

## CLIMATE CHANGE AND RESOURCE UTILIZATION IN NIGERIAN AGRICULTURE

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### ABSTRACT

*Climate change is already having predominantly adverse effects on the agricultural sector of the poorer parts of the world including Nigeria. Most crop and livestock production systems in Nigeria are low-technology based and are therefore heavily susceptible to environmental factors. This paper investigates the impact of climate change on agricultural resource utilization and productivity in Nigeria. The focus of the paper is the crop sector which is the more practised in comparison to the livestock sector. Time series data on the production of major crops (cassava, maize, and guinea corn) from the three ecological zones (coastal and rainforest, Savanna, and Sahel) obtained from the Federal Ministry of Agriculture, Central Bank of Nigeria and National Bureau of Statistics were combined. Data collected were on output, land, labour, fertilizer, seed, and credit for a period of thirty five years. Also, data from the Nigerian Meteorological Agency (NIMET) on long-term climatic variables (temperature and precipitation) for thirty five years (1975-2009) were collected. Precipitation and temperature were related with inputs variables (land, labour, fertilizer, seed, and credit). The ordinary least square regression analysis (production function) fits the data best. Decreased precipitation, increased temperature, increased hectarage cultivated, increased credit, and increased use of fertilizer have positive and significant impact on the production and productivity of the crops. Furthermore, the results show that the impact of precipitation on production is stronger than that of temperature. This suggests that the impact of climate change on production and productivity could be negative if the change increases temperature but reduces precipitation at the same rate and simultaneously. Moreover, the impact of other inputs (land, labour, credit, fertilizer, and seed) on production and productivity are positive, which supposes that increasing the availability and accessibility of these input will enhance crop production and resilient adaptation to the impacts of climate change for Nigerian agriculture.*

**Key words:** Climate change, resource utilization, agriculture, Nigeria.

### INTRODUCTION

The agricultural sector accounts for about 42 percent of Nigeria's Gross Domestic Product (GDP) while between 60 to 70 percent of the population are involved with farming (National Bureau of Statistics, 2009). These twin statistics on contribution to GDP and employment underscore the simultaneous importance of agriculture to Nigeria's macro-economic and microeconomic conditions especially on the livelihood of majority of Nigerians. However at the same time food insecurity is a major problem. Nigeria's food security situation is characterized by the threat of hunger and poverty which confront 70% of the population that live on less than ₦100 (US \$ 0.7) per day (FRN 2010).

Research and policy had before now implicated the challenge of resource availability, utilization and low productivity as among the explanations for the under performance of the Nigerian agricultural sector which manifest in the inability of the sector to adequately meet assigned roles of food source, income and provisions of raw materials among others. Smallholder farmers constitute 80% of all farm holdings but farm yield, especially crop yields are far below potentials. Explanations for this include inadequate access to and low uptake of resources, high quality seeds and inefficient production systems leading to regular shortfalls in production. Although growth rates averaged 7% in the 2006-2008 period, it is still below the

10% estimated as necessary for sustainable food security and poverty reduction and the country continues to import a substantial part of its food due to underexploited agricultural potential (FRN 2010).

It is against this background of an underperforming agricultural sector that the challenge of climate change is added. Because Nigeria's agriculture is predominantly low-technology based and heavily dependent on climate, it is very susceptible to environmental factors. The climate of an area is correlated to the vegetation and by extension the type of crop that can be cultivated. Temperature, rainfall, humidity, sunshine (day length) are some important climatic parameters at play with respect to the cropping systems, crop growth and yield, especially as irrigation use is very low (Adejuwon, 2004). Climate variability and change therefore have influence on agricultural production, resource use and productivity. The gap in knowledge exists in the dynamism of climate parameters, which require regular updating, and in this respect relating to the performance of the agricultural sector, resource use and productivity. The objective of this paper therefore is to examine these changing climate parameters and explain the implications for agricultural resource utilization and productivity. Lessons learnt would impact related researches, policies, programmes and projects, and should be of interest to the wider stakeholders' spectrum in the agricultural sector.

### **Nigeria's Climate Regime and Climate Change**

The climate in Nigeria ranges from a very wet coastal humid zone with annual rainfall around 4,000mm to the semi-arid Sahel region in the far north with annual rainfall below 600mm (Oguntoyinbo, 1982). The inter-annual rainfall variability, particularly in the northern parts is large, and often results in floods and droughts with devastating effects on food production and associated sufferings. Odjugo (2010) reported an increasing trend in temperature in Nigeria since 1901, which was gradual till the late 1960s, but sharper since the 1970s and has continued till date. A major part of the middle belt sub-humid to semi-arid areas experienced rainfall deficits from 1991-2006 over the World Meteorological Organisation reference period of 1961-1990, while a few areas to the northwest experienced surplus rainfall over the same period (Anuforom, 2009).

While climate change is contributing to aridity and desertification in northern Nigeria, it is increasing flooding and erosion (gully, sheet and coastal) in the southern parts especially in the coastal and rainforest zones (Uyique and

Agho, 2007). The Nigerian Environmental Study/Action Team (NEST, 2004), reported that sea-level rise and repeated ocean surges worsen coastal erosion, which is already a menace in the zone. The associated inundation exacerbates the intrusion of sea-water into fresh water sources and ecosystems, destroying such stabilizing systems as mangroves, and causing crop loss.

In the Savannah and Sahel, the impacts of climate change include increased variability, decreased rainfall, increased temperature and evaporation; frequent drought spells leading to water shortage; delayed and more variable onsets leading to changes in planting dates of annual crops; increasing desertification; and subsequently inadequate grazing resources; increased movement of pastoralists to the humid south for fodder and water; and in some regions to increasing rural-urban migration. These climate-related impacts and the potential adaptation measures are diverse and have to be seen in the context of Nigeria's agro-ecological, production and sociocultural diversities and in the context of rainfall and temperature trends and periodicities. Coping and adaptation measures to reduce vulnerability and strengthen the resilience of agricultural production thus range from actions at the farm households, communities, state and national levels. As such the framing policy environment also determines how effective such measures are.

### **Climate change and agricultural resource use**

There is a growing consensus in the scientific literature that over the past decades and coming decades, higher temperatures and changing precipitation levels caused by climate change had been and will continue to be unfavourable for agricultural production and productivity in many regions and countries (Yesuf *et al.*, 2008). To what extent this was and will be the case in Nigeria where both temperature and precipitation approach extremes has not received much research interest. A study commissioned by the Nigerian Environmental Study Team as part of her Building Nigeria's Response to Climate Change Project reported that climate change will have adverse implications on Nigeria's agriculture (Babatunde *et al.*, 2011).

There have been numerous studies of climate change, bulk of these were conducted in temperate and highly industrialized countries (Mendelsohn, 2000). Most of the empirical work to date on the effect of climate change on crop production has focused on Europe, the United States, Canada and Australia (Molua and Lambi, 2007). Most of the physical and economic modelling and analysis has focused on the northern latitudes and high-income countries.

Worldwide little research has focused on developing regions such as those in the tropical rainforest where the poor who may be most vulnerable to adverse changes live. Scientists fear that the most adverse effects are likely to occur in this region (Molua and Lambi, 2007).

A considerable number of studies have been done to investigate the impact of climate change on yields of crops under controlled experiments (Du Toit *et al.*, 2002; Kiker *et al.*, 2002; Durand 2006). To simulate the water requirement for optimum yield, these studies require parameter values for precipitation, temperature, crop, and soil. One noticeable limitation of this approach is that it assumes for simplicity that other inputs (such as labour, land, and fertilizer) are utilized optimally. Other studies employed the Ricardian approach of Mendelsohn, Nordhaus, and Shaw (1994) to investigate the impact of some climate variables on net revenue from commercial and subsistence farming in sub-Saharan Africa (Deressa, Hassan, and Poonyth 2005; Gbetibouo and Hassan, 2005; Benhin, 2006; Maddison, Manley, and Kurukulasuriya 2006; Kurukulasuriya and Mendelsohn 2006; Molua and Lambi, 2007). Although these studies have generated interesting results, they do not address the direct impact of climate change on agricultural productivity, specifically crop productivity, in Nigeria. This paper addresses this shortcoming by directly estimating a production function for major crops grown in the three main agro-ecological zones (Sahel, Savanna, Rainforest and Coastal zones) of Nigeria with the two relevant climate variables, that is, temperature and precipitation, together with the other traditional inputs (land, labour, capital (seeds cultivated, credit, and fertilizer).

#### INFORMATION SOURCES AND TYPES

Nigeria lies on the southern coast of West Africa between 2° and 15° E longitudes and 5° and 15° latitude, and occupies approximately 923,768 square kilometers. The southern coast faces the Gulf of Guinea. Nigeria offers an array of environment, ranging from the belt of mangrove swamps and tropical rainforest in the lower elevations along the coast, to the open woodland and savannah on the low plateau which extends through much of the central part of the country, to the plains in the north and highlands to the east. Much of the southern half of the country is characterized by a long growing period (200 – 360days) with bimodal rainfall seasons and average annual rainfall of 2000mm. The northern half of the country on the other hand has a much shorter unimodal rain distribution. Nigeria is a country with a population of over 140 million (NPC 2006). It is

divided based on the agro-ecological zones the Sahel, (North East) Savanna (North West and North Central), the rainforest and coastal zones (South West, South East, and South South) (BNRCC, 2010).

Data for the study was secondary data. The secondary data collected were climatic data; hectareage cultivated for each major crop, quantity of seed cultivated, fertilizer used, labour applied, credit used and crops output data of the major crop in each agro-ecological zone. Data on climatic variables such as annual temperature means and annual rainfall means were collected for a period of thirty five years (1975-2009) from the Nigerian Meteorological Agency (NIMET). Data on hectareage cultivated, fertilizer used, labour applied, seeds cultivated, credit used and crops' output were collected for a period of thirty five years (1975-2009) from the Federal Ministry of Agriculture, Central Bank of Nigeria, and National Bureau of Statistics. All secondary data obtained were time series data and were collected for a period of thirty five years (1975-2009). The major crop grown in the Rainforest and Coastal zones is cassava; the major crop grown in the Sahel is Guinea Corn while it is Maize in the Savanna (NBS, 2006b). Data were analyzed with regression analysis (production function approach).

**The Production Function:** The behavioural model of interest, which is the production function for major crop, is:

$$\log Y = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + \beta_6 \log X_6 + \beta_7 \log X_7 + ui, (1)$$

Where;

$Y$  is annual mean output of crop (Tonnes)

$X_1$  is mean annual hectareage cultivated land (Ha)

$X_2$  is the mean annual labour used (Man Hours)

$X_3$  is the mean annual fertilizer used (Kg);

$X_4$  is the quantity of seed cultivated (Kg);

$X_5$  is the mean amount of credit used (₦)

$X_6$  is mean annual temperature (measured in degrees Celsius)

$X_7$  is mean precipitation (measured in millimeters)

$U$  is the error term

$\beta_k$  is the vector of the  $k = 0, \dots, 7$  parameters to be estimated.

Note that since all the variables are in logarithms, the coefficients are elasticities. It is expected that the coefficients of all the inputs should be positive.

#### RESULTS AND DISCUSSION

The results from the regressions, which are reported in Table 1, show that the overall effect of input variables are significant in explaining the variation in cassava, maize, and guinea corn production in the rainforest and coastal,

Savanna, Sahel zones of Nigeria respectively, and show high t-statistics for all the variables in the rainforest and coastal zones. In the Savanna and Sahel zones, inputs like land, fertilizer, credit, temperature, and precipitation were the important determinants of maize production and guinea corn production respectively.

Moreover, the impact of mean temperature on cassava, maize, and guinea corn production and productivity is positive in each case, and negative in the case of precipitation, with precipitation having the overall highest impact on production and productivity. An increase in mean precipitation, all other things being equal, will reduce production and productivity of cassava, maize, and guinea corn respectively. This could be as a result of flooding and erosion already occurring in the area. Floods and erosion reduce farmers' output. Precipitation in the rainforest and coastal zones is already going above optimum for cassava and already inducing flooding and erosion in the area.

The cases in the Savanna and Sahel could be due to shortage of water for the growth of maize and guinea corn. As noted by Durand (2006), precipitation is the most important driver of crop production. The high-production elasticity coefficient with respect to precipitation indicates that marginal reductions in precipitation that may result from climate

change could affect cassava, maize and guinea corn production significantly. It is therefore important that farmers in the Savanna and Sahel regions be encouraged to irrigate their crops to mitigate the impact, all other things being equal. Very important is the fact that if climate change decreases mean precipitation but increases mean temperature marginally and simultaneously, the overall impact on production and productivity will be negative since the coefficient of the mean precipitation is higher. The future climate changes could have devastating negative impacts on agriculture in Nigeria, because the changes decrease crop productivity over the entire country (Babatunde *et al.*, 2011). The greatest impact occurs at the north (Sahel and Savanna), where a drier and hotter future climate is projected.

Inputs like fertilizer, credit, and land were all positive and significant in affecting cassava production in the rainforest and coastal zones; maize production in the Savanna zone; and guinea corn production in the Sahel zone. This suggests greater policy option that increasing the availability of these inputs in Nigeria will firstly enhance resilient adaptation to the impacts of climate change and secondly impact positively on agricultural production and productivity.

**Table 1: Estimated production function of major crops grown in the three main ecological zones of Nigeria using ordinary least square (OLS)**

Variable	OLS For Cassava (Rainforest and Coastal Zones)		OLS for Maize (Savanna Zone)		OLS for Guinea Corn (Sahel Zone)	
	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Constant	-0.981	-0.12	1.002	1.89*	0.460	0.102
Land (Ha)	0.256	3.58***	0.102	1.99**	2.316	1.91*
Labour (in Mandays)	0.360	1.92*	0.449	0.179	0.180	1.21
Fertilizer (kg)	0.320	1.81*	0.179	4.279***	0.419	1.92*
Seed (kg)	0.868	1.76*	0.170	1.21	0.325	0.180
Credit (₦)	0.212	1.81*	2.306	1.94*	0.180	1.82*
Temperature (°C)	5.207	1.99**	0.440	1.79*	0.256	4.279***
Precipitation (mm)	-6.188	3.12***	-0.868	-7.652***	-1.790	-10.786***
R <sup>2</sup>	0.44		0.41		0.39	
F- Ratio	6.12***		5.61***		4.92***	

\*\*\*Significant at 1% level of probability

\*\*Significant at 5% level of probability

\*Significant at 10% level of probability

## CONCLUSIONS AND RECOMMENDATIONS

This paper presents and discusses the results of the impact of climate change on maize yield in Nigeria using the production function. The results from the production function, which fit the data better, point to the fact that a percentage reduction in mean precipitation could have greater negative impact on cassava, maize, and guinea corn yields vis-à-vis the gain from an equal percentage increase in mean temperature due to climate change.

The corresponding elasticity coefficients of temperature and precipitation are 5.207 and 6.188 for the rainforest and coastal zone (cassava production), 0.440 and 0.868 for the Savanna zone (Maize production), and 0.256 and 1.790 for the Sahel zone (Guinea Corn production) respectively. There is enough evidence that shows that the mean temperature has increased. Precipitation is expected to increase in the rainforest and coastal zones of Nigeria thereby increasing inundation of floods and erosion. On the other hand, mean rainfall is expected to decrease, and its variance is expected to increase in the Savanna and Sahel Zones.

This would impact negatively on cassava, maize and guinea corn yields and consequently pose a serious threat to food security within Nigeria and the countries within the entire West African region that, in total, obtain greater proportion of their cassava, maize and guinea corn from Nigeria. This study also found that the impact of land, credit, and fertilizer on yield of cassava, maize and guinea are positive but with lower elasticities than that of precipitation. This indicates that irrigation may partially mitigate the impact of decreased precipitation on yield of maize and guinea corn in the Savanna and Sahel regions, all other things being equal. For the rainforest and coastal zones which is already experiencing erosion and flood inundation, emphasis should be building of embankments to protect farms from floods, planting trees as hedge rows, adopting full tillage for cassava farming to protect the crops from flood and erosion.

Inputs like fertilizer, credit, and land were all positive and significant in affecting cassava production in the rainforest and coastal zones; maize production in the Savanna zone; and guinea corn production in the Sahel zone. This suggests greater policy option that increasing the availability of these inputs in Nigeria will firstly enhance resilient adaptation to the impacts of climate change and secondly impact positively on agricultural production and productivity.

Statistical significant impacts exist between climatic variables (temperature and precipitation) and crop (cassava, maize, and guinea corn) yields. This indicates the importance of climate to crop production and resource utilization and productivity. Climate change beyond optimum or far below optimum will have dire consequences for agriculture in Nigeria and recommends scientific, technological and management changes that weans the agriculture away from heavy dependence on the environment. Such measures as small irrigation schemes and biotechnology are recommended. Since agriculture is the main means of livelihood for the inhabitants, livelihood, income, food security and employment will also be drastically by adverse emerging climate conditions. This scenario can be extrapolated to other regions of the world with similar climate conditions with some variations depending on local natural resource base as well as social and economic circumstances. This creates the basis for urgent action and intervention by researches and policy makers in examining and designing programmes and projects which generate lessons for adaptation in order to cushion colossal potential human tragedy in form of food insecurity, poverty and social conflict, while contributing towards the development of the agricultural sector.

## ACKNOWLEDGMENT

The Nigerian Environmental Study Action team, Ibadan, Nigeria in partnership with Marbek and CUSO-VSO of Canada that has been jointly implementing a CIDA funded Building Nigeria's Response to climate Change project since 2007. Also appreciated is Mr. Robert Onyeneke the Research Officer at BNRCC/NEST for his inputs.

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