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CLIMATE CHANGE IMPACTS ON CEREALS PRODUCTIVITY IN KWARA STATE, NIGERIA

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Abstract
Cereal production in Nigeria has not kept pace with population increase. Climate change has impact on cereal production; this could be positive or negative. This study therefore examined the impact of climate change on cereals – maize, millet and sorghum in Kwara state (1991-2013). Trend analysis, co integration and error correction models were the analytical tools employed. The highest rainfall and temperature was observed in 1991 and 1996 respectively. The results obtained from co integration and error correction model indicate that there is long run and short run relationships between cereals yield (maize and millet) and annual rainfall and temperature. Maize output was positively affected by rainfall while rainfall had a negative relationship with millet output. This is because rainfall must have been in excess for millet production. Therefore farmers should be encouraged to produce more of maize and sorghum. Researches should be towards the development of adverse climate resistant varieties of cereals in the study area to meet the ever growing demand.

Key Words: *Impact, cereal productivity, climate change, Co-integration*

Introduction

Cereal is defined as grass grown for its small and edible seed. They are members of the grass family which has been the most important source of world's food for the past 10,000 years (Onwueme and Sinha, 1999). Oguntunde (1989) identified maize, sorghum and millet as the major cereals grown in the country based on area cultivated and crop output.

According to Nwaiwu *et al*. (2013), rainfall and temperature are the two major climate parameters that significantly affect the growth and productivity of most food crops. Ismaila, *et al*. (2010) noted that temperature specifically affects cereals production by controlling the rate of physio-chemical reaction and rate of evaporation of water from the crops and soil surface.

Climate change describes the changes in the variability of average state of the atmosphere over time scales ranging from a decade to millions of years (Adejuwon, 2004). According to Inter Academy

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Council Report (IACR, 2004), adverse climate change impacts are considered to be particularly strong in countries located in the tropical Africa like Nigeria that depend on agriculture as their main source of livelihood.

Many researches had been carried out in Nigeria on the impact of climate change on agricultural production using secondary data. For example, Ayinde, *et al*. (2011) used co-integration method to analyse the effect of climate change on agricultural productivity in Nigeria. They found that temperature exerted a negative effect while rainfall change had a positive effect on agricultural productivity. Ajetomobi and Abiodun (2010) used trend and regression analysis to assess the climate change impacts on cowpea productivity in twenty states of Nigeria. Their findings revealed negative and significant relationship between cowpea yield and temperature in the northern states; while increase in precipitation leads to an increase in yield in the southern states of Nigeria. Also, Igwe, *et al*. (2013) determined the direction of causality and effect of climate change on food grain output in Nigeria (1970-2010) using the Granger causality and regression analysis. Granger causality result showed that changes in rainfall and temperature positively affected food grain output in Nigeria. Ayinde *et al.* (2013) used unit root and co integration to evaluate the effects of climate change on rice production in Niger State, Nigeria. The result showed that humidity has a negative effect while minimum temperature had a positive effect on rice production. However, there is a dearth of researches on impact of climate change on agricultural production using secondary data at the state levels. Therefore, this research intends to bridge this gap by assessing the impact of climate change on cereals crops productivity in Kwara state, Nigeria.

Methodology

Study Area

The study was conducted in Kwara State, which falls under the southern Guinea Savanna agro-ecological zone of Nigeria. Kwara state is located between latitudes 8° 05′ N to 10° 05′ N and longitudes 2° 50′ E to 6° 05′ E with an area of about 32,500 km^2 . The State has River Niger as its natural boundary along its northern and eastern margins and shares a common internal boundary with Niger State in the north, Kogi State in the east, Oyo, Ekiti and Osun States in the south and an international border with the Republic of Benin along its north-western part. Kwara state lies within a region described as tropical climate and are characterized by double rainfall maxima and has tropical wet and dry climate (Olanrewaju, 2009). Both seasons last for about six months. Kwara State is a summer rainfall area, with an annual rainfall range of 1000 mm to 1500 mm. The wet season begins towards the end of March and ends in October. A dry season in the State begins with the onset of tropical continental air mass commonly called Harmattan. The wind is usually predominant between the months of November and February (Olaniran, 2000). Temperature is uniformly high and ranges between 25^oC and 30^oC in the wet season throughout the season except in July – August when the clouding of the sky prevents direct insulation while in the dry season it ranges between 33^oC to 34^oC. In the wet season the relative humidity in the State is between 75% and

80% while in the dry season it is about 65%. The daytimes are sunny and the sun shines brightly for about 6.5 to 7.7 hours daily from November to May (National Bureau of Statistics, (NBS) 2009).

Data Collection

Climate data used in this study were daily rainfall (mm) from 1991 to 2013 and maximum and minimum temperatures (^oC) covering a period of thirty years (1991-2013). These data were collected from Lower Niger River Basin and Rural Development Authority, Hydrology Section, Ilorin, Kwara state and Nigerian Meteorology Agency (NiMet), Abuja. These climate parameters were selected based on their importance in determining the time of farm preparations and planting, growth, development and yield of crops in West Africa. The data on cereals yields (tons per hectare) were collected from the Kwara State Agricultural and Rural Development Office, Ilorin. The values obtained were average yields spanning a period of twenty-three years (1991-2013) (KWADP, 2014).

Method of Data Analysis

Unit Root Test

The first step in carrying out a time series analysis is to check for stationary of the variables. A series is said to be stationary if the means and variances remain constant over time. It is referred as I (0), denoting integrated of order zero. A variable that is non-stationary is said to be integrated of order *d*, written *I (d)*, which must be differenced *d* times to be made stationary. The Augmented Dickey Fuller (ADF) approach tests the null hypothesis that a series contain a unit root against the alternative of stationarity. If the ADF test shows that the variable is stationary in level, the variable is said to be integrated of order zero [I (0)]. If stationarity is confirmed when the variable is in first difference, then the variable is said to be integrated of order one [I (l)]; in second difference, the variable is integrated of order two [I (2)]. The data used were time series, unit root tests were performed using Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981); to determine if the data is stationary or not.

The augmented Dickey-Fuller (ADF) test is expressed as:

$$\Delta X_t = a + a_1 t + a_2 X_{t-1} + \sum_{i=1}^{p} b_i \Delta X_{t-1} + e_t \quad (1)$$

Where:

X_t = the variable under consideration

Δ = First difference operator

ΔX_{t-1} = the lagged difference of X_t

t = time or trend variable, 1991-2013

p = Lag number and e_t is the error term

These operations were also carried out on annual rainfall and temperature to investigate for their order of integration.

Co-integration and Error Correction Model Test

Two or more variables are said to be co- integrated if each is individually non-stationary (has one or more unit roots) but there exists a linear combination of the variables that is stationary. Co-integration of two or more time series suggests that there is a long-run or equilibrium relationship between them (endogenous and exogenous variables). Two conditions must be satisfied for variables to be co-integrated. First, the series for the individual variables must be non-stationary. Second, a linear combination of the non-stationary variables from a static regression involving levels of the variables must be stationary. Although co-integration is a relationship between two non-stationary, I(1), variables, it is also possible to have a mixture of different order series when there are three or more time series variables in the model. For example, it is possible that co-integration can be present when there is a mix of *I (0)*, *I(1)* and *I(2)* variables in a model (Harris, 1995). According to Pagan and Wickens (1989), in the case where variables are integrated of different orders, a subset of the higher-order series must co-integrate to the order of the lower-order series. Johanssen (1985) also found some mathematically exact and attractive results for the general case which do not rely on the assumption that all variables must be integrated of the same order before co-integration can exits. The study points out that, if X_{1t} is *I*(1) and X_{2t} is *I(0),* then X_{1t}t and the mean of X_{2t} could be cointegrated; thus, expanding the class of variables that might be tested. The Johansen procedure was used to test for the number of co-integration vectors in the model. Johansen technique was used not only because it is vector auto-regressive based but because it performs better in multivariate model (Maddala, 2001). The co-integration model was specified as follows:

$$Y_t = \alpha + \beta_1 R + \beta_2 T + e_t \text{-} \qquad (2)$$

Where:

Y_t = maize, sorghum or millet yield in time

R = Annual rainfall (mm)

T = Mean Annual Temperature (0°C)

If two variables are co-integrated, then their short-run dynamics can be described by Error Correction Model (ECM). The ECM developed by Engle and Granger is a means of reconciling the short run behaviour of an economic variable with its long-run behaviour (Gujarati, 1995). Granger and Engle (1987) proved that co-integrated series have an ECM representation and conversely, that ECMs generate co-integrated series. Thus reconciling the two approaches as well as clarifying when levels information could be legitimately retained in econometric equations. A good time series modelling should clearly describe both short-run dynamics and the long-run equilibrium simultaneously. Komolafe, (1996); Greene, (2003); Dolado, *et al*. (1999), have all shown that the existence of co-integration is an adequate condition for the incorporation of an Error Correction Term (ECT). The inclusion of ECT in a model ensures that the long run relationship is preserved. In this study, the Error Correction Model (ECM) is specified as:

$$\Delta Y_t = a_0 + a_1 \Delta R_t + a_2 \Delta T_t + a_3 ECt + U_t \qquad (3)$$

Where:

Y_t = maize, sorghum or millet yield in time t

a_1,a_2 and a_3 = short-run effects

R_t = rainfall in time t

T_t = Temperature in time t

ECt = Error correction term

U_t = Stochastic Error term assumed to be normally distributed with zero mean and constant variance.

Results and Discussion

Rainfall Trend Analysis

Figure 1 shows the annual rainfall trend from 1991 to 2013. The highest rainfall amount of 1469.4mm was observed in 1991 whereas the lowest (697.7mm) was recorded in 2001. The average annual rainfall was 1186.4 mm/year, while the inter-annual rainfall variability occurred between 1992 and 2003. Further analysis revealed that from 2004 to 2013, the rainfall was generally on an increase with a mean value of 1269.97 mm/year. This was above the long term mean annual rainfall value of 1186.4mm/year; although in the year 2010 and 2013 there was a decrease in rainfall. The implication of this is that this could result into inadequate rainfall with devastating effects on cereals output. The findings agree with that of Ismaila *et al*., 2010.

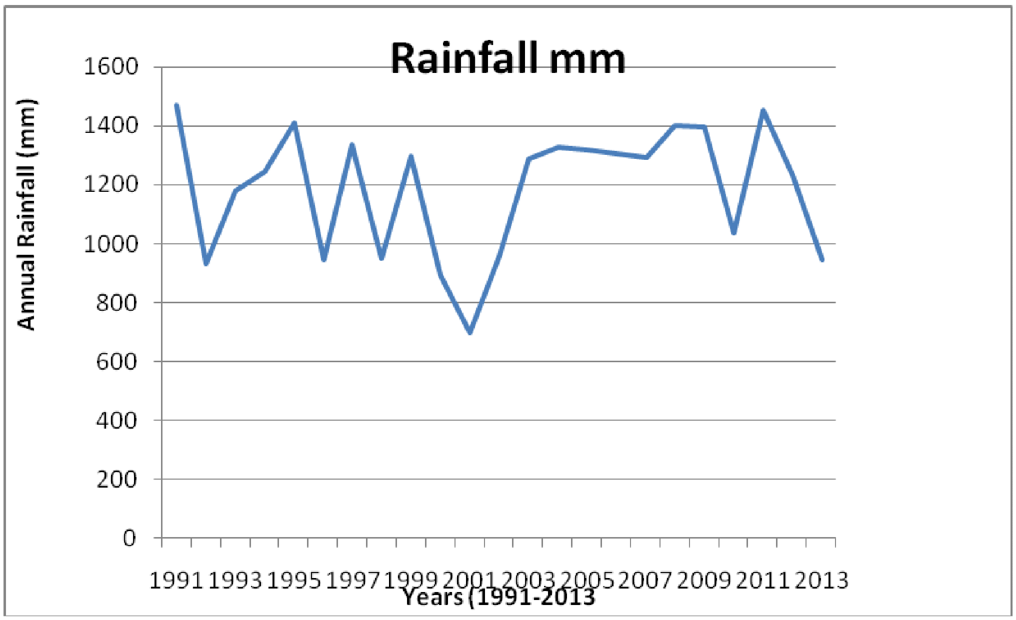

Figure 1: Rainfall trend (1991-2013)

Temperature Trend Analysis

The result for temperature trend analysis as presented in figure 2, the highest temperature was witnessed in 1996 (28.4°C) while the lowest occurred in 1998 (25.9°C). The average temperature was 27.11°C; the figure also shows that temperature has been on the increase interannually temperature variability occurred from 1992-2013. Variability occurred between 2000 and 2011. This result agrees with the findings of Falaki *et al*., (2013) that North central region (Kwara state inclusive) of Nigeria has experienced an increase in temperature of recent. On a national level, this result is in line with those Akinsanola and Ogunjobi (2014) analysis of rainfall and temperature variability over Nigeria. They found out that there is a significant increase in temperature in the country.

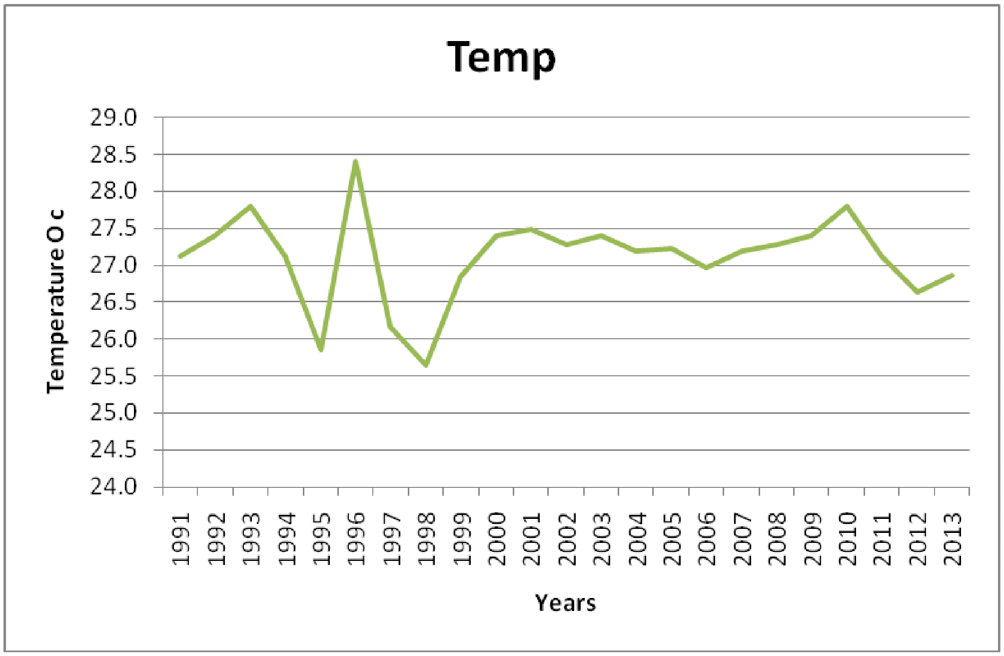

Figure 2: Temperature trend (1991-2013)

Cereals Yield trend

Figure 3 shows the pattern in yields of sorghum, maize and millet from 1991-2013. Maize recorded the lowest yield in 1997 (0.88 ton/ha) while the highest was in 2006 (1.82 ton/ha). Millet had the highest yield in 2004 (2.3 ton/ha) while the lowest was recorded in 2005 (0.75 ton/ha). On the other hand, sorghum had the highest yield in 2013 (3.87 ton/ha); while the lowest was in 1992 (1.1 ton/ha).

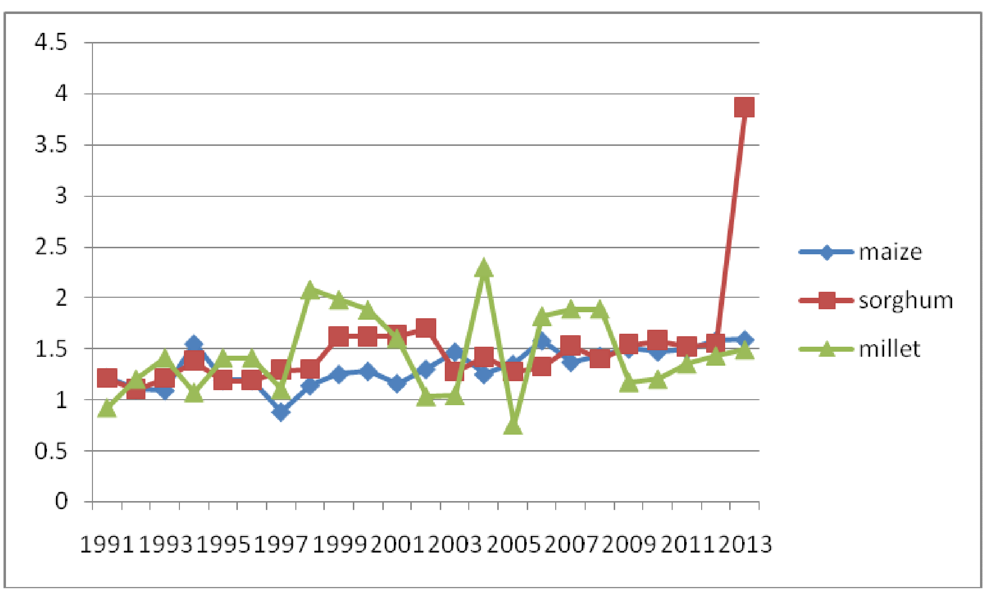

Figure 3: Cereals yield trend

Unit Root Test Results

Table 1 show that the variables are stationary at different levels except sorghum which was not stationary at all levels. Those variables that were stationary at levels show that their exist disequilibrium among them. Therefore, a co integration test can be carried out for each of the variable with the exception of sorghum output.

Table 1: Results of Stationary of the Variables from ADF Test

Variables	Levels	First difference	Unit root
rainfall	(-2.443)	(-4.132)*	I(1)
	-3.000	-3.000	
Temperature	(-3.856)*	(-6.231)*	I(0)
	-3.000	-3.000	
Maize	-1.591	(-5.202)*	I(1)
	-3.000	-3.000	
Millet	(-3.392)*	(-5.142)*	I(0)
	-3.000	-3.000	

Values in parentheses are test statistics values

Co-integration Test Result

The result of cointegration test between maize, rainfall and temperature is presented in Table 2. Trace statistics indicates two cointegrating vectors at the 0.05 level and so an error correction model is used to analyse the relationship between the output of maize, rainfall and temperature. Tables 2 and 3 shows the Johansen co integration results which indicate the number of cointegrating vectors among the variables. The maximum rank (r) indicates the null hypothesis, r = 0 means that there is no co integration between the variables but when r=1, 2 and 3, it means that there is 1, 2 and 3 co integration between the variables respectively. When the trace statistics is more than 5% of the critical value, the null hypothesis is rejected and the alternative hypothesis is accepted. The results in Tables 2 and 3 shows that the null hypothesis of zero co integrating vectors at 5% level of significant can be rejected. The trace statistics for r = 2 is greater than its 5% critical value for maize and millet output respectively. This means that there exist at most two (2) integrating vectors, an indication that there is a long run relationship between the variables. Therefore the null hypothesis was rejected and a vector error correction analysis was done.

Table 2: Co-integration Test Results for Maize

Hypothesis (rank r)	Eigen Value	Trace statistics	5% critical Value
0	………	58.7406*	29.68
1	0.85269	20.4368*	15.41
2	0.45340	8.3559*	3.76
3	0.34150	……….	……..

*Indicates co-integration among the variables

Table 3: Co integration Test Results for Millet

Hypothesis (rank r)	Eigen Value	Trace statistics	5% critical Value
0	………	83.4083*	29.68
1	0.86579	41.2326*	15.41
2	0.71430	14.9236*	3.76
3	0.50867	………	……

* Indicates co-integration among the variables

Results of vector error correction model

Tables 4 and 5 show the results of vector error correction model for maize and millet. This was done to find out the link between long run equilibrium relationships and short run (disequilibria) dynamics (Gujarati, 1995). The results in Table 4 indicate that maize output is positively affected by rainfall. This means that an increase in rainfall increases the output of maize; this is in consonant with the findings of Akpenpuun (2013) in which it was found that that climate has a significant impact on maize production in Kwara state between 2002 and 2011. On the other hand temperature had no significant relationship with maize output. This finding agrees with the finding of Ayanlade *et al*. (2010), that there is no significant relationship between temperature and agricultural production in Nigeria.

On the other hand, results on Table 5 shows that rainfall has a negative relationship with millet output. This means that an increase in rainfall will result in decrease in millet output. This result is consistent with agronomic characteristics of millet which is a drought tolerant crop (Onwueme and Sinha, 1999)

Table 4: Error Correction Model Estimates for Maize

Variable	Coefficient	Standard Error	z-Statistics	Probability
Rainfall	0.0002622	0.0000769	3.4	0.001
Temperature	-0.0226487	0.5859489	-0.36	0.715
ECt	-1.870672	0.3176232	-5.89	0.000
Constant	.0506659	0.0347503	1.46	0.145

Table 5: Error Correction Model Estimates for Millet

Variable	Coefficient	Standard Error	z-Statistics	Probability
Rainfall	-1.403364	0.1671035	-8.40	0.000*
Temperature	0.000667	0.0006751	0.99	0.323
ECt	-1.587071	0.1994111	-7.96	0.000 *
Constant	0.043532	0.3866241	0.11	0.910

ECt denotes Error correction term
*significant at 1% level.

Conclusion and Recommendations

The study shows that maize output was positively affected by rainfall this shows that the increase in output was dependent on the amount of rainfall. Therefore, there is the need to supplement the rain fed production of maize so as to be able to mitigate any decrease in the amount of rainfall in the study area. On the other hand, farmers should be encouraged to produce more of maize and sorghum; researches should be towards the development of adverse climate resistant varieties of cereals.

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