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EMPIRICAL ANALYSIS OF AGRICULTURAL PRODUCTION AND CLIMATE CHANGE: A CASE STUDY OF NIGERIA

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ABSTRACT
The study analyzes climate change and agricultural production in Nigeria. The specific objectives includes evaluation of the trend changes in climatic parameter in Nigeria; analyzing of the trend in agricultural production; and examination of the dimension and linkage between agricultural production and climatic change parameters in Nigeria. Time series data were employed for the study. The data was sourced from the Central Bank of Nigeria and National Bureau of Statistics. Descriptive statistics and granger causality test analysis were the analytical tools used. It was observed that there is continuous rise in output from 1987 to 2000 before it dropped in 2001. The rise can be seen as a result of many programs and policies of the government, such as the Lower Niger River Basin Development Authority (LNRBDA) and The Agricultural Development Program (ADP). Temperature, on the other hand, remains relatively constant and does not affect agricultural output. The Granger causality approach revealed that changes in rainfall (climatic parameter) positively affects agricultural production in Nigeria. It is, therefore, recommended that if agricultural production will be increased and sustained, irrigation is the most suitable mode of water provisions, which would have not have negative influence on the environment.

Keywords: Agricultural Production; Climate Change; Rainfall; Temperature; Nigeria

INTRODUCTION
The issue of climate change has become more threatening, not only to the sustainable development of socio-economic and agricultural activities of any nation, but to the totality of human existence (Adejuwon, 2004). Human beings have been adapting to the variable climate around them for centuries worldwide. Local climate variability can influence peoples' decision with consequences for their social, economic, political, and personal conditions and can affect their lives and livelihood (UNFCC, 2007). As further explained by United Nation Framework on Climate Change (UNFCC) the effect of climate change implies that the local climate variability that people have previously experienced and adapted to is changing and this change is observed in a relatively great speed.

The Intergovernmental Panel on Climate Change (IPCC) has warned that the latest scientific evidence points strongly towards a climate changing world (CGAIR, 2000), which has been supported by many researchers. Although, the degree of the impact of the climate change and its distribution is still debated, the current evidence of high temperatures, rising sea levels, arctic thinning, and low rainfall suggests that countries in temperate locations may benefit from small economic advantages because additional warming will increase their agricultural sector (Mendelsohn, Ariel & Arne, 2000; CICERO, 2000).

Many countries in tropical and sub-tropical regions, of which Nigeria is included, are expected to be more vulnerable to warming because of additional temperature increases that will affect their marginal water balance and harm their agricultural sector (Mendelsohn et. al., 2000). The problem is expected to be most severe in Africa, where current information is the poorest, technological change has been the slowest, and the domestic economies depends heavily on agriculture (Action aid, 2008).

Agricultural production remains the main source of livelihood for most rural communities in developing countries and sub-Saharan Africa, in particular. Here, agriculture provides a source of employment for more than 60 percent of the population and contributes about 30 percent of gross domestic product (Kandlinkar & Risbey, 2000). Rain-fed faring dominates agricultural production in sub-Saharan Africa, covering around 97 percent of the total cropland and exposes agricultural production to high seasonal rainfall variability (Alvaro, Tingju, Katrin, Richard & Claudia, 2009). Agriculture in the developing world is particularly vulnerable to climate change (Action aid, 2008). IPCC says that in some African countries, yield from rain-fed agriculture could be reduced up to 50 percent by the year 2020 (Intergovernmental Panel on Climate Change, IPCC, 2007). Also, as submitted further by Lobell, Marshal, Tebaldi, Mastrandrea, Falcon, & Naylor, (2008), central and south Asia crop yield could fall by up to 30 percent by 2050 as a result of climate change.

The location, size of, and characteristics relief in Nigeria gives rise to a variety of climates; ranging from tropical rain forest climate along the coasts to the Sahel climate in the northern parts of the country, each being different by its annual precipitation, sunshine, and other climatic elements (FGN, 1997; Adejuwon, 2004). The diverse nature of biological diversity results, mainly, in seven vegetation zones: the mangrove swamps, the salt water and fresh water swamps, tropical rain forests, guinea savannah, derived savannah, Sudan savannah, and Sahel savannah (Adejuwon, 2004). As further explained by Adejuwon, the country (Nigeria) experiences large, spatial and temporal variations in rainfall and less variation in evaporation and evapo-transpiration. Consequently, rainfall is by far the most important element of climate change in Nigeria and a good source of water supply in the country.

Climate change is the most severe problem that has been faced in this present day and is more severe than the threat of terrorism (King, 2004). In light of this, rainfall and temperature data was used for this study.
Recognizing that Nigeria is confronted by major environmental problems and every climate study indicates that Nigeria is one of the countries that are vulnerable to climate change (Obioha, 2008) and that the agricultural sector is under this threat, served as the basis for this study. The study, however, was aimed at answering questions like: Are there changes in the climatic parameter of Nigeria? Is there a decrease or increase in the level of agricultural production in Nigeria? Are there linkages and relationships between agricultural production and the climate variables under study? Are there any significant impacts of the climate change on agricultural production?

Climate variation and changes can have significant impacts on agricultural production, forcing farmers to adopt new practices in response to altered conditions. Higher temperature, changes in precipitation, and increased climate variability can affect agriculture, forestry, and rural areas (Bryant, 1997).

Several studies indicate that climate change is already taking place worldwide and that the climate system is likely to experience some amount of changes, regardless of whether emission reductions are successfully undertaken (Santer, Taylor, Wigley, Johns, Jones, Karoly, Mitchell, Oort, Penner, Ramaswamy, Schwarzkopf, Stouffer, & Tett, 1996; McCarthy, Canziani, Leavy, Dekken, & White, 2001). Despite this dire prediction, there have been relatively few empirical studies of African agriculture, as a whole, not to mention individual countries in Africa (Kurukulasuriya& Rosenthal, 2003) to which Nigeria is a major part.

It is often submitted that climate is one of the major elements that influence agricultural productivity, but the extent of these is not mostly shown and this also is one of the focuses of this study. Hence, the main objective of this study is to analyze Nigerian agricultural production and climate change. The specific objectives are to: examine the trend of climatic parameters; analyze Nigerian agricultural production; and examine the dimension and linkage between agricultural production and climatic change parameters.

METHOLODOLOGY

The study area is Nigeria. Nigeria is one of the sub-Saharan African nations in the western part of the Africa and shares land border with the republic of Benin to the west, Chad and Cameroon to the east, Niger republic to the north, and its coast lies on the gulf of Guinea (Wikipedia, 2009). In Nigeria, demarcation by climate regions proposes that three regions exist: the far south, the far north, and the rest of the country. The far south is defined by its tropical rain forest climate, where annual rainfall is 60 to 80 inches per year. The far north is defined by its almost desert-like climate, where rainfall is less than 20 inches per year. The rest of the country, everything in between the far north and the far south, is savannah and rainfall is between 20-60 inches per year (Nation Master, 2009).

The data used was obtained from the Federal Bureau of Statistics, the Central Bank of Nigeria (CBN) bulletin, Food and Agricultural Organization Publication (FAO), and Nigeria Meteorological Agency. Time series data of rainfall and temperature over a period of 22 years was used for this study. The data was disaggregated and aggregated into seven zones using simple means and averages.

The analytical tools employed in the study include descriptive tools and Granger Causality test analysis. The Granger Causality test, according to Granger (1969), involved the estimation of the following pairs

$$W_t = \sum_{i=1}^{n} \alpha_1 Z_{t-1} + \sum_{j=1}^{n} \beta_j W_{t-j} + U_{1t}$$

$$Z_t = \sum_{i=1}^{n} \alpha_1 Z_{t-1} + \sum_{j=1}^{n} \delta_j W_{t-j} + U_{2t}$$

Where U_{1t} and U_{2t} is a disturbance term; Wt = Climatic elements at time t; Zt = Agricultural output at time t; and t-1 = Lag variables. By this model, a variable that causes the order is identified. This leads to a regression model with a lag variable, which in its explicit form, is given as:

$Y_t = \beta_0 + \beta_1 X_1 + \beta_2 X_{t-1} + \beta_3 Y_{t-1} + U_t$

Where Y_t is a dependent variable estimated by the Granger model (W_t or Z_t); Y_{t-1}, X_{t-1} are lagged dependent and independent variables; Ut is an error term.

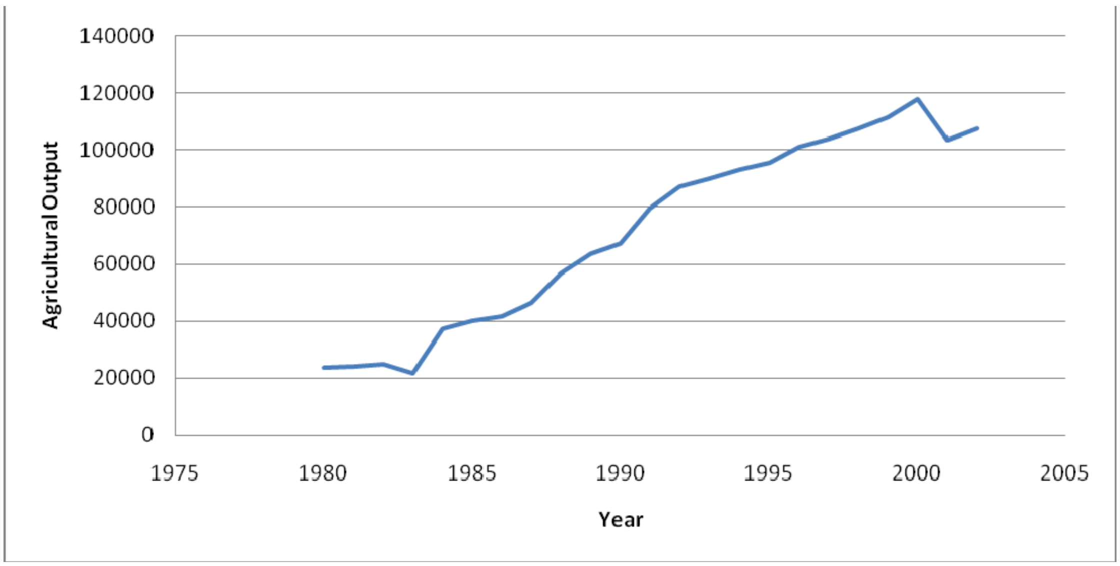
To avoid spurious effect of the regression of the data, transformation into stationary was done using Augmented Dickey-Fuller test. A non-stationary test was performed before the Granger Approach, using:

$$\Delta Y_t = Y_t - Y_{t-1}$$

RESULTS AND DISCUSSION

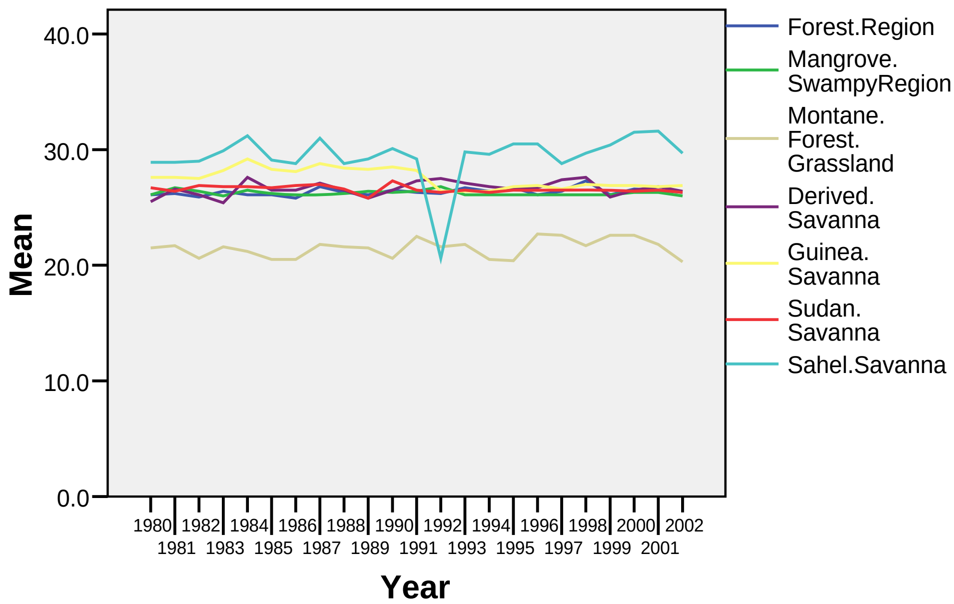
The lowest agricultural production was observed in the year 1983. This can be traced to the early Pre-sap era when Nigeria experience a sharp increase in foreign earnings as a result of increased oil revenue. Increments observed after this year can be likened to government policies aimed at improving agriculture in Nigeria. A sharp drop was also experienced in the year 2001, which may be due to climatic factors, changes in political views, and unrest observed in some parts of the country.

Fig (1) **Trend of Nigeria Agricultural Output**



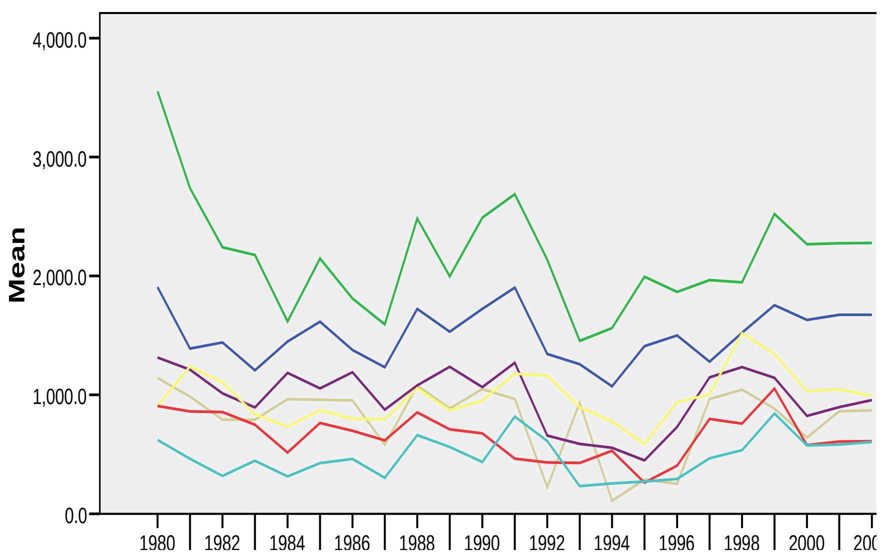
The trend of temperature in Nigeria is relatively constant, which can also be linked to the irregular movements of rainfall, which regulates the condition of the atmosphere. The sharp drop in the temperature of the sahel savannah in the year 1992 may be due to the increase in rainfall observed in this area in the preceding year and year in question.

Fig (2) **Temperature trend of Nigeria by Zones**



The rainfall pattern is irregular, as shown in figure 3. The lowest rainfall was observed in period of 1994 and 1996 for the all considered zones. After which, a sharp, but irregular, increase was observed. This is likely be the beginning of the observed climate change in Nigeria.

Fig (3) **Rainfall Trend of Nigeria by Zones**



The result of the stationary test shows that temperature changes were stationary at all levels (table 1).

Agricultural output exhibits unit root at levels, but became stationary after the first differencing. The differencing, therefore, depicts the change in production of the present year and previous year's output may be as a result of change in inventory.

The stationarity of agricultural output, after the first differencing, enables the Granger causality test to be done (Maddala, 2002)

Table 1: Result of Stationary Test

Variables	Level	1st Difference	2nd Difference	Unit Root	Decision
Agric. Output	-0.993317	-4.79998*	-7.763588*	I(1)	Non-stationary
Temperature	-5.2087*	-7.5048*	-8.6506*	I(0)	Stationary
Rain	-3.0189	-4.9767	-8.0587	I(1)	Non-stationary

Critical value at 1% = -3.7667

The result of the causality test shows that there is linear causation from rainfall to agricultural output change in Nigeria, which means that agricultural production depends on rainfall (table 2).

Table 2: Granger Causality Test Result: Output and Rainfall

Variables	Observation	F-Values	Probability	Decision
$Z \rightarrow W_1$	32	0.09095	0.76173	Reject
$W_1 \rightarrow Z$	32	3.14012	0.08690*	Accept

* Significant relationship established at 10% confidence level, Z= Output, W_1 = Rainfall

Table 3 presents the results of linkage between the Nigeria agricultural production and temperature.

Table 3: Granger Causality Test Result: Output and Temperature

Variables	Observation	F-Values	Probability	Decision
$Z \rightarrow W_2$	22	0.22409	0.64134	Reject
$W_2 \rightarrow Z$	22	0.02544	0.87496	Reject

* Significant relationship established at 10% confidence level, Z1= Output, W_2 = Temperature

This result shows that there is no directional causation from temperature to agricultural production in the year under study. This implies from the results that there is no relationship between temperature and agricultural production in Nigeria. This may be as a result of the temperature measurement, over the period examined, being relatively constant.

Table 4: Regression result of Output and Rainfall

Variable	Co-efficient	Standard Error	t-statistics	Probability
Constant	4.031846*	0.042979	93.80876	0.0000
$LY_{(-1)}$	-0.000214	0.009879	0.025760	0.9797
LX_1	0.242634*	0.009054	26.79840	0.0000
$LX_{(-1)}$	0.013680	0.008388	1.630893	0.1213
ECM	0.99967*	0.008477	117.9303	0.0000

R^2 = 0.999824, F-Statistics = 24198.0

The regression results are given by:

$LY = 4.031846 - 0.000214LY_{(-1)} + 0.242634LX_1 + 0.013680\ LX_{(-1)}$

Where Y is agricultural output, X_1 is rainfall, $LY_{(-1)}$ is lagged output, and $LX_{(-1)}$ is lagged rainfall.

The result of the regression shows that there is positive impact on agricultural output at 5% significant level. This means that the increase and decrease in the rainfall pattern affects the current output that leads to a rise or fall in output. The effect, as shown in table 4, implies that a 0.24 increase change in rainfall will likely result into a unit increase change in agricultural output and vice versa.

CONCLUSION AND RECOMMENDATION

This study analyzes the climate change and agricultural production in Nigeria. The trend analysis of agricultural production shows that there is continuous rise in output from 1987 to 2000 before it dropped in 2001. Temperature was revealed from the study as relatively constant and does not have a linkage with agricultural output. Rainfall is shown to exhibit variability. The Granger causality approach showed that there is a relationship between changes in rainfall (climatic parameter) and agricultural production.

Considering the result of the analysis, the current changes in climatic factors can be minimally controlled if the government gears their policy towards mitigation procedures and also if the private sectors focus on increasing the output of agricultural production by developing technology, which will not contribute to changes in climate, but will increase production. It is, therefore, recommended that if agricultural production will be increased and sustained, irrigation, as a constant water supply, is the most suitable mode of water provision, which will have positive influences on the environment. Hence, the efforts and policies should be gear towards providing effective irrigation facilities.

REFERENCES

Action aid. (2008). *The time is now; Lesson from farmers to adapting to climate change.* Retrieved from: www.actionaid.org, on August 10, 2009.

Adejuwon, S.A. (2004). *Impact of climate variability and climate change on crop yield in Nigeria*. Contributed paper to Stakeholders workshop on Assessment of Impact & Adaptation to Climate Change (AIACC). 2-8.

Alvaro, C., Tingju, Z., Katrin, R.., Richard, S.J., & Claudia, R. (2009). *Economy-wide impact of climate change on Agriculture in Sub-Saharan Afric.* International food policy research Institute (IFPRI) discussion paper, No: 00873 pp1

Bryant, E. (1997). Climate processes and change. Cambridge, UK: Cambridge University Press, 45.

Centre for International Climate and Environment Research – Oslo (CICERO). (2000). *Developing strategies for climate change.* The UNEP Country Studies on Climate Change Impact and Adaptation Assessment. Retrieved from: www.cicero.uio.no, on July 2, 2009.

Consultantive Group on International Agricultural Research (CGIAR). (2000). *The challenge of climate change: Poor farmers at risk.* Retrieved from: www.cgiar.org/, 4-6.

Federal Government of Nigeria (FGN). (1997). *Drought Management in Nigeria; What can people do to minimize its impact?* Abuja: Federal Ministry of Environment.

Granger, C.W.J. (1969). Investigating causal relation by econometrics and cross-sectional method. *Econometrica,* 37, 424-438.

Intergovernmental Panel on Climate Change (IPCC). (2007). *Fourth Assessment Report*. Retrieved from: www.ipcc.ch, on July 2, 2009.

Kandlinkar, M. & Risbey, J. (2000). Agricultural impacts of Climate Change; if adaptation is the answer, what is the question? *Climate Change,* (45), 529-539.

King, D. (2004). Climate change Science: Adapt, Mitigate or Ignore? *Science*, 303, 176-177.

Kurukulasuriya, P. & Rosenthal, S. (2003). *Climate Change & Agriculture : A review of impacts & adaptations*. Paper 91 in Climate Change Series, Agriculture & Rural Development and Environment Department. Washington, D.C.: World Bank.

Lobell, D.B., Marshal, B.B., Tebaldi, C., Mastrandrea, D.M., Falcon, W.P., & Naylor, R.L. (2008). Prioritizing climate change adaptation needs for food security in 2030. *Science*, 319(5863), 607-610.

Maddala, G.S. (2002). *Introduction to Econometrics*. England: John Wiley and Sons, Lt. 3rd Edition, 379 – 380.

McCarthy, J., Canziani, O.F., Leavy, N.A., Dekken, J.D., & White, C. (Eds). (2001). *Climate change 2001: Impact, Adaptation & Vulnerability.* IPCC, Cambridge, UK: Cambridge University Press, 44-65.

Mendelsohn, R., Ariel, D., & Arne, D. (2000). Climate Impact on African Agriculture. *Climate change,* (45), 583-600.

Nation Master. (2009). Nigeria History. Retrieved from: www.nationmaster.com, on September 6, 2009

Obioha, E. (2008). Climate Change, Population Drift & Violent Conflict over land resources in North Eastern Nigeria. *Journal of Human Ecology,* 23(4), 311-324.

Santer, B.D., Taylor, K.E., Wigley, T.M., Johns, T.C., Jones, P.D., Karoly, D.J., Mitchell, J.F.B., Oort, A.H., Penner, J.E., Ramaswamy, V., Schwarzkopf, M.D., Stouffer, R.J., & Tett, S. (1996). A search for human influence on the thermal structure of atmosphere. *Nature,* 382, 139-146.

United Nation Framework on Climate Change (UNFCC). (2007). Climate change impact, vulnerability & adaptation in developing countries. *Journal of Climate Change,* 8(3), 4-8.

Wikipedia (2009) “Nigeria” Available online at **www.en.wikipedia.org/nigeria** Retrieve on September, 6 2009

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