Journal of Agriculture and Environmental Sciences
June 2015, Vol. 4, No. 1, pp. 138-147
ISSN: 2334-2404 (Print), 2334-2412 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jaes.v4n1a18
URL: http://dx.doi.org/10.15640/jaes.v4n1a18

Impact of Climate Change on the Productivity of Cassava in Nigeria

Mbanasor, Jude A[1]; Nwachukwu, Ifeanyi N; Agwu, Nnanna M & Onwusiribe, Ndubuisi C

Abstract

The issue of climate has become a recurrent subject of global debate in recent times. The intensity of the debate is on the increase due to the enormity of the challenge posed by the phenomenon especially in the third world. Though the threat of climate is universal, agricultural production activities are generally more vulnerable than other sectors. The vulnerability of the Nigerian agricultural sector to climate change is of particular interest to policy makers, because agriculture is a key sector in the economy accounting for between 60-70% of the labour force and contributing about 40% to the GDP. In line with the foregoing, the study was carried out to examine the impact of climate change on the productivity of cassava with specific interest in assessing changes in climate variables; estimating growth rate in production and productivity of the enterprise and evaluating the impact of climate variables on the productivity of the enterprise. Analytically, trend analysis was performed in assessing changes in climate variables and estimating growth rate in production and productivity of the enterprise. The quadratic function of the multiple regression analysis was employed in order to ascertain the impacts of climate variables on the productivity of the enterprise. However, secondary data were collected from literature, National Root Crops Research Institute (NRCRI), National Meteorological Centre (NIMET), National Bureau of Statistics (NBS), State Agricultural Development Programmes (ADPs), Food and Agriculture Organization data base, World Bank Statistical Bulletin, United Nations Development programme (UNDP) statistical reports and other sources. In the course of data analysis, trend analysis, log quadratic trend equation and multiple regression analysis were applied. The result of the trend analysis showed that cassava production trace out a positive linear trend while annual precipitation, temperature and carbon dioxide (CO_2), over the period were unstable. However, the trend forecasts suggested increasing rates of cassava production, temperature and decreasing CO_2 emissions in the next five years. The log quadratic equation revealed that cassava production and productivity recorded positive and significant growth during the period with a compound growth rates of 0.976 and 0.969 respectively. The multiple regression model showed that precipitation posted positive coefficient in the short run but imposed a negative effect on cassava productivity over a long period of time while temperature influenced cassava productivity negatively both in the short and long run. On the basis of findings, the study suggested the adoption of appropriate and proactive adaptation cum mitigation measures. These may include use of drought tolerant/resistant varieties, adoption of sustainable land management practices and intensification of campaigns to promote healthy environmental practices among citizenry.

Keywords: Climate Change, Productivity, Cassava

Introduction

In recent times, the issue of climate change through extreme temperature, frequent flooding, drought and increased salinity of water used for irrigation has become a recurrent subject of global debate. The intensity of the debate is on the increase due to the enormity of the challenge posed by the phenomenon especially in the third world.

[1] Department of Agribusiness and Management, College of Agricultural Economics, Rural Sociology and Extension, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

This is as a result of the widespread poverty, prevailing slash-and-burn agriculture, green house emission, erosion and burning of firewood and farm residues that characterize the developing economies to which Nigeria belong (Ajetombi and Abiodun, 2010). Though the threat of climate is universal, agricultural production activities are generally more vulnerable than other sectors. The vulnerability of the Nigerian agricultural sector to climate change is of particular interest to policy makers because agriculture is a key sector in the economy accounting for between 60-70% of the labour force and contributing about 40% to the GDP (Adejuwon, 2004). The extent to which one can hold climate responsible for variability in agricultural productivity in Nigeria will, for a long time, remain a subject of research vis- a-vis the interplay of other determinants. The production of most major crops has declined in magnitude since the drought of the 1970s which was recorded as the first evidence of climate change in Nigeria. Although efforts have been made by several governments in Nigeria to revamp the sector through multifarious programmes, the rate of population growth which has made it difficult for demand to meet supply has become a source of great worry (Nwachukwu *et al.,* 2010). More worrisome is the fact that the climate change impacts in Nigeria are more predominantly man- made related than natural. Observation has shown that their causes ranged from poor drainage system, waste disposal to urban planning distortions among others. Furthermore, it has been observed that climate variability impacts usually depend on a range of climate parameters' changes and on the country's social, cultural, geographical and economic backgrounds. The location, size and the characteristics of the relief gave rise to various types of climates in Nigeria ranging from tropical rainforest along the coasts to Sahel climate in the Northern parts of the country. Annual rainfall ranges from greater than 350 mm in the fairly wet coastal area to less than 600 mm of the Sahel region in the northwestern and northeastern parts (Adejuwom, 2004).

The inter-annual variability of rainfall, particularly in the North is large, often culminates in climate hazards especially hoods and droughts with their devastating effects on food production and associated catastrophic consequences. By virtue of Nigeria's location primarily within the lowland humid tropics, the country is generally characterized by a high temperature regime almost through the year. The mean maximum temperature in the far South is between 30°C-32°C while in the North it is between 36°C-38°C. More so, the diverse nature of Nigeria's climate consequently gave rise to a high degree of biological diversity resulting mainly in six vegetation zones: the Mangrove swamps, the Salt water and Fresh water swamps, Tropical lowland rainforests, Guinea savanna, Sudan savanna and Sahel savanna. From a water balance perspective, the country 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 in Nigeria and thereby becomes a critical index for assessing agricultural and water resources in the country (Adejuwon, 2006). Based on the projections of 1PCC (1996), the humid tropical zone of Southern Nigeria, which is already too hot and too wet is expected to be characterized by increase in both precipitation (especially at the peak of the rainy season) and temperature. Already temperature increases of about 0.2°C-0.3°C per decade have been observed in the various ecological zones of the country, while drought persistence has characterized the Sudan - Sahel regions, particularly since the late 1960s. For the tropic humid zones of Nigeria, precipitation increases of about 2 - 3% for each degree of global warming may be expected. Thus, it is reasonable to anticipate that the precipitation would probably increase by approximately 5- 20% in the very humid areas of the forest regions and Southern Savanna areas. The increase in temperature in these areas would also possibly increase evaporation, reducing the effectiveness of the increase in precipitation.

It is therefore not surprising that there is a growing consensus in the scientific literature that over the coming decades higher temperatures and changing precipitation levels caused by climate change will be unfavourable for crop growth and yield in many regions and countries (Yesuf *et al*., 2008). To what extent this will be the case for Nigeria particularly in the Southeast rainforest zone where both temperature and precipitation levels reach extremes has not received substantial research interest and attention (Nwajiuba and Onyeneke, 2010). Previous studies on the trend of climate change in the rainforest zone of Nigeria to which the Southeastern states belong (Munonye and Okoh, 2008; Nwajiuba *et al*., 2008; Nnaji and Duruji, 2008; Nwajiuba and Onyeneke, 2010) failed to provide in-depth simultaneous insights of the trend of climate variables in the zone (eg. temperature, rainfall, relative humidity) affecting crop yield. However, Nwajiuba and Onyeneke (2010) tried to incorporate the climatic variables in their linear regression model but failed to include a time trend in the model. A time trend serves as a proxy to the non- inclusion of some non-climate variables which are important in agricultural productivity. This presents a research gap.

Given the fact that agriculture depends largely on the climate, it follows therefore that any change in climate is bound to impact on the sector and other socio-economic activities. The impact may be positive or negative. According to NBS (2006), the major crops in the Southeast rainforest zone of Nigeria are Cassava, Yam and Maize. Cassava, however, is the most important staple food in Nigeria. Although Nigeria grows Cassava in large quantities, its cultivation is on small farms often in fields to be set aside as fallow and even cropped on marginal soils, replacing crops that require greater soil fertility (Adebayo *et al*., 2009). Africa claims 62% of the total world production of cassava. Nearly two-thirds of total Cassava production in Africa (38.3 million tonnes) is grown in Nigeria, making it the largest producer in the world with about 19% of global market share (Sanni *et al*., 2009; Adebayo *et al*., 2009). Based on 2002 estimates, southeast was the second highest producer on per capita basis with 0.56 tonnes per person after-North central with 0.72 tonnes per person. Within the zone, Enugu and Imo states dominate Cassava production (Phillips *et al*., 2004). Remarkable successes have been recorded in Cassava from production, processing to marketing at domestic and commercial scales. In production, increases in improved varieties and crop area have been achieved through various programmes by International Institute of Tropical Agriculture (11TA), National Root Crops Research Institute (NRCRI), Root and Tuber Expansion Programme (RTEP), Agricultural Development Programme (ADP), Federal Ministry of Agriculture, the launching of presidential initiative on cassava in 2003, among others. All of these have successfully promoted new entrants and investment in the subsector (Sanni *et al*., 2009).

Methodology

The Study Area

The study was conducted in the Southeastern zone of Nigeria. The zone consists of five states namely: Abia, Anambra, Ebonyi, Enugu, and Imo States and located on latitudes 5°06'N to 6°34'N of the Equator and longitudes 6°38'L and 8°08'L of the Greenwich (Prime) Meridian (Onyeneke and Madukwe, 2010). The Southeast rainforest zone of Nigeria is a belt of tall trees with dense undergrowth of shorter species dominated by climbing plants. The prolonged rainy season, resulting in high annual rainfall above 1,800mm, humidity of above 80% during the rainy season, and temperature of 27°C annually in this area; ensures adequate supply of water and promotes perennial tree growth. The inhabitants of this zone are predominantly farmers producing mainly food crops like cassava, yam, and maize (Nwajiuba and Onyeneke, 2010). According to NPC (2007), the population of the Southeast zone stood at 16, 381, 729 persons, disaggregated into 8, 306,306 males and 8, 075, 423 females.

Sources of Data

The study employed only secondary sources of data collection. Secondary data were collected from literature, National Root Crops Research Institute (NRCRI), National Meteorological Centre (NIMET), National Bureau of Statistics (NBS), State Agricultural Development Programmes (ADPs), Food and Agriculture Organization data base, World Bank Statistical Bulletin, United Nations Development programme (UNDP) statistical reports and other sources. The secondary data collected include climatic data, market price, yield and cultivated area. The period of study spans 1961-2012.

Analytical Procedure

In assessing the changes in major climate variables and rate of growth of production and productivity, trend analysis was performed. To evaluate the impact of climate change on the productivity of the enterprise, the quadratic function of multiple regression was estimated while unit root test was conducted on the data to ensure the reliability of the results. This is necessary to avoid running spurious regression which produces biased and inconsistent estimates.

Model Specification

To ensure that the results obtained were not spurious, a unit root test was carried out using the Augmented Dickey Fuller (ADF) test to examine each of the variables for the presence of a unit root (an indication of stationarity). The ADF test minimizes autocorrelation in the error term since it involves the first difference in lags such that the error term is distributed as white noise.

The test formula for ADF is shown as: $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1} + e_t$ ....(1)

Here the lag length j chosen for ADF ensures U_t is empirical white noise. The significance of the tested variables against the null that = 0 is based on the t statistics obtained from the OLS estimated. If the null hypothesis of non stationarity cannot be rejected, the variables are differenced till they become stationary, that is, till the existence of a unit root is rejected.

To achieve objectives one and two, trend analysis was performed.

However, for measuring the acceleration or deceleration in the growth rate, log quadratic trend equation was fitted and stated thus.

$$LnQ_t = a + b_t + C_t^2 + U_t \quad (3)$$

A positive significant value of c indicates acceleration while a negative significant value implies a deceleration. A non significant value shows stagnation in the growth process. This is in line with Onyenweaku (1993; 2004).

The quadratic function of the multiple regression for assessing the impact of climate change on the productivity of cassava is stated thus:

$$Y_{it} = a_i + b_j T_{jt} + c_j P_{jt} + d_j R_{jt} + f_j T^2 + g_j P^2 + h_j R^2 + e\tau + w_{jt} \quad (4)$$

Where:

Y =Yield per hectare of cassava (tons/ha)
T = Annual mean temperature (°c)
P = Annual mean Precipitation (mm)
R= Carbon dioxide emission (CO_2)
T= Time index, denoting annual observations from 1961-2009
W = error term

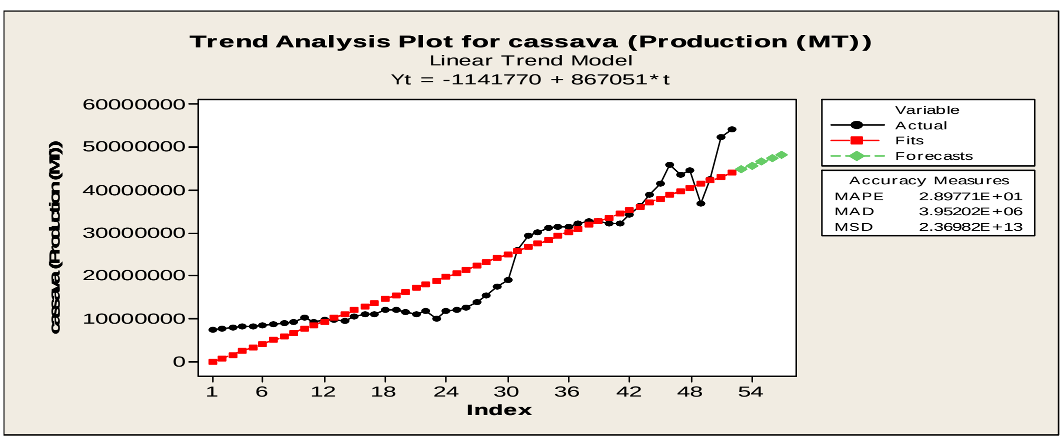
This statistical model relates yield per hectare to meteorological data in line with Torvanger *et al* (2004) and Ajetombi and Abiodun (2010). It is hypothesized that temperature, precipitation, humidity and sunshine duration positively influence crop yield

Results and Discussion

The Changes in Major Climate Variables and Cassava Production (1961 – 2012)

From the result of the analysis, Cassava production in Nigeria maintained a stable trend with a slight increase from 1961 to 1985 before experiencing a sharp increase from 1986 to 2001. There was sharp decrease in 2008 while since 2009 the output continued to increase. This was clearly illustrated in Figures 1 and 5.

Figure 1: Cassava Production Trend in Nigeria

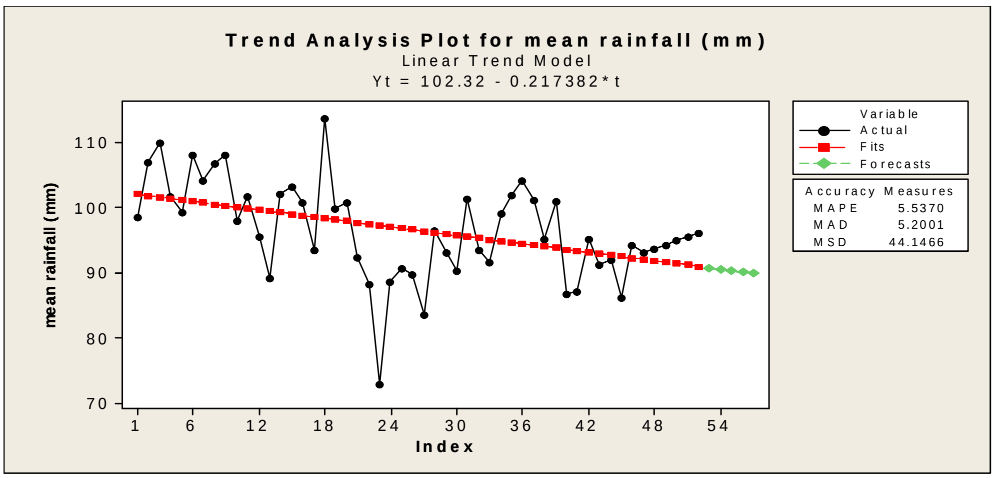


Art 1: the trend in Nigeria cassava production. Source: UNDP, FAO stat and World bank various issues.ss

Source: Computations from the data obtained from the UNDP, FAO stat and World Bank various issues.

The trend analysis in figure 1 showed that cassava production in Nigeria maintained a linear positive trend. The Mean Absolute Percentage Error (MAPE) which measures the rate of accuracy of the fitted time series indicated the accuracy of the fitted time series. The Mean Absolute Deviation (MAD) which expresses accuracy in the same unit of the data indicated that it was 3.95 accurate while Mean Squared Deviation (MSD) indicated that the trend is 2.369 accurate. The trend suggests that there will be continued increase in cassava production for the next five years. In figure 2, it could be seen that the trend in the annual precipitation of Nigeria has been unstable, with precipitation level at the highest in 1997 and at the lowest in 1984. The estimated anomalies of the climate variables indicated that the amount of rainfall and number of wet days varied appreciably from year to year (Oluwasegun *et al,* 2010).This trend and series in the precipitation level also appeared in figure 5. The trend forecast indicated that the level of precipitation in Nigeria will decrease in the next five years. The Mean Absolute Percentage Error (MAPE) which measures the rate of accuracy of the fitted time series indicates the accuracy of the fitted time series. The Mean Absolute Deviation (MAD) which expresses accuracy in the same unit of the data was 5.200 accurate while Mean Squared Deviation (MSD) of the trend was 44.147 accurate.

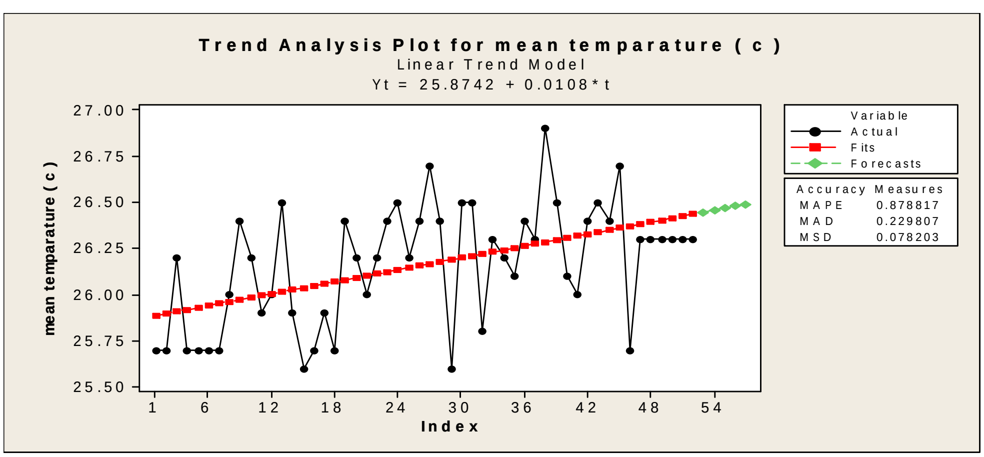
Figure 2: Precipitation Trend in Nigeria



Source: Computations from the data obtained from the UNDP, FAO stat and World Bank various issues

The trend in the annual temperature of Nigeria has been unstable as shown in figure 3, with the temperature hitting the highest point in the year 2000. It is expected that the annual temperature will continue to increase from the five years trend forecast. The Mean Absolute Percentage Error (MAPE) was 0.8788 while The Mean Absolute Deviation (MAD) was 0.229 accurate. However, Mean Squared Deviation (MSD) was 0.078 accurate.

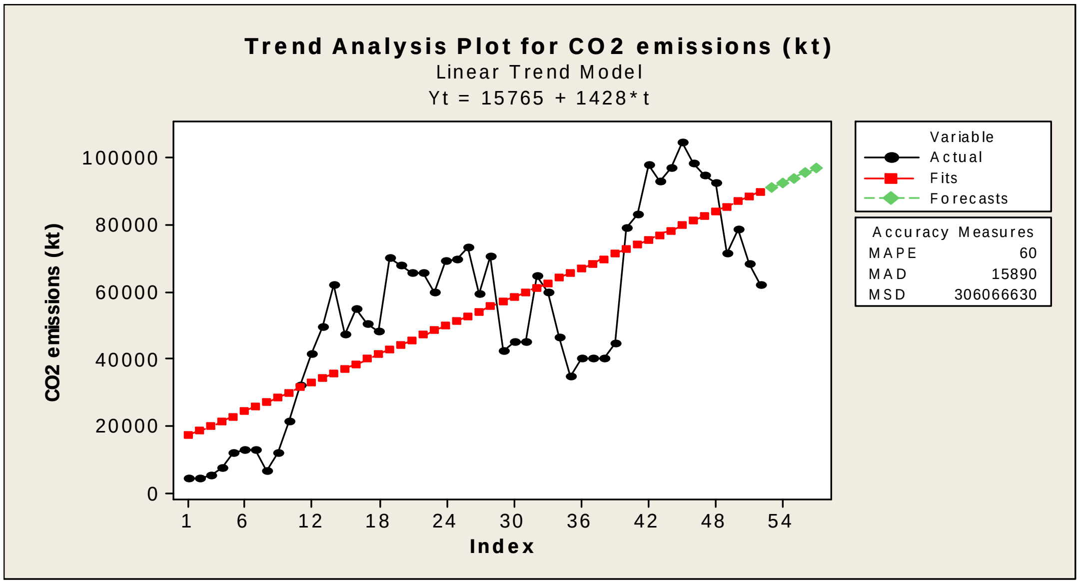
Figure 3: Temperature Trend in Nigeria



Source: Computations from the data obtained from the UNDP, FAO stat and World Bank various issues

As shown in figure 4, the Carbon dioxide (CO_2) emissions in Nigeria were very low in the early 1960's but experienced a sharp increase in the early 1970's and thus maintained an unstable trend. The CO_2 emission was the highest in 2006. The five years trend forecast suggests that the CO_2 emission will likely to increase. The Mean Absolute Percentage Error (MAPE) was 60. The Mean Absolute Deviation (MAD) was 1589 accurate. Despite the unstable nature of CO_2 emissions, the trend experienced general decline. The pattern of trend traced out by the Carbon dioxide emissions could be attributable to the low level of industrialization in the country.

Figure 4: CO_2 Emission Trend in Nigeria



Source: Computations from the data obtained from the UNDP, FAO stat and World Bank various issues

3. 2: The Rate of Growth in Production and Productivity of Cassava

To examine the growth rate in production and productivity of cassava, a log-quadratic trend equation was fitted to the data with also the intent to establish whether the commodity experienced stagnation, acceleration or deceleration within the study period. The results of the analysis are presented in Table1. The result presented in Table 1 showed that cassava production and productivity recorded positive and significant growth during the period. With compound growth rates of 0.976 and 0.969 in production and productivity, it implies that the output of cassava in tonnes and per areas cultivated has been growing. The apparent enabling environment which fosters the country's comparative advantage coupled with the multiplicity of expansion programmes such as the presidential initiatives have played contributory roles. More so, Echebiri and Edaba (2008) had noted that Nigeria grows cassava more than any other country in the world, with the production of cassava concentrating in the hands of numerous farmers located primarily in the south and central regions of Nigeria. Given that the estimated time terms had significant positive coefficients, there is an indication of marked acceleration in the growth trend in production and productivity of cassava in the study area during the period.

Table 1: Estimated Growth Equations in Production and Productivity of Cassava

Variable	a_t	b_t	c_t^2	R^2	F	r
cassava production	7627000 (5.663)***	-100419.421 (-0.864)	18113.454 (8.570)***	0.952	487.602***	0.976
cassava productivity	10.297 (45.826)***	-0.012 (-0.07)	0.021 (6.797)***	0.939	371.862***	0.969

Source: Computations from the data obtained from UNDP, FAO stat and World Bank various issues. Note: *** statistically significant at 1%; Values in parenthesis are t- values.

3.3 Evaluation of the Impact of the Climate Change Variable on Cassava Productivity from 1961-2012

Prior to the estimation of the impact of climate change variables on cassava production, the test variables were subjected to stationary test using Augumented Dickey - Fuller test (ADF) to ascertain the order of integration of the variables. The unit root test attempts to determine whether a given time series data is consistent with a unit root process. The presence of unit roots could lead to false inferences in regression between time series. From the results of the Augumented Dickey Fuller (ADF) unit root test presented in Table 2, all the variables were not stationary at levels. The coefficients compared with the critical values revealed that all the variables were stationary at first difference and on the basis of this; the null hypothesis of non-stationary was rejected and safe to conclude that the variables are stationary. This implied that the variables are integrated in order one.

Table 2: Unit Root Test of the Time Series Data

	ADF statistics (level)	order of integration	ADF statistics (first difference)	order of integration
cassava production	-1.62885	NI	-4.99165***	I(1)
mean precipitation	-3.22800**	I(0)	-7.61002***	I(1)
mean temperature	-5.45727***	I(0)	-9.23462***	I(1)
CO2 emissions	-1.77078	NI	-4.11705***	I(1)
mean precipitation squared	-3.24847*	I(0)	-7.73733***	I(1)
mean temperature square	-5.46084**	I(0)	-9.22688***	I(1)
CO2 emission squared	-1.75666	NI	-3.92627**	I(1)

Source: computations from the data obtained from the UNDP, FAO stat and World Bank various issues.

Note that ***,** &* indicates that the ADF test statistics are significant at 1%, 5% & 10% respectively; while -4.1498, -3.5005 & -3.1793 are Mackinnon critical value for rejection of hypothesis of unit root applied at 1%, 5% & 10% respectively.

The regression analysis on the impact of climate change variables on the cassava productivity in Nigeria is presented in Table 3. The R squared value of 0.490 indicated that 49% of the total variation in the dependent variable (cassava productivity) was accounted for by the independent variables included in the model. The F - statistic of 7.226 indicated that the model statistically fitted at 1% level of probability and confirms the overall explanatory power of the model. The Durbin Watson value of 0.533 which indicates the presence of positive autocorrelation has been taken care of by the unit root test. The result of this analysis is therefore reliable and can be used for drawing inferences. Precipitation had a positive coefficient and was statistically significant at 10% risk level. This implied that increase in the level of precipitation could lead to an increase in cassava productivity of Nigeria. Precipitation squared was statistically significant at 10% probability level with a negative coefficient, implying that the long run increase in the quantity of precipitation could probably lead to a decrease in cassava productivity. This long run increase in the quantity of precipitation could lead to flooding, erosion and water logging of farmlands which decreases yield of the farmers. Temperature had a negative coefficient and was statistically significant at 10% probability level. This indicated that increase in the temperature over a period of time could lead to a decrease in cassava productivity while the temperature squared was also significant at 10% risk level with a negative coefficient. This implied that increase in the temperature over a longer period of time could lead to a reduction in cassava productivity in Nigeria. Carbon dioxide (CO_2) emissions and (CO_2) squared were not statistically significant though with positive coefficients. This implied that the emissions had no significant effects on the cassava productivity in Nigeria.

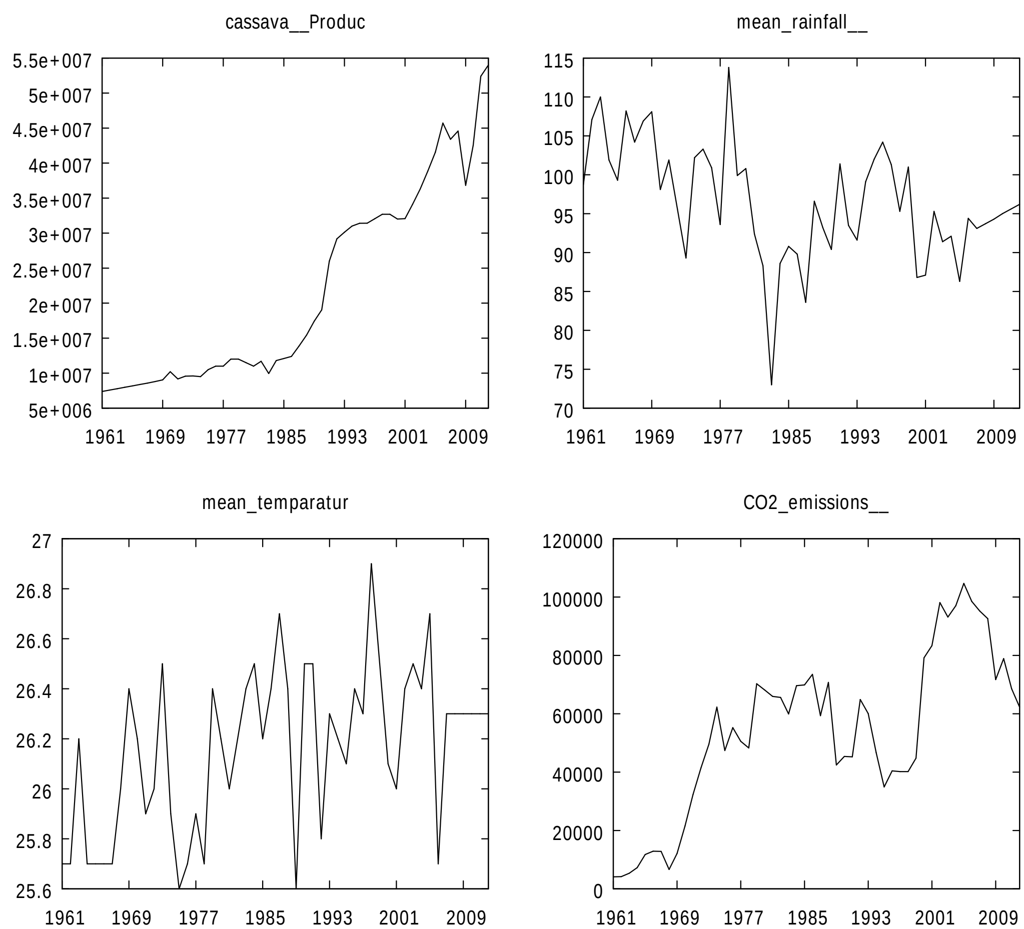
Table 3: Estimates of the Impact of Climate Change Variables on Cassava Productivity

Variable	Coefficient	Std. Error	t-Statistic	Prob.
mean precipitation	6077864.	3253785.	1.867937	0.0681*
mean temperature	-32727344	13027383	-2.512196	0.0156*
CO2 emissions	81.06178	202.5542	0.400198	0.6909
mean precipitation squared	-29877.96	17212.34	-1.735845	0.0893*
mean temperature square	-816885.2	305365.5	2.675106	0.0103*
CO_2 emission squared	0.002160	0.001770	1.219945	0.2287
R-squared	0.490640	Mean dependent var		21835094
Adjusted R-squared	0.435274	S.D. dependent var		14029302
S.E. of regression	10542773	Akaike info criterion		35.28795
Sum squared resid	5.11E+15	Schwarz criterion		35.51309
Log likelihood	-911.4866	Durbin-Watson stat		0.533074
F stat	7.226306			

Source: Computations from the data obtained from the UNDP, FAO stat and World Bank various issues.

Note that ***, ** and * indicates that the test statistics are significant at 1%, 5% & 10% respectively

Figure 5: Series in Nigeria Major Climate Variables and Cassava Production



Source: Computations from the data obtained from UNDP, FAOstat and World Bank various issues

Conclusion

Having examined the impact of climate change on Cassava productivity in Southeastern Nigeria, the need to adopt improved agricultural and environmentally sensitive technologies has become imperative. As shown by the results, precipitation posted positive coefficient but imposed a negative effect on cassava productivity over a long period of time while temperature influenced cassava productivity negatively both in the short and long run. On per state basis, Enugu recorded the highest cost structure with the least loss due to climate change impacts while Abia incurred the loss as a result of climate change. Imo State, however, posted the highest net profit. Although observations have shown that much of the climate change menace in Nigeria was triggered more predominantly by man-made causes such as poor drainage system, water disposal habits etc, it is necessary therefore to emphasize the adoption of appropriate and proactive adaptation cum mitigation measures. These may include use of drought tolerant/resistant varieties, adoption of sustainable land management practices and intensification of campaigns to promote healthy environmental practices among citizenry.

References

Adebayo, A. S., Haggblade. I. Sanni and A. Westby (2009). Innovations for Agricultural Value Chains in Africa: Applying Science and Technology to Enhance Cassava, Dairy and Maize Value Chains. A Publication of Meridian Institute.

Adejuwon.S.A. (2004). Impacts of Climate Variability and Climate Change on Crop Yield in Nigeria. Lead Paper Presented at the Stakeholders. Workshop on Assessment of Impacts and Adaptation to Climate Change, Conference Center, Obafemi Awolowo University, Ile-Ife 20-21 September, 2004.

Adejuwon.J. (2006). Food Security, Climate Variability and Climate Change in Sub- Saharan West Africa. A Final Report Submitted to Assessments of Impacts and Adaptations to Climate Change (AIACC), Project No. AF23, The International START Secretariat, Washington, USA.

Ajetombi, J. and A. Abiodun (2010). Climate Change Impacts on Cowpea Productivity in Nigeria. African Journal of Food, Agriculture, Nutrition and Development, 10(1): 2258-2271.

Echebiri, R. N and Edaba M.E.I (2008). Production and Utilization of Cassava in Nigeria: Prospects for Food Security and Infant Nutrition. PAT; 4 (1): 38-52: ISSN: 0794-5213 Online copy available at www.patnsukjournal.com/currentissue.

Food and Agriculture Organization (FAO) (2012). A Cassava Industrial Revolution in Nigeria. http://www.fao.org/docrep/007/y5548e/y5548e07.htm

Folayan, J. A. and Bifarin, J. O. (2013). Profitability Analysis of Honey Production in Edo North Local Government Area of Edo State, Nigeria. Journal of Agricultural Economics and Development Vol. 2(2), pp. 060-064, February 2013 Available online at http://www.academeresearchjournals.org/journal/jaed ISSN 2327-3151 ©2013 Academe Research Journals.

Ghosh, B.K. (2010). Growth and Variability in the Production of Crops in West Bengal Agriculture. Trends in Agricultural Economics, 3(3): 135 146.

IPCC (International Panel on Climate Change) (1996). Impacts, Adaptations and Mitigation of Climate Change: Scientific- Technical Analysis. Cambridge University Press. Cambridge, UK.

Kurukulasuriya, P. and Rosenthal. (2003). Climate Change and Agriculture A Review of Impacts and Adaptations. Climate Change Series, 91, Agriculture and Rural Development Department and Environment Department Joint Publication, The World Bank. Washington DC.

Mendelsoln, R. and A. Dinar (1999). Climate Change, Agriculture and Developing Countries: Does Adaptation Matter? The World Bank Research Observer, 14: 277 93.

Mendelsoln, R., A. Dinar, A. Basist. P. Kurukulasuriya. M.I. Ajwad, F. Kogan and C. Williams (2004). Cross sectional Analysis of Climate Change Impacts. World Bank Policy Research Working Paper, 3350.

Munonye, J. and V. Okoli (2008). Rainfall Variability and Arable Crop Production in the Humid South of Nigeria. In: C. Nwajiuba (ed) Climate Change and Adaptation in Nigeria. Farming and Rural Systems Economics by W. Doppler and S. Bauer Volume 95. Margraf Publishers. Weikersheim, German

Nnaji, A. and C. Duruji (2008). Implications of Climate Variations for Crop Yield. In: C. Nwajiuba (ed). Climate Change and Adaptation in Nigeria. Farming and Rural Systems Economics by W. Doppler and S. Bauer Volume 95, Margraf Publishers, Weikersheim, Germany.

Nwajiuba, C., R. Onyeneke and J. Munonye (2008). Climate Change: Perception and Adaptation by Poultry farmers in Imo State. In: Nwajiuba(ed). Climate Change and Adaptation in Nigeria.Farming and Rural Systems Economies by Doppler W. and Baiter S. Volume 95.Margraf Publishers, Hohenheim. Germany.

Nwajiuba, C. and R. Onyeneke (2010). Effects of Climate on the Agriculture of Sub- Saharan Africa: Lessons from Southeast Rainforest zone of Nigeria. A Paper Presented at the Oxford Business and Economics Conference Program, U.K.

National Bureau of Statistics (NBS) (2006). Agriculture Filling Data Gap-2.pdf.www.nigerianstat.gov.ng.

National Population Commission (NPC) (2007) Details of the Breakdown of the National and State Provincial Population Totals 2006 Census. Federal Republic of Nigeria Official Gazette. 94(24): 1-26.

Nwachukwu. I.N.. N. M. Agwu. J. Nwaru and G. Imonikhe (2010). Competitiveness and Determinants of Cocoa Export from Nigeria. Report and Opinion, 2(7): 51-54.

Oluwasegun, O. A and J.M. Olaniran (2010). Effects of Temporal Changes in Climate Variables on Crop Production in Tropical sub-humid South-western Nigeria. African Journal of Environmental Science and Technology, 4(8): 500-505, August .

Oyeneke, R.U. and D.K. Madukwe (2010). Adaptation Measures By Crop Farmers in the Southeast Rainforest Zone of Nigeria to Climate Change. World Science Journal. 5(1): 32-34.

Onyenweaku. C.E. (1993). Investigation on the Hypothesis of Deceleration in Crop Production in Nigeria. 1960/61-1987/88. Modeling Simulation and Control D. France, 7(1): 27-40.

Onyenweaku.C.E. (2004). Stagnation, Acceleration and Deceleration in Agricultural Production in Nigeria. 1970-2000. Journal of Agriculture and Food Science, 2(2): 131-140.

Phillips, T., D.S. Taylor, E. Sanni, and M. Akoroda (2004). A Cassava Industrial Revolution in Nigeria: The Potential for a New' Industrial Crop. IFAD/FAO, Rome. Italy. 43 pp.

Sanni. L.O., O.O. Onadipe, P. Ilona, M.D. Mussagy. A. Abass and A.G.O. Dixon (2009). Successes and Challenges of Cassava Enterprises in West Africa: A Case Study of Nigeria, Benin and Sierra Leone. International Institute of Tropical Agriculture IITA), Ibadan, Nigeria. 19pp.

Torvanger.A., M. Twcna and B. Romstad (2004). Climate Change Impacts on Agricultural Productivity in Norway . CICERO Working Paper 10.

World Bank (2003). Global Economic Prospects. Washington, DC, USA

Yesuf, M. S.Difalce; T.Deressa; C. Ringler and G. Kohlin (2008). The Impact of Climate Change and Adaptation on Food Production in Low-Income Countries: Evidence from the Nile Basin, Ethiopia, International ‘Food Policy Research Institute Discussion (1FPRI) Paper No. 00828. Environment and Production Technology Division. IFPRI, Washington D.C.