, (2006) noted that one of the major causes of poverty is destruction of natural resources, leading to environmental degradation, high temperature, drought and consequently reduced productivity. Nigeria's forest is being depleted because of rising population, migration, land hunger, poverty and starvation (Akah, 2010).

In addition, the Nigerian agriculture is almost entirely rain-fed and hence inherently susceptible to the vagaries of weather. Three main categories of irrigation development exist in Nigeria today, namely public irrigation schemes, which are systems under government control (formal irrigation); the farmer-owned and operated irrigation schemes (informal irrigation) and residual flood plains fadama irrigated scheme. Even with the present irrigation efforts, Madu, *et al* (2010) noted that Nigeria has not developed irrigation to the same extent as other developing nations, particularly in Asia. Only about a million hectare is currently irrigated in Nigeria. In contrast, India, which has about 3.5 times the land mass of Nigeria, irrigates nearly forty-five (45) times as much land.

As global warming accelerates, it is expected that agricultural adaptation to climate change can only be meaningful, if irrigated agriculture gains prominence. Unfortunately agricultural practice in Nigeria is still predominantly rain-fed and therefore particularly vulnerable to the impacts of climate change as noted before (FAO, 2008; Medugu, 2008 and IFAD, 2007). The consequences are that the increasing frequency and severity of droughts are likely to cause: crop failure; high and rising food prices; distress sale of animals; de-capitalization, impoverishment, hunger, and eventually famine. Households will probably try to cope with their cash and food shortage by cutting and selling more firewood thereby exacerbating land degradation and accelerating the onset of desertification, and by moving temporarily or permanently to more favoured areas. In line with this projection, Medugu (2009) stated that Nigeria is one of the countries expected to be most affected by the impacts of climate change through sea level rise along her coast line, intensified desertification, erosion and flooding disasters and general land degradation.

Land tenure and fragmentation systems could also limit the capacity of farmers to adapt to climate change. Among most African peoples, farmland is not owned but held in trust by the present generation on behalf of their future descendants. It could be held by individual families, extended families or entire village communities and then fragmented to individual farmers, who only enjoy user rights. Outright purchase of farmland is not common, but rental for a period of time could be possible (Nweke and Enete 1999). This limits the level of individual farmer's investment in the development of a farmland, since the user right could be withdrawn anytime. In addition, the fragmented nature of farmland could hamper the farmers' capacity to adopt innovative farming practices that may be necessary for climate change adaptation. IFAD (2010) reported that about 90% of Nigeria's food is produced by smallholder farmers who cultivate small plots of land, usually less than 1 hectare of land per household.

6 Trade Liberalization and Market Development

As a consequence of the IMF and World Bank induced Structural Adjustment Programmes (SAP), there was a liberalization of exchange rates, drastic reduction of agricultural subsidies in Nigeria. SAP contained agricultural specific reforms such as (i) end to marketing monopolies; (ii) reduced parastatal involvement in the supply of inputs, marketing and processing; (iii) reduced subsidies, price controls and

impediments to private sector activities; (iv) no restraints on foreign trade; and (v) promotion of the private sector.

Markets are very important for agricultural development, because they help to link the farm, rural and urban economies, which are critical factors in the development processes. Because of the reduction of obstacles to international trade, trade liberalization was expected to generate changes in the patterns and structure of production at all levels – including smallholder-farming systems in Nigeria. This is because the rapid growth of market development consequent upon trade liberalization should be accompanied by changes in the patterns of production and natural resource usage.

All over the world, producer prices are normally an incentive for farmers to produce more. However, one consequence of the liberal trade policy has been an influx of cheap imports of products such as textiles, sugar, vegetable oil, wheat, rice, etc., to the detriment of Nigerian farmers. At the same time, Nigeria's exports have not benefitted significantly from the governments liberal trade policy as a result of large share of petroleum in its exports and because most of the non-oil exportables are not competitive internationally. In addition, the prices of most agricultural export commodities have been falling in recent times as a result of decline in international prices (Bigman 2002). The farmers' incomes (producer prices) from export will therefore be static at best, if not dropping; hence, it becomes fairly difficult to sustain production (World Bank, 2006). The World Economic Forum (WEF) 2006 report ranks Nigeria 88 out of 117 countries on its global competitiveness indicators (GCI). Despite the large domestic market, only a small proportion of producers have been able to develop into sizeable businesses able to compete internationally, as shown by the long-term decline in non-oil exports. Total factor productivity (TFP) growth has been low and appears to have fallen consistently between 1970 and 2000. Increases in productivity per capita have been negligible. In agriculture, yields have been falling and, in manufacturing, there is considerable unused capacity (World Bank, 2006)

In other words, trade liberalization has had generally negative implications for the Nigerian farmers as their poverty increased (Nwafor *et al.* 2007), essentially because of their unfavourable competitive position in comparison with their developed country counterparts, for reasons such as the ones mentioned above and the continued heavy agricultural subsidy in these countries. For instance, the World Bank (2008) reported that farmers in developing countries cannot compete with highly subsidized farmers in industrialized countries who can afford to sell crops below production costs. The World Bank estimates that removing all cotton subsidies and import tariffs would boost global economic welfare by an estimated $283 million per year. This is, because, agriculture is the major, sometimes the only source of export earnings for many poor countries. These countries want to sell their goods in the United States and European markets, but often have a hard time doing so because of trade barriers, like tariffs.

In addition, poor infrastructure and high input costs (for example energy and credit) put Nigerian goods at a competitive disadvantage. For example, while the Senegal basin produces nerica at about 7.5 tons per hectare, Nigeria at best records 4.0 tons per hectare under nerica trials (WARDA, 2005). The high cost of production tends to make Nigerian exports uncompetitive.

The foregoing suggests that trade liberalization has had the opposite of its intended effects on the Nigerian farmers – increasing their poverty instead of enhancing their income base, and money is a critical factor in climate change adaptation. The result of a study conducted by Centre for Environmental Economics and Policy in Africa across African countries showed that lack of access to credit or saving is one of the major problems encountered by farmers in adapting to the effects of climate change (Dewit, 2006). According to Deressa (2008), the analysis of barriers to adaptation to climate change in the Nile basin of Ethiopia indicates that lack of money is a major constraint to adaptation by farmers.

7 Policies, institutions and public goods

The development of dynamic farming systems, capable of adapting to the challenges of climate change, requires a conducive and stable policy environment. This has generally been lacking in Nigeria as successive governments most often make a u-turn on policies put in place by predecessors. Atser (2007) stated that weak infrastructure and inconsistency in government policies have always been major snags in the development of agriculture in Nigeria. Some of the problems that could result from inconsistent agricultural policies in Nigerian included: high apathy on the part of the farmers regarding anything from government because nobody knows how long such may last; erratic import policies characterized by frequent changes in both import tariffs and quantitative import restrictions, thus creating much uncertainty for producers; and failure to set up a satisfactory credit system for farming and agro-processing (Pinto 1987 and Bevan *et al.* 1999).

At the moment, there are scanty and ill-equipped weather stations, and agricultural infrastructure (Odjugo, 2010). The World Bank (2006) reported the existence of inadequate storage facilities and dilapidating agricultural infrastructure in Nigeria. In addition, the only small portions of the national grain storage systems that were constructed in the country are not properly managed and the entire network is far from being completed (Mogues, *et al.* 2008). The shortage of storage facilities poses serious threats to farmers in food preservation, most especially during harvest periods. As a result, most crop farmers are often in a rush to send farm produce to market immediately after harvest, not minding the associated low prices. This could act as a disincentive to investment in agriculture and hence portend serious threats to agricultural adaptation to climate change.

Moreover, while the economic restructuring being implemented in Nigeria has generally conferred some macroeconomic stability, farmers have continued to face unfavourable terms of trade and poorer access to many agricultural inputs such as improved seed and agro-chemicals, as well as lower and more uncertain food prices. As part of the structural adjustment process, governments have focused on the core facilitation roles of Ministries of Agriculture (MOA). Despite

the clarion call from several quarters for power to be decentralized from the centre in Nigeria, the federal government has continued to monopolise power, with the result that state and local government structures have suffered progressively reduced budgets, resulting in cuts of staff and service delivery capacity, and in most cases the private sector has not yet filled the vacuum. Mogues, *et. al*. (2008) and FAO, (1996) recognised the concentration of efforts in the agricultural sector in Nigeria at the federal level and stated that agricultural funding at States and private-sector has been so weak and negligible, as is the case throughout most of Sub-Saharan African countries. For instance, at the State level, agricultural budget execution is very low and varied, in Imo and Enugu states, the annual agriculture share of capital budget averaged about 2.3% and 2.4% respectively (Mogues, *et. al*, 2008; Nigeria House Committee on Agriculture, 2005). At the local government level, the study of Nwoko and Nege (2007) using Odukpani Local Government Area of Cross River State constituted an extreme case in which agricultural spending was very low, averaging only 0.5 percent throughout the period. This trend clearly revealed centralised nature of the national agriculture spending and related policies at the federal level at the disadvantage of agricultural activities at the State and local government levels in the country. Almost everything one hears about agriculture in the country is dominated by the federal ministry of agriculture.

8 Information and human capital

The evolution of farming systems based upon increasing climate change, specialization or integrated intensification has required extra knowledge on the part of farm operators. The need for better information and enhanced human capital has also increased, as production systems have become more integrated with regional, national and international market systems. Many farmers in developed countries now have a much better understanding of the nature of the demand that they are responding to – in terms of its implications for varieties, timing, and packaging and permitted chemicals. As a result, they have progressively modified their production practices and their portfolio of products in response to changing patterns of demand. This knowledge-based approach has not yet been adopted in Nigeria.

Lack of education, information and training is frequently a key limiting factor to smallholder development. The report of IFAD (2007) confirmed that the poor state of the country's education has also had its toll on the poor people, majority of who are farmers in rural areas. In addition, they are faced with limited social services and infrastructure. FAO (2008) reported that about 90 per cent of Nigeria's food is produced by small-scale farmers who cultivate small plots of land and depend on rainfall rather than irrigation systems as a result of their low knowledge base, access to facilities and poor financing. Nyong (2005) noted that low flexibility of Nigerian farmers to allow for substitution in production practices, especially for export crops, cereals and other agriculture is a major limiting factor which results from low human capital, technological capacities, credit market access and infrastructure. Garba (2006) summed up this issue when he said that one of the major causes of poverty in Nigeria is low endowment of human capital.

The continued reduction in government expenditure on extension and agricultural training has reduced the access of farmers to technology and market information. Unfortunately, the emerging alternative sources of agricultural information like the internet are yet to expand to the rural areas, and may in fact not be able to, because of language and cost barriers. It is expected that farmers' organizations and the private sector will take the lead towards increased extension, training activities, internet connectivity, technical and market information provision. However, the present level of contribution by farmers' organizations and private sector in these areas including research is still very low compared to what is obtainable in developed countries such as Japan and Mexico. In Nigeria, agricultural research is carried out predominantly in public sector institutions (FAO 1996 and Agbamu, 2000) while private-sector activity in agricultural research is negligible, as is the case throughout most of Sub-Saharan Africa (World Bank, 2007).

Despite women's increasingly prominent role in agriculture, they remain severely disadvantaged in terms of their access to productive resources. African culture generally discriminates a lot against women especially in area of inheritance (land). For instance, in places where women do not own or inherit land; difficulties have always been experienced in their expanding farming activities and reaping the benefits of innovation (Anyanwu and Agu, 1995). An FAO survey showed that female farmers receive only seven percent of all agricultural extension services world-wide and that only 11 percent of extension agents are women. Poor institutional/organizational framework of agricultural institutions in Nigeria has served as one of the greatest constraints faced by women farmers. Institutional/organizational barriers limit farm women's access to farm support services such as extension, education, information services, cooperative and other relevant agricultural services. Eboh and Ogbazi (1990) observed that, women are rarely organised into agricultural cooperative societies or other functional associations while agricultural extension programmes and other supporting services have traditionally concentrated more on educating male farmers; hence, women still largely depend on their husbands for farm related information (Raffety, 1998).

9 Recommendations

Governments' poverty and HIV/AIDS programs should not only be decentralized for purposes of being closer to reality but should also be made participatory in structure for effectiveness. In addition, agricultural adaptation to climate change should be mainstreamed into government's poverty alleviation programme.

There should be an explicit national agricultural research policy framework to provide a conducive environment for continuity and effectiveness in agricultural programmes/projects

An effort should be made by government to decentralise research funding and activities to reduce concentration at the federal level. For instance, the ownership structure of research institutes could be decentralized to the lower tiers

of government where the farmers at the local levels can actively benefit.

There is a need to radically depart from reliance on rain-fed food production through heavy utilization of irrigation. There is therefore the need for adequate provision of irrigation and drainage infrastructures which could be regarded as crucial for climate change adaptation

Agriculture needs to become professionalised with educational training incentives and development of human capital in the direction of crop and livestock production. A better educated farmer would for instance be able to absorb new information faster.

The Nigerian government should take a bold step to establish better-equipped weather stations as against the scanty and ill-equipped ones we currently have in Nigeria. With this, accurate weather forecast and predictions will be possible and this will help to prevent weather-related disasters through early warning and effective response/adaptation system. In addition, efforts need to be made towards tackling the dilapidated infrastructure in the country.

With the increasing rate of erratic rainfall patterns, drought and desertification, drought resistant and short duration high yielding crops should be developed through research efforts and made available to farmers.

Investment on improved agricultural technology by government and other stakeholders are very necessary for agriculture to be able to cope with climate change.

The high climate variability that characterizes the African continent presupposes that people have developed successful indigenous adaptation strategies. It is therefore advocated that indigenous knowledge and practices should be integrated into formal climate change mitigation and adaptation strategies.

There is need for effective capacity building to strengthen the most vulnerable group in agricultural production with requisite knowledge and information necessary for climate change mitigation and adaptation.

Desertification and other unhealthy environmental practices must definitely be curtailed if Nigeria must meet the 2015 target of the Millennium Development Goal (MDGs) of fighting hunger and poverty.

Farmers should also have regular information on current issues related to climate change and agriculture. This can be achieved through the strengthening of the nation's extension services perhaps by devolving the bulk of the services down to the local councils, which is closer to the farmers, and encouraging farmers to form farmer groups for enhanced capacity through group efforts. This may help them take advantage of the internet.

10 Conclusions

The foregoing has highlighted the critical challenges faced by the Nigerian agriculture in trying to adapt to the problem of climate change. Both government and the private sector, which should drive the agricultural sector through consistent policies, robust funding and infrastructure development, have failed to accord agricultural adaptation the priority it deserves. Moreover, the anticipated benefit from trade liberalization has failed to trickle down to the African farmer. In addition, the farmers have been slow in changing their farming practices such as bush burning, deforestation, rain-fed agriculture and land tenure systems, and they lack the requisite education, information and training necessary to adapt to climate change. These challenges need urgent attention by the relevant authorities because the problems of climate change are already with us. This paper has made recommendations that may guide the actions of these authorities – the government should not only decentralize its programs on poverty/HIV-AIDS and agricultural research (funding and activities), but should make them participatory. In addition, there should be explicit national agricultural policy framework, adequate provision for irrigation, drainage, weather forecasting and other agricultural technological infrastructure, an incentive for training in agriculture, participatory and on-going capacity building for farmers, drought resistant and short duration high yielding crops development, integration of indigenous and modern knowledge on climate change adaptation, strengthening of the extension services, and encouragement of formation of farmer groups.

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