Climate Change Influence on Crop Yields and Crop Yield Variability in Nigeria

Ajala Adedolapo kemi
Department of Agricultural Economics, Faculty of Agricultural Sciences,
Ladoke Akintola University of Technology, PMB 4000,
Ogbomoso, Oyo State. Nigeria

Ajetomobi Joshua Olusegun
Department of Agricultural Economics, Faculty of Agricultural Sciences,
Ladoke Akintola University of Technology, PMB 4000,
Ogbomoso, Oyo State. Nigeria

Abstract:

Agriculture in Nigeria is now exposed to natural threats through increased variability of weather patterns, increased frequency and sternness of extreme events of the climate and this has consequently affected the economy of the nation since agriculture contribute to the nations' gross domestic product. This research employed the statistical approach suggested by Just Pope to investigate the relationship between the unadjusted mean yield, yield variance and adjusted mean yield of selected food crops and temperature (in centigrade) and precipitation (in millimeters) for the period 1981 – 2018 in Nigeria. The analyses focused on maize, rice, beans and groundnut for all the states in Nigeria using 3530 Cross sectional data on yield of selected food crops obtained from the Nigeria general household survey data- wave 4. Data on the two important climate variables required for crop growth - temperature and precipitation – used for the analysis were obtained from the Nigerian Metrological Agency.The result indicated that increase in temperature negatively influence maize and rice adjusted mean yield and positively influence beans and groundnut adjusted mean yield. However, increase in precipitation positively influence the yield level of maize and rice and it negatively influence the yield of beans and groundnut, this study therefore recommended that weather index insurance will be helpful to farmers

Key words: Climate, food crops, yields, variability Nigeria.

1. Introduction

The Nigerian Economy is based on agriculture and it plays a central role in the overall economic development of the nation, its wide range of climate variation across the states allows it to produce a wide variety of food and cash crops, the main reason why crop production takes a substantial facet of agricultural production and exports in Nigeria. In 2019, Nigerian agriculture shared 22.12% contribution to total gross domestic product. Generally speaking, many factors are influencing crop production which includes soil, relief, climate and diseases among others. In relation to climate, rainfall plays a dominant role in controlling variables in tropical agriculture since it supplies soil moisture for crop growth. The heavy dependence of Nigeria Agriculture on climate affects crop productivity which leads to the variations of production in this sector which have negatively influenced the overall economic growth of the nation since the sector contributes a lot to the economy of the country as major raw materials supplier which are used in several processing industries as well as a source of foreign exchange earnings for the country, it also provides employment which account for 60-70 % of the labour force Ajetomobi *et al*. (2010).

IFPRI 2016 submitted that only 1% of the land area in Nigeria is under irrigation despite that fact that about 77% of the total agricultural land is put into cultivation, this shows that agricultural production especially food crop production in Nigeria is heavily dependent on the climate.

According to (IPCC, 2007; Deressa et al, 2008; BNRCC, 2008) the existence of climate change has become so evident in many countries particularly low income countries where climate is the primary determinant of agricultural productivity who often have low adaptive capacities. The influence of changes in climate on agricultural activities both physical and economic has been shown to be significant for low input farming systems, such as subsistence farming in developing countries in sub- Saharan Africa that are located in marginal areas and have the minimum capacity to adapt to changing climatic conditions;(Kates 2000; McGuigan *et al.* (2002). Its influence as explained by Adejuwon, (2004) implies that the local climate variability which people have previously experienced and adapted to is changing at a rather great speed and the consequences is that the change in climate is bound to influence crop productivity in particular and other socio-economic activities generally..

The existence of climate change has been established in Nigeria since the 1970s this recent climate change has become more threatening not only to the sustainable development of socio- economic and agricultural activities of any nation but also to the totality of human existence. According to Ajetomobi *et al*. (2010), the drastic changes in rainfall pattern and rise in temperature in Nigeria will introduce unfavourable growing conditions into the cropping calendars thereby altering the growing seasons of crops which could successively decrease crop productivity. Reduction in crop productivity will have economic consequences on farm profitability, agricultural supply and demand, trade and price. The country has witnessed erratic precipitation, droughts and floods in recent years, off season rainfall and dry spells which have altered the growing seasons across the country because of the high reliant on rainfall for agricultural practices (Ezeibe and Eze, 2012). The climate change influence could also be seen in the pressures that result from actions taken to increase agricultural production, however, the influence on the yields and productivity of selected crops depends on the agricultural system practised

Several studies on climate change and global warming influence in recent times claims that the duo have influenced agriculture, particularly for crop yields. Lourn and Fogarassy (2015) analysed the impact of climate change on cereals production (millet and maize) in the Gambia. They concluded that the effects of periodic rainfall and temperature variability on cereals yield were greater than that of the long-term changes in climatic variables. Nwalieji and Uzuegbunam (2012) assessed the effects of climate change on rice production in Anambra State, The serious effect of climate change on rice production according to their findings are reduction in crop yield and grain quality, destruction of farm land by flood, high incidence of weeds, pests and diseases.

This study analysed the influence of climate change on unadjusted mean yields, yields variability and mean yield of rice, beans, groundnut and maize in Nigeria and reveal the trends of the selected food crop within the selected years for the study. Rice and maize are major cereal crops that provide the nation with daily caloric intake and are widely grown across the both on large and small scale production. Rice is currently grown in more than 70% of the states in the country (Ajetomobi *et al*. 2011) while maize is being cultivated in the rainforest and the derived savanna zones of Nigeria (Iken & Amusa, 2004). Ajetomobi et al, (2010) also submitted that increase in temperature due to extreme climatic events may undermine any positive effects by reducing the net revenue generated from the yield of rice. In spite of its high yield potential, maize production is still faced with numerous limitations which intermittent drought during the growing season, which significantly reduce maize yield (Ayanlade & Odekunle, 2006). Beans and groundnut on the other hand are leguminous crops that provide the country with protein and oil. Beans responds differently to climate, according to Ajetomobi and Abiodun (2010), the duo concluded that the response beans production to climate change varies from one geographical location to the other and the responds to climate change will affects its productivity. Khanal and Mishra (2017) submitted that groundnut is sensitive to short term changes in weather and seasonal annual long term changes and variation in climate.

2. Material and Methods

Study Area

This study investigated the influence of climate on crop yield using four food crops across the Nigeria, The Federal Republic of Nigeria is located in the tropical zone of West Africa between latitudes 4°N and 14°N and longitudes 2°2'E and 14°30'E with the total land area of 923 770 km^2. The country's north-south extent is about 1 050 km and its maximum east-west extent is about 1 150 km and estimated population of about 131,859,731 inhabitants. (July 2006 estimate, World Fact book) Nigeria is bordered to the west by Benin, to the northwest and north by Niger, to the northeast by Chad and to the east by Cameroon, while the Atlantic Ocean forms the southern limits of Nigerian territory. Land cover ranges from thick mangrove forests and dense rain forests in the south to a near-desert condition in the north eastern corner of the country. Total cultivable area is estimated at 61 million ha, which is 66% of the total area of the country. Nigeria has different biophysical characteristics, agro-ecological zones, socio-economic conditions and ethnic nationalities. Presently, the country has thirty-six states and Abuja as the Federal Capital Territory, the country is also sub divided into six geopolitical zones.

Data Description and Sources

The dependent variable for study is yield per hectare of selected food crop while the explanatory variables are weather data, namely, monthly mean temperature, measured in centigrade while the monthly precipitation measured in millimeters. The precipitation used in the analysis is the monthly precipitation for the cropping season rather than yearly precipitation. The explanatory variables used in the regression model were time series covering the period of 1981-2018 obtained from Nigeria Meteorological Agency. The Nigerian Meteorological Agency is the primary source of Meteorological data in the country. The Nigerian Meteorological Agency (NIMET) has a weather station network that is covering almost all the agro ecological zone in the country. Presently there are about 38 meteorological stations located in each state across the country with two locations in Lagos state. The dependent variable is the yield per hectare, the analyses were based on all the state producing maize, rice, beans and groundnut in Nigeria for the main period 2018-2019. Data for the total production of each crop per state and the total agricultural area per state for each crop were collected from the General Household Survey (GHS). The (GHS) is the result of a partnership that the Nigeria Bureau of statistics (NBS) has established with the Federal Ministry of

Agriculture and Rural Development (FMARD), it survey of over 5,000 households which was carried out annually throughout the country. Data for 3530 farming household from wave 4 GHS data which covered the 2018 and 2019 post planting activities was used for this research work. Time series data on the annual yields of selected food crops used for the trends of yields from 1981 -2018 was obtained from FAOSTAT.

Empirical Model

This study is built on the concept that climate is one of the key determinants of crop productivity. Determining the effect of climate variability on crop yields is the first step in assessing potential costs and climate change adaptation strategies (Cabas *et al*., 2010). Regression models have the potential flexibility to assimilate both socioeconomic factors and the physiological determinants of yield and climate together. Going by this approach, in order to isolate the effects of climate from the effects of other confounding variables including modern inputs and the socioeconomic variables an appropriate production function is specified.

Production risk, also known as stochastic production function developed by Just and Pope (1978) is often used by researchers to analyze effect of production inputs on crop yields. More formally, the effect of climate on crop yield is specified as follows:

$$Y = f(X,\beta) + h(X,\alpha)^{\frac{1}{2}}\epsilon \qquad (1)$$

Y is crop yield; X is vector of independent variables; $\in$ is stochastic error term which is assumed to be independently and normally distributed with mean of zero and variance of one. The first term $[f(X,\beta)]$represents the effects of inputs on mean of crop output or yield, also known as the deterministic component of crop yield; and second term$[h(X,\alpha)^{\frac{1}{2}}\epsilon]$ represents the effects of inputs on variance of crop output or yield, as known as the stochastic component of crop yield. The symbols β and α represent vector of model μ deterministic and stochastic components respectively. The idea behind the above specification is that the effects of the independent variables on mean crop yield should not a-priori be tied to the effects of independent variables on the variance of crop yield.

The two methods commonly used in estimating the stochastic production function are the Maximum Likelihood (ML) methods and the Feasible Generalised Least Square approach (FGLS). ML method provides more efficient parameter estimates in smaller samples but for large samples as the case of this study the FGLS approach is preferable. The Feasible Generalised Least Square approach earlier used by (Cabas *et al*., 2010) was adopted in this study; it was used in estimating the effects of independent variables on the variance of crop yield

$$Y = f(X,\beta) + \mu \qquad (2)$$

$$ln\mu^* = h(X,\alpha)^{\frac{1}{2}} + \epsilon \qquad (3)$$

$$Y^* = f^*(X,\beta) + \mu^* \qquad (4)$$

$$Y^* = Y/\exp(h(X,\beta)^{\frac{1}{2}});\ f^*(X,\beta) = f(X,\beta)/\exp(h(X,\beta)^{\frac{1}{2}});\text{ and } \mu^* = \mu/\exp(h(X,\beta)^{1/2})$$

The symbol μ represents the heteroskedastic (non-constant) error term of the production function; Y^* and μ^* are the values of crop yield and the error term adjusted for heteroskedasticity, and exp. $(h(X,\beta)^{\frac{1}{2}})$ is the exponential function used to find the antilog of the heteroskedastic error term. Going by the procedure of Cabas *et al*. (2010) equation (1) is usually estimated in three steps using FGLS. The first stage of the FGLS estimation procedure regresses crop yield, Y, on the vector of explanatory variables, X, as in equation (2) with the resulting least squares residuals used on the various crop yield. At the second stage to estimate the marginal effects of explanatory variables on the variance of crop yield. In the second stage, the squares of residuals from the first stage are regressed on $h(X,\alpha)$as in equation (3). If equation (2) is not in logarithmic form, it is advisable to use the log of the squared residuals from the first stage rather the untransformed values. The third and final stage uses the predicted error terms from the second stage as weights for generating the FGLS estimates for the mean yield equation as in equation (4) The resulting estimator of β in the final step is consistent and asymptotically efficient under a broad range of conditions and the whole procedure corrects for the heteroskedastic disturbance term (Just and Pope, 1978; Cabas *et al*., 2010).

Techniques of data analysis

The yield from their agricultural production was regressed on climate variables and other variables like age, years of education, cost of labour, and cost of fertilizer. Data used includes household attribute, farm size, level of education of farmers, climate variables, farming experience, educational status. The model specification as given by Just and Pope (1978) is as follows:

$$Y = f(X,\beta) + h(X,\alpha)\varepsilon \qquad E(\varepsilon) = 0, var(\varepsilon) = 1 \qquad (5)$$

Where:

Y is the crop (Beans, groundnut, maize and rice) yield for 2018/19 planting season obtained from the GHS

$f(\cong)$ Is an average production function

X is a set of independent explanatory variables (climate variables, farmers' demograghic characteristics and farm input variables).

The functional form h (≅) for the error term ε is an explicit forms of heteroskedastic errors, which permits estimation of variance effects. Estimates of the parameters of $f(\cong)$ give the average effect of the independent variables on yield, while h (≅) gives the effect of each independent variable on the variance of yield as follows

$$E(Y) = f(X,\beta) \text{ and } var(Y) = h^2(X,\alpha) \qquad (6)$$

The interpretation of the signs and magnitudes on the parameters of h (≅) are straightforward. If the marginal effect on yield variance of any independent variable is positive, then increases in that variable increase the standard deviation of yield, while a negative sign implies increases in that variable reduces the yield variance. Cobb Douglas and linear production form are chosen for the average yield function, f(X). The functional forms are consistent with the Just and Pope postulates which is an additive interaction between the average and variance functions.

Description and Summary Statistics of Model Variables.

Table 1 shows the summary of the model variables that were used for this study. The mean crop yields range from 144.71 kg/ha for beans to 9179.69 kg/ha for rice, the study selected five input variables (fertilizer, pesticide, herbicide, hired labour and machinery) indicating use of farm inputs as independent variables (Table 1). This category of non-climate variables are hypothesized to have positive effect on all crop yields since enhanced use of fertilizers, pesticides, herbicide, hired labour and machinery are likely to increase crop yield. Generally speaking, the study shows that farmers in Nigeria do not adequately use farm inputs for various reasons which financial position may be the major.

The average expenditures on farm inputs are ₦ 397.50, ₦ 2634.20, ₦ 2399.72 and ₦ 6024.25 for fertilizer, herbicide, pesticide, hired labour respectively.

The average number of machinery used was 2 approximately which is low. Other explanatory variables obtainable from the survey data are gender, age and years of formal education of farmers. Age and education have assumed positive effect on crop yield. Average age of farmer is about 43 years who are mostly male; farmers have average of 9 years of formal education which is believed to assist their methods of farm operations. Though the selected crops are widely grown by food crop farmers across the country cultivate on minimum of 1 plot, and an average of 4 hectares, while the maximum land used for cultivation is 84hectares. Normal temperature during the effective growing season of crops is about 27℃, these shows the level of warmness of the country. It was theorized that high temperature will have negative impact on crops in question. Normal rainfall during effective growing season for crops about 346.57 mm per month, since all crops needs wet conditions up to a certain threshold, it is expected that rainfall will have positive effect on the yields of all the crops

Table 1: Description and Summary Statistics of Model Variables

Variables	Observation	Mean	Std. Deviation	Minimum	Maximum
Crop Yield					
Maize (kg)	1270	2720.90	17720.63	1.87	544683.3
Beans (kg)	1034	144.71	16699.19	0.59	501600
Rice (kg)	714	9179.69	55293.74	0.73	581400
G. Nut (kg)	512	1119.00	4754.17	2.56	62233.33
Climate					
Rainfall (mm)	3530	584.57	251.70	186.06	1199.45
Temperature (℃)	3530	27.20	1.60	20.68	30.20
Socioeconomic					
Gender (=1 if female)	3530	0.14	0.35	0	1
Age(years)					
Education (years)	3530	43.03	13.37	25	73
Farm size (ha)	3530	9.05	5.01	0	18
	3530	4.02	7.27	0.01	80
Farm inputs					
Fertilizer (₦)	3530	397.50	3189.18	0	50000
Herbicide(₦)	3530	2634.20	2164.56	0	33000
Pesticide(₦)	3530	2399.72	1989.34	0	27000
Hired labour (₦)	3530	6024.25	9298.29	0	76000
Machinery	3530	1.60	0.15	2	8

Source: Computed from wave 4GHS data and Nigeria Meteorological Agency data

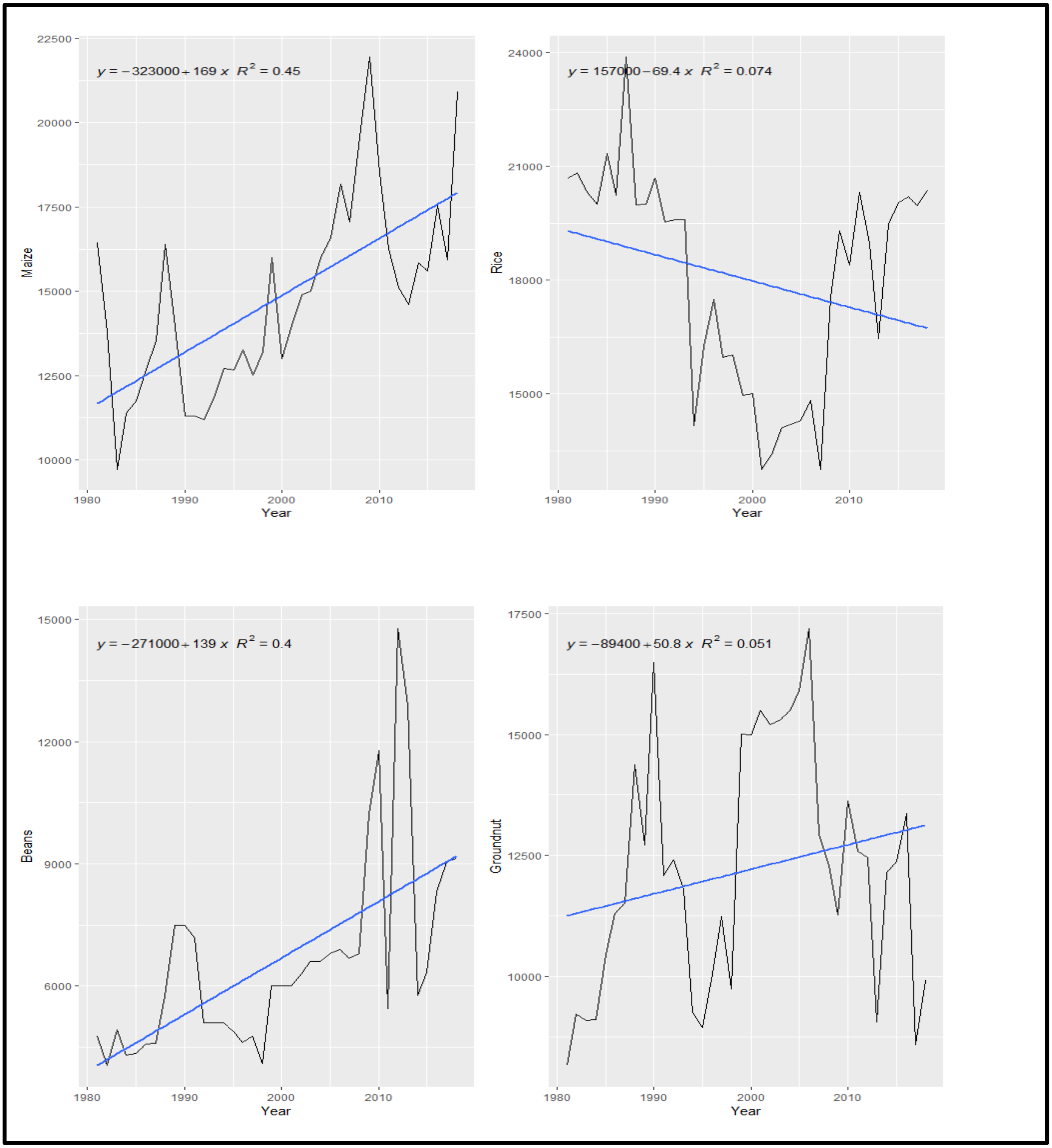

Figure 1: Trends of selected food crops from 1981-2018

Influence of Climate on Mean and Variance of Crop Yield

This section presents the influence of climate change on the yield of the food crops selected for this study. The estimation was done using Feasible generalised least square regression. This was done in three steps, influence of climate on unadjusted mean yield, climate influence on crop yield variability, climate influence on adjusted mean yield of crops in Nigeria.

Climate influence on unadjusted mean yield

The first stage of the FGLS was estimated by running the ordinary least squared regression (OLS) of crop yields on the sets of the independent variables selected for this study. Table 3 present the result for the unadjusted mean yield for the study, the climate variables used are the average monthly temperature and the average monthly precipitation for the growing season of the selected crops. The estimation results of the unadjusted mean yield showed a statistically significant positive coefficient temperature for maize while precipitation has a statistically negative significant coefficient. 1 ℃ rise in temperature will cause 4.18kg/ha increase in the unadjusted mean yield per year, and 1mm rise in precipitation will reduce the unadjusted mean yield by 1.56kg/ha /year. Maize is grown in the raining season and the negative influence may be as a result of heavy rainfall which may leads to flooding. This result is in line with Akpalu *et al*. 2008; they submitted that a rise in temperature will increase the average yield of maize by 0.4 percent. The coefficient for temperature is positive for Beans and groundnut unadjusted mean yields, which showed that temperature had positive influence on their yields while the influence of precipitation on their yield is negative. Rise in the unit of temperature increased the yields of beans and groundnut by 0.4kg/ha and 2.9kg/ha and rise in precipitation reduce their yield by 0.2kg/ha and 1.2kg/ha per year respectively. Groundnut and beans are often grown in the warm part of the country thus the negative influence may be linked with be in excess rainfall which is more that the rainfall for the growth of beans and groundnut. According to Birthal *et al*. 2010 groundnut performs well even under low rainfall conditions if the rainfall is evenly distributed during the growing period, Dhandhalya and Shiyani (2009) also revealed that moisture stress at critical growth stages can reduce yield substantially). The study revealed a positive significant increase in the unadjusted yield of rice as precipitation increases, this is not contrary to the apriori expectation since most species of rice is known to be cultivated in a water logged environment.

The study revealed that farmer's level of education increased the unadjusted yield of maize, beans and rice, The unadjusted yields of the crops increased as additional land was put into cultivation for all the crops except rice i.e., the increase in the farm size reduced the yield rice, this is contrary to the findings from the study by Issahaku and Maharjan (2014). Their study revealed that increased farm size reduced the yields of maize, rice, and that farmer's education has no influence on the unadjusted yields of crops. The coefficient of fertilizer is negative for groundnut (p=0.01), rice (p=0.5) respectively this indicates an inverse relationship between fertilizer and the unadjusted yield of the crops; this implies that the application of additional fertilizer to rice and groundnut plant will reduce the yields of the crops. This may be because the excessive use of fertilizer may increase the growth of weed at the expense of the crops and wastage of the fertilizer during application may not be ruled out. Pesticide had a negative significant influence on groundnut and rice yield at 10% and 5% respectively, Labour had positive significant effects on maize (0.10) and rice (0.05) yields, the increase in the cost of labour resulted to increase on the unadjusted yields. The R^2 of the model for these crops varies from ranges from 8.80% for Beans to 22.50% for rice.

Table 2: Results of first stage Feasible Generalized Least Squares

	Maize	Beans	G,Nut	Rice
Temperature	4.180***	0.418***	2.975***	1.676
	(0.568)	(0.891)	(1.074)	(1.382)
Precipitation	-1.569***	-0.214	-1.273***	0.700***
	(0.097)	(0.184)	(0.222)	(0.239)
Age	-0.189	0.088	-0.139	0.484
	(0.130)	(0.148)	(0.204)	(0.297)
Education	0.032**	0.061***	0.062	0.037**
	(0.020)	(0.017)	(0.023)	(0.040)
Farm size	0.149***	0.180***	0.235***	0.007
	(0.023)	(0.022)	(0.033)	(0.062)
Fertilizer	-0.011	0.008	-0.038***	-0.034**
	(0.010)	(0.007)	(0.010)	(0.017)
Herbicide	-0.001	-0.001	0.016	0.001
	(0.022)	(0.008)	(0.045)	(0.073)
Labour	0.015*	0.009	0.007	0.039**
	(0.008)	(0.008)	(0.027)	(0.018)
Pesticide	0.009	-0.006	-0.200*	-0.307**
	(0.025)	(0.008)	(0.111)	(0.135)
Constant	2.477**	4.739	5.612	-2.475
	(1.980)	(3.383)	(3.633)	(4.249)
Observations	1,270	1,034	714	512
R^2	0.182	0.198	0.209	0.136
Adjusted R^2	0.177	0.180	0.191	0.111
Residual Std. Error	1.608 (df =1260)	1.429 (df = 1024)	1.247 (df = 704)	1.484 (df = 502)
F Statistic	41.079*** (df = 9; 1260)	11.046*** (df = 9; 1024)	11.839*** (df = 9; 704)	5.327*** (df = 9; 302)

Notes *** means significant at 1%, ** means significant at 5% and * means significant at 10%; the dependent variable is the log of crop yield; and Figures in parenthesis are standard errors of regression estimates.
Source: Author's computation

Crop Yield Variability

Table 3 presents the regression coefficients of the second step FGLS which is the climate change influence on crop yield variance. Climate had varying influence on the yield variance of the selected crops. The result indicated that temperature had an inverse relationship with maize and rice yield variances and no significant influence on the yield of beans and groundnut. A degree rise in temperature reduced the maize and rice yield variances in Nigeria, by 3.79 kg/ha and 4.55 kg/ha per year respectively. Conversely, precipitation had a positive significant influence on the yield variances of maize, beans and rice by 0.8kg/ha, 0.9kg/ha, and 1.7kg/ha per year respectively, however precipitation has no influence on the yield variance of groundnut. Increase in the years of formal education of the farmers increases the yield variances of beans while high level of education of maize farmers reduced their yield variances. This may be due to the fact that farmers with high level of education have farming as their secondary occupations and as result received little or no attention since they are likely to be engaged with other jobs. Large farm size had a positive influence on maize and beans yield variances in Nigeria, which means the bigger the size of the farm the higher the yields produced from maize and beans farms. Increase in the amount of fertilizer used reduced the maize and groundnut yield variances, but increased the yield variance of beans.

Herbicide significantly increased the yield variance of rice and reduced beans yield variance Labour reduced the yield variance of rice while Pesticide had a negative statistical significant influence on beans variance. The R^2 ranges from 11% for groundnut yield and 29% for rice

Table 3: Results of Second Stage Feasible Generalized Least Squares

	Maize	Beans	G.Nut	Rice
Temperature	-3.791***	1.744	-1.226	-4.551**
	(0.807)	(1.395)	(1.896)	(2.060)
Precipitation	0.896***	0.971***	0.377	1.767***
	(0.138)	(0.288)	(0.392)	(0.357)
Age	-0.054	0.364	-0.067	-0.257
	(0.185)	(0.232)	(0.361)	(0.443)
Education	-0.050*	0.046*	-0.004	0.010
	(0.029)	(0.027)	(0.041)	(0.059)
Farmsize	0.063*	0.177***	0.072	0.071
	(0.033)	(0.034)	(0.058)	(0.093)
Fertilizer	-0.058***	0.025**	-0.021**	0.040
	(0.014)	(0.012)	(0.018)	(0.025)
Herbicide	0.007	-0.038***	-0.053	0.228**
	(0.031)	(0.013)	(0.079)	(0.109)
Labor	-0.016	-0.013	0.004	-0.055**
	(0.011)	(0.012)	(0.048)	(0.027)

Table 3 (Continuation)

Pesticide	0.0282***	0.0701**	0.1703	-0.112
	(0.035)	(0.013)	(0.197)	(0.202)
Constant	6.980**	-13.421**	0.933	3.469
	(2.813)	(5.297)	(6.412)	(6.332)
Observations	1,270	1,034	714	512
R^2	0.141	0.154	0.115	0.295
Adjusted R^2	0.136	0.145	0.106	0.168
Residual Std. Error	2.284 (df = 1260)	2.238 (df = 1024)	2.201 (df = 704)	2.211 (df = 504)
F Statistic	7.878*** (df = 9;1260)	6.439*** (df = 9;1024)	0.706 (df = 9; 704)	3.545*** (df = 9; 504)

Notes *** means significant at 1%, ** means significant at 5% and * means significant

Adjusted Mean Crop Yield

Table 4 presents the climatic influence on the adjusted mean of crop yield this was done running the regression of crop yields on the sets of independent variables selected for this study using the estimated error terms from Table 3 as weight. The explanatory power of the mean crop yield regression improves with stronger goodness of model fit; The R^2 and the adjusted R^2 of this model is higher for all crops than that of the unadjusted crop yields and yield variances. Climate variables had mixed influence on the adjusted mean yields of selected crops. Temperature had a negative and significant coefficient for rice and maize. Rice is often planted in water logged areas in Nigeria; excessive increase in temperature reduces the available water for plant use which may affect the growth of crops. The adjusted mean yield of rice is reduced by 0.52 kg/ha with a unit increase in temperature (1 ℃) and increased by 0.7kg/ha per year with a 1mm increase in precipitation. This result is consistence with Binuomote and Ajetomobi (2017), they submitted that climate change affects rice yield negatively due to rising temperature and declining rainfall. The adjusted mean yield of maize is reduced with a unit rise in temperature by 4.88 kg/ha while it increased with increase in precipitation by 1.5kg/ha/per. This is in line with the submission made by Mahadeb *et al*. (2014) that a high maximum temperature has a significant negative influence on yields of maize.

Temperature had a positive and significant influence on the adjusted mean yields of beans and groundnut while it is the inverse for precipitation. Beans and groundnut requires more sunlight than rainfall, this explains why beans thrive well in the northern part of the Nigeria; a degree rise in temperature increased the mean yield of beans by 1.0kg/ha and groundnut by 3.3kg/ha per year; the yields reduces by 0.1kg/ha for beans and 0.5kg/ha for groundnut at 1mm increase in precipitation. The farmers' age had an inverse relationship on the yield of maize and groundnut and a direct relationship on the yield of beans, rice which meant that younger farmers who engage in the cultivation of maize and groundnut will have more yields than the older farmers, while the yield of beans and rice will be higher for older farmers. This might be due to the fact that older farmers applied their farming experience on the farming system adopted which reflected on their yields. Farmers' years of formal education has positive and significant on the adjusted yield of all the food crops reviewed under this study, this meant that the exposure of farmers to education improves their farming system which in turn improves crop yields. Contrary to the findings of Cabas *et al.* (2010), who submitted that there is an inverse relationship between crop yield and farm size, the hypotheses he submitted holds for only rice but holds contrary for remaining three crops selected for this study. This study reveals that crop yield will keep increasing as more and more marginal land is put into cultivation, this holds contrary to the submission by Issahaku and Maharjan (2014) who submitted that putting large plots of land into use does not necessarily equates to the increase in yield generated.

This study shows that as additional fertilizer is put into use the adjusted mean yield of maize, groundnut increases by 0.02kg/ha and 0.01kg/ha respectively the adjusted yields rice reduces by 0.01kg/ha. This may be because addition use of fertilizer supported the growth of weeds of the expense of rice. The adjusted mean yields of all the crops selected increased with additional labour input, while pesticide of selected crops varied for each of the crops under this study.. In line with expectations, the adjusted mean yields of maize and beans increases with additional pesticide inputs on the plants.

The third stage of the FGLS (the adjusted means yield) had the best goodness of fit compared with the crop yield variance and the unadjusted mean yield.

Table 4: The Result of the Third Stage Generalized Least Squares

	Maize	Beans	G. Nut	Rice
Temperature	-4.880**	1.058***	3.316***	-0.520**
	(0.027)	(0.077)	(0.085)	(0.220)
Precipitation	1.581***	-0.173***	-0.505**	0.782***
	(0.011)	(0.034)	(0.063)	(0.095)
Age	-0.080***	0.659***	-0.578***	0.175**
	(0.017)	(0.039)	(0.065)	(0.083)
Education	0.042*	0.041***	0.025***	0.070***
	(0.014)	(0.005)	(0.026)	(0.003)
Farmsize	0.044***	0.056***	0.094***	-0.006**
	(0.001)	(0.003)	(0.005)	(0.002)

Table 4: (Continuation)

Fertilizer	0.0203**	0.4502	0.0102***	-0.0172***
	(0.0710)	(0.4200)	(0.0201)	(0.0620)
Herbicide	-0.0172***	0.0801	-0.0671**	0.0221***
	(0.0560)	(0.0321)	(0.0251)	(0.0041)
Labor	0.0070**	0.0803***	0.1702***	0.0501***
	(0.0020)	(0.0302)	(0.062)	(0.1800)
Pesticide	0.0282***	0.0701**	0.1703	0.0101
	(0.0180)	(0.0821)	(0.0184)	(0.2001)
Constant	-2.154***	0.075	0.149	-3.148*
	(1.150)	(0.077)	(0.096)	(2.080)
Observations	1,270	1,034	714	512
R^2	0.799	0.928	0.899	0.845
Adjusted R^2	0.756	0.918	0.848	0.820
Residual Std. Error	1.942 (df = 1665)	2.334 (df = 1024)	1.729 (df = 404)	1.181 (df = 304)
F Statistic	40,775.400*** (df = 9; 1260)	54,254.020*** (df = 9; 1024)	70,100.600*** (df = 9; 704)	27,334.300*** (df = 9; 502)

Notes *** means significant at 1%, ** means significant at 5% and * means significant at 10%; the dependent variable is the log of crop yield; and Figures in parenthesis are standard errors of regression estimates.
Source: Author's computation

IV. Conclusion

Climate variables have major influence on crop yield distribution, there are enough evidence to prove that the climate is changing, this study showed that temperatures significantly influenced reduction in rice and maize yields, while rainfall significantly reduced the yields groundnut and beans in Nigeria. The results of influence climate variables on yields reduction shows that developing a weather index based crop insurance product for food crops farmers in Nigeria will be helpful to farmers. Also irrigation system of farming should be encouraged to combat the drought incidence in some farm location of Nigeria

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