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Simulating the effect of climate change on the output of major crops in Benue State Nigeria

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This study was carried out to simulate the effects of climate change on the output of major crops (yam, rice and soya beans) in Benue state, Nigeria. The study used time series data from1986 to 2012.The Johansen Cointegration test employed confirmed long run equilibrium relationships among the variables. The variables were cointegrated of the (1,1,) order. Following the use of Error Correction Model (ECM), the result showed that relative humidity had a significant effect on the output of yam with a negative coefficient of (-8.17). Temperature and relative humidity had significant effect on rice output with temperature having a positive coefficient of 4.69 and relative humidity negative of (-2.22). For maize output, temperature had a significant effect with a positive coefficient of 5.76.For soya beans output, temperature had a positive coefficient of 42.94 and relative humidity, negative coefficient of (-46.49). The maximum mean rainfall, temperature and relative humidity recorded in the area between 1986 and 2012 were 108.36mm, 32.72^{0}c and 61.87% respectively. The forecasted result of rainfall, temperature and relative humidity between 2013 - 2062 showed the following maxima, 131.26mm, 34.20^{0}c and 70.56% respectively. The result of forecasted outputs (using Average Model Forecasting Approach) of crops showed increases from the computed means. Simulation of one percent (1%) increase over the preceding year of rainfall for ten years (2013 - 2022) showed increment in the outputs of all the crops, for yam, rice and soya beans as 2.41%, 0.41% and 1.43% in that sequence, using the Monte carlo simulation methods. Based on the findings, the study recommended that, there is need to educate and encourage farmers by relevant agencies to improve traditional methods of mitigating extreme effects of climate change variables. Adequate funding of climate related research centers by Government for up to date and timely release of accurate climatic information to help farmers prepare early against unfavorable climatic conditions, there is need for public sensitization on the causes and dangers associated with climate change as well its implication on agriculture, since climate change is mostly caused by human activities.

Keywords: Climate change, soya beans, yam, rice

INTRODUCTION

In decades to come the world will be experiencing higher temperatures and fluctuating precipitation levels. The consequence of this will be declining agricultural productivity particularly in developing and low income countries where climate is the major determinant of agricultural productivity (Apata et al 2009). African economy generally is predominantly agrarian and fundamentally dependent on the vagaries of weather, due to inability to cope as a result of poverty and low technological development, culminating into low level of cropping capabilities by the farmers as opined in Ziervogel et al, 2006, Nwafor 2007; Onyenechere 2010, concerning the potential calamity and catastrophy in the agricultural industry of these developing economies caused by climate change. Concerted efforts must be geared towards unveiling this multidimensional calamity to all stakeholders for enhanced integrated mitigation in the agricultural sector.

Climate change is one of the most serious environmental threats facing mankind worldwide. It has direct impact on food production, which is attributable to the natural climate cycle and human activities, and has adversely affected agricultural productivity in Africa (Ziervogel et al., 2006). Though climate change is global, likewise its impacts; but the most adverse effects will be felt mainly by developing countries, especially those in Africa Nigeria inclusive, due to their low level of coping capabilities (Nwafor, 2007). As the planet warms, rainfall patterns shift, and extreme events such as droughts, floods, and forest fires become more frequent (Zoellick, 2009), which results in poor and unpredictable yields, thereby making farmers more vulnerable, particularly in Africa. Farmers (who constitute the bulk of the poor in Africa), face prospects of tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases (Zoellick, 2009). As the people of Africa strive to overcome poverty and achieve economic growth, this phenomenon threatens to deepen vulnerabilities, erode hard-won gains and seriously undermine prospects for development (Zoellick, 2009).

Climate Change phenomenon has devastating effects on agriculture in several ways. For instance, uncertainties in the onset of the farming season, due to changes in rainfall characteristics (early rains may not be sustained, and crops planted at their instance may become smothered by heat waves) can lead to an unusual sequence of crop planting and replanting which may result in food shortages due to harvest failure. Harsh weather conditions such as thunderstorms, heavy winds, and floods, devastate farmlands and can lead to crop failure. Crop pests and diseases migrate in response to Climate Changes and variations (for example the tsetse fly has extended its range northward) and will potentially pose a threat to livestock in the drier northern areas. It is estimated that by 2100, Nigeria and other West African countries are likely to have agricultural losses of up to 4 % of GDP due to climate change (Mendelsohn et al, 2000). Parts of the country that experienced soil erosion and operate rain-fed agriculture could have declined in agricultural yield of up to 50 % between 2000 – 2020 due to increasing impact of climate change (Agoumi, 2003).

Empirical evidence exist that Climate change and agriculture are interrelated processes, both of which take place on a global scale (Aye and Ater 2012). Climate change affects agriculture in a number of ways, including through changes in average temperatures, rainfall, and climate extremes (e.g., heat waves); changes in pests and diseases; changes in atmospheric carbon dioxide and ground-level ozone concentrations; changes in the nutritional quality of some foods; and changes in sea level(Hoffmann 2013)

Historical records show that the climate system varies naturally over a wide range of time scales. In general, climate changes prior to the Industrial Revolution in the 1700s can be explained by natural causes, such as changes in solar energy, volcanic eruptions, and natural changes in greenhouse gas (GHG) concentrations. Recent climate changes, however, cannot be explained by natural causes alone. Research indicates that natural causes are very unlikely to explain most observed warming, especially warming since the mid-20th century. Rather, human activities can very likely explain most of that warming (NRC, 2010).

The world's population keeps increasing, hence the need for increased agricultural production to meet food demand. However, changes in climate may greatly hamper the genuine efforts of farmers to bridge the gap between rising population and food availability. This situation is likely to be more prominent in developing and low income countries where solar radiation, temperature and precipitation are the main drivers of crop growth thereby making agriculture to be highly dependent on climate patterns and variations. The likely consequence is that the entire world's food security is threatened and poverty level increased. This situation will most likely occur in developing countries like Nigeria and Benue state in particular which is the food basket of the nation, with more than 80% of its population deriving their livelihood from the agricultural sector (Ater and Biam 2014).There is therefore the need for redoubled efforts towards tackling this menace.

Concerns about the issue of climate change on agricultural production have led to a number of studies, Aye and Ater 2012 examined the impact of climate change on grain yield and variability in Nigeria. However none of the studies recognized the probabilistic nature of climate change variables and hence its effects on crops yield. Therefore simulating the effect of climate change on major crops in the state is indispensable. Such action will be paramount for planning, corrective and preventive measures for food and security sustenance.

The broad objective of the study is to simulate the effects of climate change on major crops in Benue state. The specific objectives are to:

(i) estimate effects of climate change on specific output of tubers, legumes and cereals in Benue state from 1986-2012.

(ii) forecast effects of climate change on specific output of tubers, legumes and cereals in Benue state in the next fifty (50) years.

(iii) stimulate effects on output of crops if climatic variables change by 1% over the preceding year for ten years.

Hypotheses

H_{O1}: There is no long run relationship among crop output and climatic variables.

H_{02}: Increases in future climate change variables will not have significant effect on output of farmers of major crops.

METHODOLOGY

The Study Area

This study was conducted in Benue state, Nigeria. The State was created in 1976, is located in the North-central Nigeria. Makurdi as its Capitals lies between latitude 8^0 and 10^0 N and between longitude 6^0 and 8^0 E, with a land mass of 6.595 million hectares (BNARDA 1998).

Benue State shares boundaries with Cameroun to the South, Nasarawa to the North, Taraba State to the East . Cross River to the South, Enugu and Kogi States to South West and West respectively (Anonguku et al, 2010). The State has a population of 4,253,641, by sex distribution the State has a population of 2,144,043 males and 2,109,598 females, making it the ninth most populous State in the Country (Gazette, 2009) with most of its population living in the rural areas and basically surviving on Agricultural practices.

Benue State is generally referred to as the food basket of the Nation due to its richness in agricultural resources with a variety of crop production. With a tropical climate, the State has two distinct seasons, namely rainy and dry seasons. The rainy season stretches from April - October and the dry season from November –March. Agriculturally, the State is segmented into three Agricultural zones of A, B and C. the major ethnic groups in state include Tiv, Idoma, Igede, Etulo, Aakpa, Jukum, Hausa, Akwaya and Nyifon. The state (Benue) has a Guinea savannah kind of vegetation, characterized with scattered trees and coarse grasses.

Method of Data Collection

The study used secondary data strictly, time series data were collected spanning from 1986 to 2012. Data on temperature, rainfall and relative humidity were collected from Nigerian Meteorological Station Oshodi Lagos Nigeria, while data on yield and prices were collected from Benue Agricultural and Rural Development Authority (BNARDA).

Methods of Data Analysis

Analytical tools utilised comprised inferential statistics such as the Unit root test, Error Correction Model (ECM), and Co integration test were used to check inherent problems associated with secondary data.

More specifically, Error Correction Model (ECM), was used to address objective (i), while objectives(ii) was addressed using Average Approach Forecasting Model and objective (iii) used the Monte Carlo Simulation Approach. Hypotheses 1was tested using Johanson co integration test while 2 was tested using the t-test.

Model Specification

Error Correction Model (ECM)

$Y_t = \alpha + \gamma \Delta X_t + \delta(Y_{t-1} - X_{t-1}) + u_t$

Where :

= first difference of output of crop

output Y_t= output of crop in time t

α = constant or intercept

γ = beta coefficient for independent variables (area cultivated, rainfall temperature and relative humidity)

X_t = independent variables

δ= adjustment parameter that reflects the short-run adjustment to equilibrium when Y_t and X_t deviate from their equilibrium relation

u_t = error term

Similarly,

$P_t = \alpha + \gamma \Delta X_t + \delta(P_{t-1} - X_{t-1}) + u_t$ Where:

P_t= price of crop in time t

Average Model Forecasting Approach

F_t = = (Y_1 +…………………+ Y_T)/ T

Where:

F_t = the forecast for period

= mean output of crop for past years under study Y_1……… Y_T = past data on crop output

T = number of years of the past data Similarly,

F_t = = (P_1 +…………………..+ P_T)/ T

Where:

= mean price of crop for the past years under study

P_1…………P_T = past data on crop prices

The Monte Carlo Simulation Approach

This simulation approach is expressed as follows:

$$Y_{tk} = \beta_0 + \sum_{i=1}^{n} \beta_i (X_{it}) + \sum_{i=1}^{n} \propto_i (Z_{it})$$

$Z_i = pdf(Z_{it})$

Such that E($B_i \times f(Z)$)

$$\hat{Y}_{tk} = B_0 + \sum B_i X_{it_t} \frac{1}{N} \sum \propto_i \times f(Z_{it})$$

Where Y_{tk} = output of crops k at time t

$\hat{Y}_{tk}$= Estimated output of crops k

∑= Summation

B_0 = Intercept

B_i = Beta coefficient with independent variable X_i

X_i = Independent variables assumed to be known with certainty.
Z_i= independent variables assumed to have uncertainty values.
Pdf = Probability distribution function.
f = Frequency distribution
k = indexes of crop with k = 1, 2, 3……..5
t = time
Similarly,

$$P_{tk} = \beta_O + \sum_{i=1}^{n} \beta_i(X_{it}) + \sum_{i=1}^{n} \propto_i (Z_{it})$$

$$\hat{P}_{tk} = B_0 + \sum B_i X_t \frac{1}{N} \sum \propto_i \times f(Z)$$

Where
P_{tk}= price of crops k at time t
$\hat{P}_{tk}$= Estimated price of crops k

T-test

$$t = \frac{\bar{Y}_1 - \bar{Y}_2}{\frac{\sqrt{S_1^2 + S_2^2}}{n}}$$

Similarly,

$$t = \frac{\bar{P}_1 - \bar{P}_2}{\frac{\sqrt{S_1^2 + S_2^2}}{n}}$$

Where
$\bar{Y}_1$= Mean of simulated output under base line Scenario
$\bar{Y}_2$ = Mean of simulated output under 10% increase in climatic variables
$\bar{P}_1$ = Mean of simulated price under base line Scenario
$\bar{P}_2$= Mean of simulated price under 10% increase in climatic variables
S_1^2 =Standard deviation of Y_1 and P_1 respectively
S_1^2 =Standard deviation of Y_2 and P_2 respectively
n = sample size.

RESULTS AND DISCUSSION

Secondary data for 28 years (1986-2012) was used for results and discussion in this study. In order to check the inherent characteristics of time series data (unit root and cointegration) tests were carried out on the data for confirmation of the presence of unit root. Unit root is a feature of some stochastic processes (random processes) that can cause problems in statistical inference involving time series models. For the purpose of this research the test statistic employed in detecting and correcting the problem of unit root was Philips-perron unit root test. Philips-perron unit root test that can be used both at level and difference level, it is used in time series analysis to test the null hypothesis that a time series is integrated of order 1. The decision rule for results obtained from Philips-perron unit root test is to reject the null hypothesis that "there is no unit root" if the test statistic is lower than the critical values.

Cointegration and Error Correction Estimates of The Crops Output, Area, Rainfall, Temperature And Relative Humidity In The Study Area

For the sake of this research the Johansen cointegration was employed which revealed the number of cointegrating vectors in the series. The test was conducted for crop output and selected climatic variables in the study area to estimate long run relationship among variables. The results are summarized in Tables 1-3 revealing the number of cointegrating equations as well as rejecting or accepting the hypothesis that "there is no long run relationship among variables in the model". It can be seen in Tables 1-3 that cointegration exist among variables, though individual variables may deviate in the short run, their equilibrium position with one another can be established in the long run making them predictable in long run situations.

Although, cointegration tells the presence of a long run relationship among variables, it does not however indicate the nature and character of the relationship. To establish the nature of the relationship in the long run Vector Error Correction Model (VECM) was employed. The result of VECM for the study is summarized in tables (4-6), Table 4 shows that all of the climatic variables used, only relative humidity has significant effect on the output of yam at one percent (1%) significant level with a negative coefficient of (-8.17) implying that if relative humidity increases by one percent (1%), then yam output will decrease by 8.17% in the long run. The non-significant effect of rainfall and temperature on the output of yam partly agrees with the findings of (Zakari et al, 2014) that variations in rainfall weakly explain variations in the output of yam produced. Rice output in Table 5 shows relative humidity and temperature both having significant effect on output of rice with temperature having a positive coefficient of 4.69 and relative humidity negative coefficient of 2.22 implying that if temperature increases by one percent rice output will increase by 4.69% while rice output will decrease by 2.22% if relative humidity increases by one percent. Table 6 which shows results of soya beans shows that temperature and relative humidity have significant effect on soya beans in the study area, temperature has a positive coefficient of 42.94 while relative humidity has a negative coefficient of 46.49, this means that if temperature increases by 10% soya beans output will increase by 42.94% while soya beans output will decrease by 46.49% if relative humidity increases by 10%. This result affirms the findings of (Ibrahim et al 2016) that interaction of temperature and relative humidity have significant effect on soya bean output.

Table 1: Johanson cointegration test of long run relation among yam yield, yam area, rainfall, temperature and relative humidity.

Eigen Value	Likelihood Ratio	Critical Value 5%	1%	Hypothesized number of CE(s)
0.92	136.14	87.31	96.58	None**
0.76	74.10	62.99	70.05	At most 1**
0.52	37.92	42.44	48.45	at most 2
0.36	19.43	25.32	30.45	at most 3
0.28	8.38	12.25	16.25	at most 4

*(**) denotes rejection of the hypothesis at 5% (%) significant level.
L.R Test indicates 2 Co integration equation(s) at 5% significance level.
Source: Yam yields and yam area data adopted from BNARDA (1986-2012) rainfall, temperature and relative humidity data adopted from Nigerian Meteorological station Oshodi Lagos Nigeria.

Table 2: Johansen coIntegration test of long run relation among rice yield, rice area, rainfall, temperature and relative humidity.

Eigen Value	Likelihood Ratio	Critical Value 5%	1%	Hypothesized N0 of CE(s)
0.90	133.18	76.02	84.45	none**
0.78	76.73	53.12	60.16	at most 1**
0.63	39.02	34.91	41.02	at most 2*
0.31	13.84	19.96	24.60	at most 3
0.17	4.57	9.24	12.97	at most 4

(**) denotes rejection of the hypothesis at 5% (1%) significance level. L.R.
test indicates 3 Co Integration equation(s) at 5% significance level.
Source: Rice yield and rice area adopted from BNARDA (1986-2012) rainfall, temperature and relative humidity data adopted from Nigerian meteorological station Oshodi Lagos, Nigeria.

Table 3: Johanson Co-integration test of long run relationship among soybeans yield, soya beans area, rainfall, temperature and relative humidity.

Eigen Value	Likelihood Ratio	Critical Value 5%	1%	hypothesized Number of CE (s)
0.92	130.27	68.52	76.07	none**
0.82	70.15	47.21	54.46	at most 1**
0.49	29.52	29.68	35.65	at most 2
0.35	13.55	15.41	20.04	at most 3
0.12	3.06	3.76	6.65	at most 4

*(**) denote rejection of the hypothesis at 5% (1%) significant level.
L.R test indicates 2 Co-integration equation (s) at 5% significance level.
Source: Soya beans yield and soya beans area adopted from BNARDA (1986-2012) rainfall, temperature and relative humidity data adopted from Nigerian meteorological station Oshodi Lagos, Nigeria.

Table 4: Vector error correction estimates of long and short run relationship among yam output, yam area, rainfall, temperature and relative humidity.

Co integration Eq;	**Co integration Eq$_1$**	**Co integration Eq$_2$**
Yam yield	1.00	0.00
Yam Area	0.00	1.00
Rainfall	-0.01(-0.04)	-0.14 (-0.48)
Temperature	2.21 (0.31)	8.10 (1.00)
Relative Humidity	-6.84 (-3.67) ***	-8.17 (-3.82) ***
Constant	13.32	1.12

ECT:		**Yam Output**		**Yam Area**		**Rainfall**	**Temperature**			**R/Humidity**
Coint Eq$_1$		$\binom{0.56}{-2.52}$	$\binom{-0.40}{-2.05}$	$\binom{-0.58}{-1.15}$	$\binom{0.46}{9.10}$			$\binom{0.50}{3.69}$		
Coint Eq$_2$		$\binom{0.34}{1.81}$		$\binom{0.21}{1.23}$		$\binom{0.55}{1.28}$		$\binom{-0.42}{-9.80}$		$\binom{-0.36}{-3.11}$
Yam yield t-1	$\binom{0.87}{2.18}$	$\binom{1.06}{3.00}$	$\binom{-0.25}{-0.27}$	$\binom{-0.19}{-2.14}$	$\binom{0.11}{0.46}$					
Yam area t-1	$\binom{-0.88}{-2.10}$		$\binom{-0.92}{-2.46}$	$\binom{-0.12}{-0.13}$	$\binom{0.24}{2.54}$		$\binom{0.16}{0.62}$			
Rainfall t-1		$\binom{-0.03}{-0.28}$	$\binom{-0.01}{-0.12}$	$\binom{-0.15}{-0.61}$	$\binom{-0.02}{-0.69}$		$\binom{0.05}{0.82}$			
Temp. t-1		$\binom{0.02}{0.04}$		$\binom{0.62}{1.09}$		$\binom{-2.59}{-1.76}$	$\binom{0.67}{4.62}$		$\binom{1.34}{3.38}$	
R/H t-1	$\binom{-0.65}{-2.17}$	$\binom{-0.64}{-2.39}$	$\binom{1.24}{1.79}$	$\binom{-0.26}{-3.75}$	$\binom{-0.20}{-1.05}$					
Constant		(2.27)		(1.60)		(0.69)		(-0.63)		(-0.13)
Determinant residual covariance				1.94E-13						

Log Likelihood 188.5057
Akaike Information Criteria -10.92046
Schwarz Criteria -8.385198
***, (**) * indicates significance at 1%, 5% and 10% respectively.
Source: Yam yields and yam area data adopted from BNARDA (1986-2012) rainfall, temperature and relative humidity data adopted from Nigerian Meteorological station Oshodi Lagos Nigeria.

Table 5: vector error correction model of long and short run relationship among rice yields, rice area, rainfall, temperature and relative humidity

Co Integration Eq=	**Coint Eq1**	**Coint Eq2**	**Coint Eq3**
Rice yield	1.00	0.00	0.00
Rice area	0.00	1.00	0.00
Rainfall	0.00	0.00	1.00
Temperature	$\binom{4.69}{5.74}$***	$\binom{12.22}{1.70}$***	$\binom{-1.41}{-0.28}$
R/Humidity	$\binom{-2.22}{-6.03}$***	$\binom{-2.39}{-3.11}$***	$\binom{4.36}{1.95}$***
Constant	(-4.44)	(-6.34)	(-1.04)

ECT		**Rice Yield**		**Rice Area**		**Rainfall**	**Temperature**		**R/Humidity**
Coint Eq1		$\binom{-2.08}{-4.00}$	$\binom{-0.17}{-0.31}$	$\binom{-0.52}{-0.71}$	$\binom{0.11}{1.28}$			$\binom{0.39}{2.98}$	
Coint Eq2		$\binom{0.36}{2.09}$		$\binom{-0.37}{-2.00}$	$\binom{0.16}{0.64}$		$\binom{-0.18}{-6.35}$		$\binom{-0.25}{-5.81}$
Coint Eq3		$\binom{-0.17}{-2.02}$	$\binom{0.16}{1.70}$		$\binom{-0.16}{-1.34}$	$\binom{0.01}{0.54}$			$\binom{-0.08}{-3.54}$
Rice yield t-1	$\binom{0.72}{1.84}$		$\binom{0.25}{0.59}$		$\binom{0.07}{0.14}$		$\binom{-0.10}{-1.34}$		$\binom{-0.22}{-2.20}$
Rice area t-1	$\binom{-0.34}{-1.71}$		$\binom{-0.43}{-2.00}$	$\binom{-0.16}{-0.56}$	$\binom{0.12}{3.70}$		$\binom{0.22}{4.41}$		
Rainfall t-1	$\binom{0.01}{0.06}$		$\binom{-0.11}{-0.56}$	$\binom{-0.13}{-0.53}$	$\binom{-0.02}{-0.72}$		$\binom{0.03}{0.70}$		
Temp. t-1		$\binom{2.30}{2.31}$	$\binom{2.60}{2.40}$	$\binom{-0.64}{-0.46}$	$\binom{0.39}{2.37}$		$\binom{0.80}{3.17}$		
R/H t-1	$\binom{-1.05}{-2.19}$	$\binom{-0.56}{-1.10}$	$\binom{1.00}{1.48}$		$\binom{-0.32}{-4.05}$		$\binom{-0.24}{-2.04}$		
Deterministic Residual Covariance								4.04E-12	

Log Likelihood 150.5688
Akaike Information Criteria -7.405507
Schwarz Criteria -4.577715

Table 6: Error correction model of long and short run relationship among soybeans yield, soybeans area, rainfall and relative humidity

Co-integration Eq;	**Coint Eq1**	**Coint Eq2**
Soybeans yield	1.00	0.00
Soybeans area	0.00	1.00
Rainfall	$\binom{0.97}{0.61}$	$\binom{1.35}{0.79}$
Temperature	$\binom{42.94}{1.96}$ ***	$\binom{44.80}{1.90}$ ***
R/Humidity	$\binom{-46.49}{-1.71}$ ***	$\binom{-45.40}{-1.55}$
Constant	35.97	23.72

ECT		**Soybean Yield**		**Soybean area**		**Rainfall**	**Temp.**	**R/Humidity**	
Coint Eq1	$\binom{-2.20}{-4.58}$	$\binom{-2.27}{-3.84}$	$\binom{1.19}{1.51}$		$\binom{-0.02}{-0.33}$	$\binom{0.34}{2.80}$			
Coint Eq2		$\binom{2.11}{4.67}$		$\binom{2.11}{3.79}$		$\binom{-1.11}{-1.50}$	$\binom{0.02}{0.34}$		$\binom{-0.03}{-2.62}$
Soybeans yield t-1	$\binom{1.66}{4.59}$		$\binom{2.04}{4.60}$		$\binom{-0.51}{-0.86}$	$\binom{0.10}{1.79}$		$\binom{-0.13}{-1.47}$	
Soybeans yield t-	$\binom{0.29}{1.34}$		$\binom{0.49}{1.86}$		$\binom{-0.08}{-0.22}$	$\binom{0.04}{1.33}$		$\binom{-0.10}{-1.81}$	
Soybeans area t-1		$\binom{-2.19}{-4.87}$	$\binom{-2.80}{-5.10}$	$\binom{0.43}{0.59}$		$\binom{-0.12}{-1.76}$	$\binom{0.11}{1.00}$		
Soybeans area t-2		$\binom{-1.21}{-3.84}$	$\binom{-1.22}{-3.15}$	$\binom{-0.30}{-0.57}$	$\binom{-0.04}{-0.91}$	$\binom{0.08}{1.02}$			
Rainfall t-1		$\binom{-0.23}{-1.01}$	$\binom{-0.23}{-0.80}$	$\binom{0.12}{0.32}$		$\binom{0.01}{0.17}$		$\binom{0.09}{1.46}$	
Rainfall t-2		$\binom{-0.39}{-1.73}$	$\binom{-0.43}{-1.55}$	$\binom{0.26}{0.70}$		$\binom{-0.02}{-0.57}$	$\binom{0.03}{0.06}$		
Temperature t-1	$\binom{-0.18}{-0.19}$	$\binom{-0.06}{-0.05}$	$\binom{-1.03}{-0.64}$	$\binom{-0.75}{-4.94}$	$\binom{-0.16}{-0.63}$				
Temperature t-2	$\binom{0.87}{0.95}$		$\binom{-6.57}{0.51}$	$\binom{1.63}{1.09}$		$\binom{-0.71}{-4.94}$	$\binom{-0.44}{-1.93}$		
R/Humidity t-1	$\binom{-5.08}{-3.39}$	$\binom{-6.57}{-3.56}$	$\binom{3.38}{1.37}$		$\binom{-0.15}{-0.66}$	$\binom{0.68}{1.80}$			
R/Humidity t-2	$\binom{-1.07}{-1.30}$	$\binom{-2.85}{-2.83}$	$\binom{0.45}{0.34}$		$\binom{0.21}{1.62}$		$\binom{0.77}{3.75}$		
Constant		$\binom{0.17}{4.63}$	$\binom{0.12}{2.50}$	$\binom{0.03}{0.46}$		$\binom{-0.00}{-0.51}$	$\binom{0.01}{1.36}$		

Determinant Residual Covariance =1.23E-13

Log Likelihood =186.089
Akaike Information Criteria = -9.284077
Schwarz Criteria = -5.602659

Descriptive Statistics of Climatic Variables And Crop Output In The Study Area Before And After Forecasting

Data on output of crops under study between the period 1986-2012 showed that Yam yielded a mean output of 1336.95MT/Ha, Rice, 228.29MT/Ha and Soya beans, 117.79MT/Ha before forecasting. The highest output recorded within the period were 2746.62, 264.98 and 208.65MT/Ha for yam, rice and soya beans respectively. Upon forecasting (2013-2062), yam increased to a mean output of 2302.95MT which represents 1643% increment in output over a fifty year period, rice and soya beans increased to 235.14, and 833.79 respectively. The maximum output for these crops over the period of fifty years (2013-2062) will be 7823.25, 236.46 and 2065.MT/Ha respectively as shown in Table 7.

Table 7: Descriptive Statistics of Output and Area Cultivated of Yam, Cassava, Rice, Maize and Soybeans in Benue State after Forecasting (2013-2062)

	Yam Output	**Rice Outut**	**Soybeans Output**
Mean	23302.95	235.4	833.79
Median	15167.0	235.12	676.29
Maximum	78238.5	236.6	2065.45
Minimum	2937.25	233.9	222.52
Std. Deviation	20999.4	0.36	531.03

Source: Modified data on output and area cultivated of crops adopted from BNARDA(1986-2012)

Descriptive Statistics of Simulated Values of Rainfall Effects On Output And Prices of Major Crops In Benue State For One Percent Increase In Rainfall Over The Preceding Year For Ten Years (2013-2022).

Table 8 shows descriptive statistics of simulated effects of rainfall on the output on these crops, it reveals that for yam production, the mean of the base output (1986-2012) increases from 4706.29 million metric tonnes to 4874.98 million metric tonnes for ten years, given that rainfall increases by 1% over each preceding year giving 3.6% increment over ten year period. Similarly, rice output increases by 0.4%, and soya beans 1.5%, given 1% yearly increase in rainfall for ten years(2013-2022).

However to determine the effect of simulated rainfall on the output of crops, a t-test analysis was carried out which revealed a tabulated t-test value of 1.8330 (5%) as against the calculated t-test values of 0.7413, 0.3646 and 0.3795 for output of yam, rice and soya beans respectively, which indicates no significant effects in future increases (1%) in rainfall on output and of major crops in the study area, thereby accepting in the hypotheses that future increment in rainfall have no significant effect on the output of major crops in Benue state, there by confirming the result of (Zakari et al 2014).

Table 8: Descriptive statistics on simulated effects of rainfall on the output of major crops in Benue state.

	Base line output (MT/HA) (1986-2012)	Scenario 1 output (MT/HA) (2013-2022)
YAM statistics		
Mean	4760.29	4874.98
Median	4755.05	4819.52
Maximum	6158.55	6847.67
Minimum	3263.57	3195.44
Std. Dev.	1010.93	1264.57
RICE statistics		
Mean	290.09	291.28
Median	264.47	273.61
Maximum	421.94	416.66
Minimum	209.55	187.75
Std. Dev.	72.65	79.29
SOYA- BEANS statistics		
Mean	213.95	217.0
Median	211.34	213.98
Maximum	279.19	28.12
Minimum	161.58	162.02
Std. Dev.	39.86	42.09

Source: Modified dataon output of crops adopted from BNARDA (1986-2012)

CONCLUSION AND RECOMMENDATI0N

Conclusion

Climate has being the major determinant of agricultural production in Africa due to poverty and lack of required technology to combat negative effects of changes in climate. The study gave an insight into the future regarding productivity of these crops using past trends of climate on Agriculture. The study concludes that climatic variables particularly temperature and relative humidity significantly affect outputs of crops while rainfall has no significant effect on the output of these crops over a projected period. Which implies if rainfall continues to increase by just one percent over each proceeding year for ten years then output of these crops will remain relatively higher.

Recommendation

Based on results obtained from the study, the following recommendations are important:

i There is need to educate and encourage farmers by relevant agencies to improve traditional methods of mitigating extreme effects of climate change, for example, mulching to reduce the harsh effects of Temperature on crops while in the field.

ii Adequate funding of climate related research centers by Government for up to date and timely release of accurate climatic information to help farmers prepare early against unfavorable climatic conditions,

iii There is need for public sensitization on the causes and dangers associated with climate change as well its implication on agriculture, since climate change is mostly caused by human activities.

REFERENCES

Agoumi, A. (2003). Vulnerability of North African countries to climatic changes: adaptation and implementation strategies for climatic change. Developing Perspectives on Climate Change: Issues and Analysis from Developing Countries and Countries with Economies in Transition. IISD/Climate Change Knowledge Network

Anonguku, I., Anonguku, L.M. and Lawan, A.U. (2010).Socio-economic characteristics of Farmers and Level of Livestock Pilferage in Benue State, Nigeria.International Journal of Agricultural Economics, Management and Development. Vol.1.pp189-194

Apata, TG., Samuel, KD., &Adeola, AO. (2009, August).Analysis of climate change perception and adaptation among arable food crop farmers in South Western Nigeria. In Contributed paper prepared for presentation at the international association of agricultural economists' 2009 conference, Beijing, China, August 16 (Vol. 22).

Aye,G.C., and Ater PI. (2012): Impact of Climate Change on Grain Yield and Variability in Nigeria: A Stochastic Production Model Approach.

Biam, C.K., &Ater, P.I. (2014).Impact Assessment of the Root and Tuber Expansion Programme (RTEP) in Benue State, Nigeria.Management and Administrative Sciences Review, 3(5), 650-659.

BNARDA (1998). Crops Area and Yield Survey, Report by Benue Agricultural and Rural Dvelopment Authority (BNARDA), pp 35."Department of Defense Modeling and Simulation the term as be defined(M&S) Glossary", dod 5000.59-M, Department of Defense, 1998

Gazette (2009). Federal Republic of Nigeria, Vol.96, No. 2 Abuja

Hoffmann, U., Section B: Agriculture - a key driver and a major victim of global warming, in: Lead Article, in: Chapter 1, in Hoffmann 2013, pp. 3, 5

Ibrahim, F.D, Ibrahim, P.A, Odine, A.I and Jirgi, A.J.(2016). Ipact of climate change on soybean production in Lapai local Government Area of Niger State.

Mendelsohn, R., Morrison, W., Schlesinger, M. E., &Andronova, N. G. (2000). Country-specific market impacts of climate change. Climatic change, 45(3-4), 553-569.

NRC (National Research Council) (2010).Advancing the Science of Climate Change.The National Academies 500 Fifth Street, NW Washington,DC20001 T.202.334.2000

Nwafor, J.C. (2007, June). Global climate change: The driver of multiple causes of flood intensity in Sub-Saharan Africa. In International Conference on Climate Change and Economic Sustainability held at NnamdiAzikiwe University, Enugu, Nigeria (pp. 12-14).

Onyenechere, E.C (2010). Climate change and spatial planning concerns in Nigeria: Remedial measures for more effective response. Journal of Human Ecology-New Delhi, 32(3), 137.

Zakari,A.B, Mohammed, M.I. and Medugu L.S. (2014). Impact of climate change on yam production in Nigeria.

Ziervogel, G., Bharwani, S., & Downing, TE.(2006, November).Adapting to climate variability: pumpkins, people and policy.InNatural Resources Forum (Vol. 30, No. 4, pp. 294-305). Blackwell Publishing Ltd.

Zoellick, R.B. (2009). Climate smart future.The Nation Newspapers. Vintage Press Limited, Lagos, Nigeria, 18