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Implication of Climate Change on Agriculture and Food Security in Nigeria

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Abstract

Climate change remains one of the focal areas of world leaders for both its global importance, and most especially, its threat to the existence of world's habitants. The study examined the challenges of climate change in Nigeria and its implication on agriculture and food security over a period from 1980-2016.Time series data and econometric techniques were used to analyze the data. Specifically, descriptive statistics, co-integration, bound test and regression analysis with the option of ordinary least square were employed. The results showed that, there is variability in Nigeria rainfall and temperature. It also showed that climate change has significant effect on agricultural productivity. Other factors such as price and labour input have a significance effect on agricultural productivity. The result also showed that rainfall is more significant than temperature as a determinant of agricultural output in Nigeria. It is therefore recommended that the need for adequate provision of irrigation and drainage infrastructure which could be regarded as crucial for climate change adaptation should be provided by all agencies and persons concerned to boost agricultural productivity in Nigeria.

Keywords: climate change, ecosystems, agriculture, and food security.

Introduction

The effects of climate change on our ecosystems are already severe and widespread, and ensuring food security in the face of climate change is among the most daunting challenges facing humankind. While some of the problems associated with climate change are emerging gradually, action is urgently needed now in order to allow enough time to build resilience into agricultural production systems. (FAO 2016). Previous research shows that agriculture plays a pivotal role in the development of the Sub-Saharan Africa (SSA) as the major source of income, food, employment, and in its effectiveness in reducing poverty. For instance, the African Development Bank Group (AfDB) Feed Africa Strategy (2016) disclosed that in 2014 over 60 percent of the people in Africa lived in rural areas and relied on agriculture for their livelihoods, and that women in Africa made up at least half of the agricultural labor force (John & Simplice 2017). Nigeria has ambition of diversifying her economy from crude petroleum dependency. The country is also battling with problem of food security with a growing population that is increasing geometrically while food production is been done arithmetically and Nigeria mostly depends on importation of food. The agricultural sector has a multiplier effect on any nation's socio-economic and industrial fabric because of the multi functional nature of the sector (Ogen, 2007). It has the potential to be the industrial and economic spiral board from which the country's development can take off. Insecure land tenure, scarcity of fund and credit

facilities, labour scarcity despite overall high unemployment and stagnant technology has crippled its further development. But now government is trying her best to tackle most of the problems which has some positive impact in solving these problems. This sector mostly depends on nature which involves rising temperature, changing sea level and rainfall system leading to poor performance in Agricultural sector.

Agriculture still remains the main stay of the world economy. This is because it has a large share of national output and employs a majority of the labour force, most especially in most developing countries of the world. Agriculture employs 65% of Africa labour force, out of which 75% are women. It also accounts for 32% of GDP growth in sub Sahara Africa (World Bank 2012). Apart from its contribution to GDP and employment, agriculture also provides food for human consumption, plants and animals.

Nigeria has not been immune or isolated from the effects of the uncertainties of weather conditions and climatic extremities imposed by global warming and climatic change. The most practical effect noticeable by the entire Nigerian public is the vagaries of seasons and flooding. From the 2012 climatology observations, the rains started very early in most parts of Nigeria, even at awkward months of February and March, in say southwest Nigeria (World Bank 2012).

The idea of food security was presented for the first time at the world food conference in 1974 with the aim of having adequate availability of food on a national scale. Today it is a condition in which all people have access at all times to enough food of an adequate nutritional quality for a healthy and active life. (World Bank 1986 as cited in Tolleens 2000). Food security exists at both the macro and micro levels. The macro dimension is possession by a nation of the capacity to produce enough food through production or imports to feed its population. As a way of overcoming food shortages, successive administration have engaged in massive food importation thereby making the country become externally food dependant but without having sustainable capacity to improve its food production capacity internally. Lack of available grazing land is aggravated by the privatization of land through Reduced Emission from Deforestation and Degradation + Ecosystem co-benefits (REDD+1) where foreigners are in control of the fertile lands in Nigeria in the name of food security. This is what is described as politics of the belly by Bayart (1993) and land grabbing by Galaty (2013). Foreign Direct Investment (FDI) in the agricultural sector is neither a way of resolving food insecurity nor a means of providing employment for the teeming population of the youth but an attempt to produce and export to their country to maintain political stability through food security and safety. This is a strategy embarked on by China, India, Europe and Middle East (Galaty, 2013).

The quality and productivity of land is strongly influenced by climate change and can be degraded by the combined effects of climate variations and human activities. Climate change has become one of the most serious environmental problems, undermining food production and contributing to famine. Human caused climate change is likely to affect land degradation processes by altering rainfalls averages variability and extremes, and by increasing evaporation and transportation of water from soil, vegetation and surfaces water. The unexpected climate change couple with the poor economic growth and poor macroeconomic management in the last two decades has prompted the following questions: (I) Is climate change connected with Agriculture and food security? (II) Climate change, Agricultural and food security, do they reinforce each other? If so, what are the

critical links? Worldwide agriculture also contributes to the growth and sustenance of the manufacturing sector through its contributory role of providing needed raw materials. Agro – based industries are for in greater number than other industries driven by non-agricultural produce. The overall significance of agricultural to the world economy and individual states economies is that, there is the need for sustainable agriculture. Climate change is a dangerous development to the sustainability of agriculture. It is very important to actually examine the implication of climate change to agriculture and food security in general terms, and to Nigeria in particular.

Theoretical Highlights and Brief Literature

The assumption is that crop production follows the Cobweb Theory, where the present year's planting will depend on the last years produce price. We treat the supply of crop output and the production to be the same, what is planted and harvested (production) is also what is supplied as output. The decision before planting about the size of area of planting and the variety of the crops to plant can be influenced largely by price obtained in the last trading season. Thus, the relationship between output and price as:

$$Y_t = f(P_{t-1}) \ldots\ldots\ldots\ldots\ldots (1)$$

Where: "Y" is crop output measured in tons and "P" is the price per ton.

If the last year's price was high, this year's planting will be more ambitious than that of the last years and hence this year's output will increase. As much as last year's price determine this year's output, this year's climate condition will affect directly this year's output. In this case we reduce the climate change to be the level of '' Rainfall and degree of temperature".

We combine this relationship respectively as;

$$Y_t = f(P_{t-1}, R_t, T_t) \ldots\ldots\ldots\ldots\ldots (2)$$

Where "p" is the price per metric tons, "R" is the annual rainfall in millimeters and "T" is the degree of temperature and small t is the time period from 1980-2013. The explanatory variables are as defined respectively above.

Production function is specified and the yields of different species of crop are examined under different climatic conditions (Reinsborough, 2003), a production function represents the relationship between the output and the combination of factors or inputs, used to obtain it.

$$Q = f(L, K) \ldots\ldots\ldots\ldots\ldots (3)$$

Where: "Q" is the quantity of products, "L" is the quantity of labour force and "K" is the quantity of capital.

There can be other inputs; "K" and "L" are just examples. The Cobb-Douglas production function is a particular form of the production function. It is widely used because it has many alternative characteristics as we will see below.

The basic form of the Cobb-Douglas production function is as follows

$$Q(L, K) = AL^{\beta} K^{\alpha} \ldots\ldots\ldots\ldots (4)$$

Where: "Q" is Total Output, "L" is Labour input, "K" is capital input, "A" is a positive constant and β and α are constants between 0 and 1.

The Cobweb model says that prices are formed by endogenous factors, namely, forecasting errors. For example, in response to high prices of a particular crop farmers increase their production which leads to lower price for this crop in the next period. Responding to these lower prices, farmers reduce their production of this crop in the second period, only to see the rising prices in the third period as a result of this supply reduction, and so on (Barre, 2011). The second model assumes that economic agents rationally use all the available information and price dynamics are caused by exogenous factors, especially climatic change (i.e. weather shocks. These two approaches also differ in the solutions they propose for tackling price volatility on agricultural product and food security. If the last year's price was high, this year's planting will be more ambitious than that of the last years and hence this year's output will increase. As much as last year's price determine this year's output, this year's climate condition will affect directly this year's output. In this case we reduce the climate change to be the level of '' Rainfall and degree of temperature".

The rational expectations approach advocates methods that allow for spreading the risk among a larger number of economic agents such as insurance schemes, temporal and spatial arbitrage, including storage and free trade policies. In contrast, the measures proposed by the Cobweb approach for price stabilization and climate change usually involve production quotes and other government interventions for managing the commodity supply within the country (Mitra & Boussord, 2012).

Climate change affects food and water resources that are critical for livelihood in Africa where much of the population especially the poor, rely on local supply system that are sensitive to climate variation. Disruption of existing food and water systems will have devastating implications for development and livelihood. These are expected to add to the challenges climate change already poses for poverty eradication (De wit and Stankiewiez 2006).

The agricultural sector has a multiplier effect on any nation's socio-economic and industrial fabric because of the multi functional nature of the Sector (Ogen 2007). There is variability in Nigerian rainfall and temperature. The study also shows that the change in climate has significant effect on agricultural productivity. This is clearly revealed in the rainfall variable however temperature seem not an important variable of climate in determinants of agricultural productivity in Nigeria economy (Ayinde et al 2011).

The impacts of rainfall variability on water availability for maize yield in Guinean ecological zone of Nigeria have been analyzed and mapped using Geographical Information system in this study. This conforming Nigerian slogan that "Rainwater is the husband of maize yield". That is production and the yield of maize actually depends on the spatio – temporal distribution, nature, variability and reliability of rainfall. It has been shown that rainfall variability affects water availability consequently affects maize yields by reducing length of growing season, especially in the drought year (Odekunle et al 2007).

According to the United Nations (2015), there are still 836 million people in the world living in extreme poverty (less than USD1.25/day). And according to the International Fund for Agricultural Development (IFAD), at least 70 percent of the very poor live in rural areas, most of them depending partly or completely on agriculture for their livelihoods. It is estimated that 500 million smallholder farms in the developing world are supporting almost 2 billion people, and in Asia and sub-Saharan Africa these small farms produce about 80 percent of the food consumed (IFAD, 2011). The rural poor often depend partly on forests for their livelihoods (World Bank, 2002). It is estimated that between 660 and 820 million people (workers and their families) depend totally or partly on fisheries, aquaculture and related industries as a source of income and support (HLPE, 2014).

"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996). This definition points to four dimensions of food security: availability of food, accessibility (economically and physically), utilization (the way it is used and assimilated by the human body) and stability of these three dimensions. What is needed is not only enough food being produced globally –enough food is produced globally now but there are still almost 800 million hungry people – but that everybody has access to it, in the right quantity and quality, all the time (FAO 2017).

Data Description and Estimation Methodology

The model according to the theories above as follows:

$$Q= f (R_1, T_2, P,L \text{ and } C)\ldots\ldots\ldots (5)$$

Where: "Q" is Agricultural output, "R_1 is the annual rainfall (mm), "T_2 is the annual temperature (C^o), "P" is indices of average world price in the last period of Nigeria's major Agricultural commodities in Naira per ton, "L" is the Labour input and "C" is the capital input.

Using Cobb Douglas production function, we take the natural logarithm of variable as:

$$Q_t= (\beta_0 , R_1^{\beta 1},T_2^{\beta 2},P^{\beta 3}, L^{\beta 4} C^{\beta 5})\ldots\ldots\ldots\ldots (6)$$

$$LnQ_t= \beta_0+\beta_1 LnR_t+\beta_2 LnT_t+\beta_3 LnP_{t-1}+\beta_4 LnL_t+\beta_5 LnC+\mu_t \ \ldots\ldots (7)$$

Where $Q_t$is Agricultural output, "R" is annual rainfall (mm), "T" is annualTemperature (C^0), P_{t-1} as indices of average world price in the last period ofNigeria's major Agricultural commodities in Naira per ton, "L" is Labour force and "C" is Capital input. β_0 as intercept, β_1 β_2 as parameters subscript t-1represent Lag period. Where $\mu_t$is a white noise error term with mean equal to Zero, a constant and finite variance and non-serial correlation of the disturbance error term.

The model has five explanatory variables that are expected to impact relatively on the crop output in Nigeria. The crop output is what has been announced and reported in the national bureau of statistics appendices of Nigeria and various central bank bulletins.

In estimating the above specified equations, this study engaged co-integration and regression analysis to analyze the data and to measure impact. The co-integration analyses involved unit roots test is perform on both level and first difference to determine whether the individual input series are stationary and exhibit similar statistical properties. It must be noted that regressing a non-stationary

time series data gives a spurious or nonsense regression. To detect this, a unit root test is perform. A time series data is stationary if the joint distribution of any set of n observation$X_{1-(1)}$, $Xt_{(t_2)}$, $Xt_{(n)}$ is the same as joint distribution of any set of $Xt_{(1+k)}$, $Xt_{(2+k)}$, ……. $Xt_{(n+k)}$, for all n and k.

The study area is Nigeria. The data for this study used time series data collected from Federal Bureau of Statistics, the Central Bank of Nigeria (CBN) bulletin, Food and Agricultural Organizational Publication (FAO) and Nigeria Metrological Agency database measures between 1980 to 2013. The choice of the duration year is as a result of availability of data from Nigeria Metrological Agency (NIMET).

Estimation Results and Discussion

The result of different statistical test is presented below, ranging from the result of unit root test, co integration test, bound test and OLS regression result.

Table 1: Unit root test

VARIABLES	*ADF*	*PHILIPS PERRON*
Capital input	I(1)	I(1)
Labour input	I(1)	I(1)
Price	I(1)	I(1)
Out put	I(1)	I(1)
Rainfall	I(0)	I(0)
Temperature	I(0)	I(0)

Source: Author's computation

Table 2: Result of ADF and PHILIP PERRON

VARIABLES	*ADF*		*PHILIP PERRON*	
	Statistics	**p-value**	**Statistics**	**p-value**
(LNCAP)	-5.713213	0.0003	-7.760722	0.0000
(LNLABOUR)	-4.943084	0.0019	-4.955989	0.0019
(PRICE)	-5.142251	0.0012	-5.139485	0.0012
(LNOUTPUT)	-5.668237	0.0003	-5.668978	0.0003
(LNRAINFALL)	-3.450978	0.0618	-18.41015	0.0000
TEMPERATURE	-4.568883	0.0047	-4.522550	0.0053

Source: Author's computation

Table 3: **Presentation of Co integration Test**

VARIABLES	**LAG LENGTH**
Lnoutput	1

Ln capital	3
Ln labour	1
Ln Rainfall	0
Ln temperature	0
Ln price	1

Source: Author's computation

Table 3 shows the lag length for each of the variables.

Table 4: Presentation of Bound test

	0.100		0.050		0.010		F- stastics
Critical value	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	
	3.13	4.21	3.41	4.52	3.96	5.13	0.808597

Source: Author's computation

The study examines the relationship between all the variables and agricultural productivity in the year under review. From Table 1, 2 and 3 the unit root, (ADF and Philip Perron) and the co integration equation chosen was based on the conformity of the coefficient with economic theory and it's statistical significance. Since it has been ascertained that variables exhibit unit root I (1) (non stationary) at their levels but stationary after differencing except for rainfall and temperature which are I (0) series and exist a short run relationship between the variables. Conducting bound test is necessary as reveal by Table 4, because of the combination of I(1) and I(0) series in which rainfall and temperature are I(0) and all the rest are I(1) series as both ADF and philip perron shows. The F-statistics of the bound test are lower at (1%, 5% and 10% level of significance) than the critical value of the lower bound. Therefore there is no co integration i.e. no long run relationship among the variables.

Presentation of Regression Results

Table 5 Dependent Variable: LNOUTPUT

VARIABLES	***COEFFICIENTS***	***t-statistics***	***Prob***
D(LNLABOUR)	51.42515	1.972298	0.0593
D(LNCAP(-1))	0.069809	1.289385	0.2086
D(LNPRICE(-1))	0.571388	2.854396	0.0084
LNRAINFALL(-1)	1.695978	6.031679	0.0000
LNTEMP(-1)	-23.80809	-0.758103	0.4552

R^2 0.825351, Durbing-waston sta 1.029538, prob (F-stat)= 0.0000,

Source: Author's computation

Naturally speaking, rainfall can be considered to have positive effect on agriculture productivity. From the results as shown in Table 5 above, one percent change in rainfall will lead to 1.69 percent increase in agriculture output. The positive effect of rainfall on agriculture productivity is to the extent when rainfall is not over flooding as this is revealed in the negative effects of previous year's rainfall on the agricultural productivity. This implies that heavy rainfall of last year could lead to erosion and leaching. Generally speaking, we expect that an increase in temperature may lead to food shortage, this may be that high temperature depletes soil nutrient making it hard on livestock and agricultural production. But in this case the study reveals that change in temperature did not have significance effect on agricultural output.

Change in price also have a positive effect on agricultural output, one percent change in price will lead to about 0.57 percent increase in agricultural output. Capital investment on the other hand has no significant effect on agricultural output as reveal by the result. Labour input also has a positive effect on agricultural output; One percent change in labour input will lead to 51.42 percent increase in output. It means no matter the amount of other input that is available to farmer without a reasonable amount of labour input the output will not change. The R^2 shows that about 82% of the variation in agriculture productivity is explained by combined effect of all variables. Rainfall and price have from the results a positive effect on agricultural productivity (output).

Conclusion and Future Research

The study shows that there is variability in Nigeria rainfall and temperature. It also shows that climate change has significant effect on agricultural productivity. Other factors such as price and labour input have a significance effect on agricultural productivity. The result also shows that rainfall is more significant than temperature as determinants of agricultural output in Nigeria. This is in line with the findings of Ayinde et al (2011). Food and Agriculture organization of the United Nations (FAO) and the CGIAR research program on climate change agriculture and food security (CCAFS) (2013) which also serves as training guide for gender and climate change research in agriculture and food security for rural development.

The study also reveals 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 economy diversification has failed to trickle down to the Nigerian farmer.

From the Findings of the survey, Nigerian government needs to give agriculture a serious priority. Agricultural output or productivity can be increased and sustained by developing both agricultural technologies that are environmentally sensitive and also put a serious monitoring and control measure on some economic variable such as price, labour and capital. Considering the results of the analysis and due to the great significance of rainfall on agricultural practice, Nigeria should start to invest on irrigation farming rather than relying more on rain-fed agriculture that is highly unreliable and becoming more unpredictable according to the findings.

Encouragement of formation of farmers groups for them to be able to control the availability of labour, capital and price of product to enhance or solve problem of shortage, excessiveness and fluctuations. The problem of climate change are already with us, therefore these constraints should be properly addressed for self sufficient in food production and for export, thereby enhancing virile economy. Though this study focused on climate change and it's implication on agriculture and food security in Nigeria, the study therefore suggests a further analysis on climate change and its impact on environment and economic development in Nigeria.

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