Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.1, 2015

Climate Change and the Cocoa Production in the Tropical Rain Forest Ecological Zone of Ondo State, Nigeria

T.T. Amos O. A.Thompson
Department of Agricultural Economics and Extension, The Federal University of Technology, Akure, Nigeria

Abstract
The study examined whether or not there is long run equilibrium relationship between Cocoa yield and climate change (i.e. Rainfall, Temperature and Humidity). This is to ascertain the impact of climate change on cocoa yield in the study area. The unit root test was carried out and it was established cocoa and rainfall were non-stationary among the three selected climate change determinant (i.e. Rainfall, Humidity and Temperature.). Both at 1% and 5% level of significance, their absolute values were greater than the critical values (i.e. for cocoa;-2.855384>-3.610453 & -2.938987 and for rainfall; -1.591781>-3.610453 &-2.938987). Therefore, the other two climate change determinants variables (i.e. Temperature and Humidity) were not considered for co-integration since the unit root test revealed that they were stationary. Also, the Co-integration test was carried out; the trace statistic test reveals that at both 1% and 5% level of significance, that at 2 and 1 equations were co-integrated, since their absolute values were greater than the critical values at 1% and 5% level of significant. The Max-Eigen values also reveals that at both 1% and 5% level of significance, that at most 2 and 1 equations were co-integrated, since their absolute value 25.27>15.41 and 20.04; 20.61>14.07 and 18.63,. This corroborated the trace statistics, therefore, it was concluded that there is a long run equilibrium relationship between cocoa yield and rainfall. The results established the fact that cocoa is highly susceptible to drought and the pattern of cropping of cocoa is related to rainfall distribution.
Keywords: Cocoa, Rainfall, Humidity, Temperature and Co-integration

INTRODUCTION

Cocoa (Theobroma Cacao) is an international crop. This crop of Latin American origin had determined both the economic and political fate of many countries of the world of which Trinidad, Ghana, Nigeria, Cote D'Ivoire, Brazil, Costa Rica and Fernando Po are prominent. Cocoa is a major cash crop of the tropical forest, most notably in West Africa where export earning from its sales from a major part of the economic (Mayhew and Perry, 1998). Chocolate a major product derived from the raw cocoa beans had been a very important beverage in European countries, America, and Asian countries. While most of the consuming countries are non-producers of the raw cocoa-beans, most of the producing countries consume about 5-10 percent of the commodity (ICCO, 1994).

Nigeria was the second world largest cocoa producer in the 1960 producing between 250,000 to 308,000 metric tons for export yearly and generating about 50 percent of Nigeria's revenue. Cocoa production witnessed a downward trend after 1970/1971 season when its export declined to 216,000 metric tones and this reduced Nigeria's market share to about 6 percent to date and fifth world largest cocoa producer. (ICCO, 2008). Currently, cocoa is grown in commercial quantity in nine State of the Federation with Ondo and Ekiti states combined producing about 53.32% of the total Nigeria cocoa production (Folayan, 2005). Both the Ekiti and Ondo states governments have been having substantial part of their annual revenue accruing from sales of cocoa beans (Folayan, 2005).

However, crop yield cocoa inclusive depends on climate and water supply generally (Dennett et al, 1981) and it is agreed that rainfall is an important climatic element for assessing water supply for agriculture in the tropics (Omotosho, 2001). More so, crop production is affected biophysically by meteorological variables, including rising temperatures, changing rainfall, precipitation regimes, and increased atmospheric carbon dioxide levels (Parry *et al*, 2004). One persistent problem of water supply to agriculture is manifested by seasonal and variable nature of rainfall (Jonathan *et al*, 2009). Rainfall variability is not only limited to seasonal fluctuation but also includes year to year variability in the onset, cessation and duration of the rains which are also characterized by dry spells of unpredictable magnitude (Mortimore, 1989).

Therefore, since agricultural production in part of tropic is rain-fed, and recognizing that the constraints of rain-fed agriculture in Nigeria in particular as the erratic rain distribution (Jonathan *et al*, 2009), there is need to determine both the short and the long run relationship between cocoa production and climate change (rain fall, temperature and humidity) in the study area (i.e. Ondo and Ekiti State), this is with the aim of knowing the extent of the effects of climate change (rainfall variability) on cocoa production in the study area and make recommendations on how do mitigate such effects on the production of cocoa in the study area.

THEORETICAL FRAMEWORK

This study sees cocoa as contributing to the economic welfare of the farmers and the citizen of Ondo State and this is determined by the annual production. Imodu (1995) reported that "Cocoa is one of the major foreign exchange earners to the country and in particular it has contributed immensely to raising the generated revenue of the producing states in Nigeria". Ondo States governments for example have been having substantial part of their annual revenue accruing from sales of cocoa beans. In Ondo State the revenue accruing to the state increased from ₦1.04 million in 1980 to about ₦209.66 million in 2003 (Folayan, 2005).

Therefore, cocoa production in Ondo State contributes to the economic welfare of the citizens of the State. However, cocoa yield in the states is determine by the rainfall variability in the two states, since agricultural production in part of tropic is rain-fed, and recognizing that the constraints of rain-fed agriculture in Nigeria in particular as the erratic rain distribution (Jonathan et al, 2009). Therefore, water supply determine cocoa yield at any point in time (Adejuwon and Odekunle, 2006).

Therefore, rainfall variability which is as a result of climate change will affect cocoa production either positively or negatively. Rainfall stability in term of availability of water will increase cocoa production and which will invariably affects the economic welfare of the citizens of both states positively. Since cocoa production is water dependent (Omotosho, 2007). While rainfall variability as a result of climate change will affect cocoa production negatively and this will impact negatively on the economic welfare of the cocoa farmers and the income generated by the government from graded cocoa in Ondo State.

METHODOLOGY

Study Area

Ondo State is purposively selected for the study because the State is the highest producer of cocoa in Nigeria (National Bureau of Statistics, (NBS) 2010). The state is made up of 18 Local Government Areas, it is located in the South-western Zone of Nigeria (Adejuwon and Odekunle, 2006). The state lies between longitudes 4"30" and 6" East of the Greenwich Meridian, 5" 45" and 8" 15" North of the Equator (Emielu, 2000). The state lies entirely in the tropical rainforest (Salako, 2006). Ondo State is bounded in the North by Ekiti/Kogi States; in the East by Edo State; in the West by Oyo and Ogun States, and in the South by the Atlantic Ocean (Olarenwaju, 2004). The land area of the state is 14,788.723 square kilometres (km^2) (Ayoade, 2004). While the population of the state is 3,441,024 comprising 1,761,263 Males and 1,679,761 Females, National Population Commission, (NPC) 2006.

Since the state lies in the tropical rainforest, the state has a bimodal rainfall distribution but with less intensity. There is a distinct dry and rainy seasons. The state has an average annual rainfall and temperature of 1489mm and 26.5^{o}C respectively (Omotosho, 2007). In Ondo state, there is lower layer vegetation mostly dense with abundance herbs, shrubs and some grasses. While the top layer of the state accounts for valuable economic trees such as Mahogany, Iroko, Obeche among others (Akeh and Gbuyiro,2006). The state has a high density of human population with agriculture as primary occupation of the people. The state is known for the cultivation of maize, cocoyam, cassava, vegetable, yam, oil palm etc (Oyekale, 2009).

Data Collection

Annual cocoa production in Ondo State was collected from the annual bulletins of Central bank of Nigeria and from the National bureau of Statistics. The annual cocoa production data were collected from 1970 to 2010. The secondary data were used to determine the influence of climate change on cocoa output level in Ondo State. Also, average yearly weather data from 1970 to 2010 include; rainfalls, temperature, relative humidity within rainforest zone were obtained from the archive of Nigerian Meteorological Agency (NIMET).

Data Analysis

Co-integration technique was used to ascertain both the short and the long run equilibrium relationship between cocoa production and climate change in the study area.

Therefore, the ADF unit root test estimation was done to test the hypothesis that Cocoa had a unit root (i.e. $H_0: \beta = 1$) using equation 1

$\Delta C_{t=}\ \beta_1\Delta C_{t-1} + \beta_2\Delta C_{t-2} + \text{----} + \beta_p\Delta C_{p-1} + V_t$ ------------------------ équation 1

Where C_t is the exogenous regressor (i.e. Cocoa) with a constant trend.

β is the parameter to be estimated

V_t is the error term.

Also, the ADF unit root test estimation was done to test the hypothesis that Rainfall had a unit root (i.e. $H_0: \alpha = 1$) using equation 2

$\Delta R_{t=}\ \alpha_1\Delta R_{t-1} + \alpha_2\Delta R_{t-2} + \text{----} + \alpha_p\Delta R_{p-1} + \varepsilon_t$ ------------------------ équation 2

Where R_t is the exogenous regressor (i.e. Rainfall) with a constant trend.

α is the parameter to be estimated

ε_t is the error term.

Furthermore, the ADF unit root test estimation was done to test the hypothesis that Temperature had a unit root (i.e. H_0: ρ = 1) using equation 3

$\Delta T_{t=}$ $\rho_1 \Delta T_{t-1} + \rho_2 \Delta T_{t-2}$ + ----+ $\rho_p \Delta T_{p-1} + u_t$ ------------------------ équation 3

Where T_t is the exogenous regressor (i.e. Temperature) with a constant trend.

ρ is the parameter to be estimated

u_t is the error term.

The ADF unit root test estimation was equally done to test the hypothesis that Humidity had a unit root (i.e. H_4 : a = 1) using equation 4

$\Delta H_{t=}$ $a_1 \Delta H_{t-1} + a_2 \Delta H_{t-2}$ + ----+ $a_p \Delta H_{p-1} + u_t$ ------------------------ équation 4

Where H_t is the exogenous regressor (i.e. Humidity) with a constant trend.

a is the parameter to be estimated

u_t is the error term.

The next step was the co-integration test. Equation 5 was used to determine the long term equilibrium relationship between the outputs of Cocoa in Ondo State (i.e. Cocoa Yields) and the climate change (i.e. Rainfall, Temperature and Humidity).

$$\Delta Y_t = \prod Y_{t-1} + \sum_{i=1}^{p-1} \Delta Y_{t-1} + б_i X_t + \varepsilon_t \text{ ---------------------------------} \quad \text{equation 5}$$

However, equation 5 was transformed as follows;

$$\prod = \sum_{i=1}^{p} A_i - I_i, \quad б_i = -\sum_{j=i+1}^{p} A_j \text{ ---------------------------------} \quad \text{equation 6}$$

where Y_t = (C, R, T, H) is a k-vector of non-stationary I(1) variables;

C: Cocoa Outputs in Ondo and Ekiti State (i.e. Yields)

R: Rainfall value in Ondo and Ekiti State

T: Temperature value in Ondo and Ekiti State

H: Humidity value in Ondo and Ekiti State

t: 1970-2010

Where *k is the* 4 × 4 matrices **A**, for *i* = 1,...,*k* are matrices of coefficients relating the 4 variables in $\mathbf{Y_t}$ to their lagged values. where $б_1$ = - (**I** - **A** -...-$\mathbf{A_1}$), *i* = 1,...,*k* -1, and **Π** = - (**I** - **A** -...-**A**) are all 4 × 4 matrices. This specification usefully separates the short-run and long-run adjustments to changes in the variables in Y_t, capturing these in the matrices $б_1$ and **Π** respectively.

Also, the trace statistics for the null hypothesis of cointegrating relations were computed as follows:

$$LR_{tr}(r/k) = -T\sum_{i=r+1}^{k}\log(1-\lambda_i) \text{ and } LR_{max}(r/r+1) = -T\log(1-\lambda_{r+i}), \text{ which can be}$$

transformed as = LR_{tr} (r/k) - LR_{max} (r+1/k) for r= 0,1,-------,k-1.

Where λ_i is the i-th largest eigenvalue of the ∏ matrix in equation 6.

RESULTS AND DISCUSSION

Unit Root Test

We test for the presence of unit roots and identify the order of integration for each variable using the Augmented Dickey–Fuller (ADF). The null hypothesis is considered as non-stationary. The test on the variables (i.e. Cocoa, Humidity, Temperature and Rainfall) gave the following result shown in Table 1.

Table1. Results of ADF Unit Root Test

Variable	ADF-statistic	Critical value (1%)	Critical value (5%)	Result
Cocoa	-2.855384	-3.610453	-2.938987	non stationary
Humidity	-6.452821	-3.610453	-2.938987	stationary
Temperature	-5.934024	-3.610453	-2.938987	stationary
Rainfall	-1.591781	-3.610453	-2.938987	non-stationary

Source: Computed from Cocoa and Weather Series Data

The computed ADF test-statistic for Cocoa (-2.855384) is greater than the critical values (-3.610453 and -2.938987) at 1 and 5% significant level, respectively), thus we can conclude that Cocoa has a unit root that is it is a non-stationary series. While the computed ADF test-statistic for Humidity (-6.452821) is lesser than the critical values (-3.610453 and -2.938987) at 1 and 5% significant level, respectively), thus we can conclude that Humidity has no unit root (i.e. stationary series). Also, the computed ADF test-statistics for Temperature (-5.934024) is lesser than the critical values (-3.610453 and -2.938987) at 1 and 5% significant level, respectively), thus we can conclude that Temperature has no unit root (i.e. stationary series). However, the computed ADF test-statistic for Rainfall (-1.591781) is greater than the critical values (-3.610453 and -2.938987) at 1 and 5% significant level, respectively), thus we can conclude that Rainfall has a unit root that is it is a non-stationary series.

As shown in Table 1, for the variables of Cocoa and Rainfall, the results shows that it is evident that we found the presence of a unit root at conventional levels of statistical significance at both 1 and 5% for the variables of Cocoa and Rainfall. To see whether they are integrated of order one I(1) at both 1 and 5% level, we performed Augmented Dickey–Fuller tests on their first difference. The results of the unit root test show in table 2 that the first differences of both series are stationary which are found to reject the null hypothesis of unit root.

Table2. Results of ADF on First Difference of Cocoa and Temperature

Variable	**ADF-statistic**	**Critical value (1%)**	**Critical value (5%)**	**Result**
Cocoa	-7.525729	-3.615588	-2.941145	Stationary
Rainfall	-8.540910	-3.615588	-2.941145	Stationary

Source: Computed from Cocoa and Weather Series Data

Therefore we can conclude that only Cocoa and Rainfall series involved in the estimation procedure are regarded as I(1), and it is suitable to make co integration test.

Johansen Co-integration test

As proved by previous test the two variables (i.e. Cocoa and Rainfall) under analysis are integrated of order 1 (namely I(1)), hence now the cointegration test is performed. The proper way to test for the relationship between Cocoa and Rainfall is certainly to test for a co-integrating equation. In testing co-integration relationships, we use the Johansen and Juselius method of testing. For selecting optimal lag length for the co-integration test, we adopt the Schwartz Information Criterion (SIC) and Schwarz criterion (SC) Criterion. The co-integration tests results performed on the variable Cocoa and Rainfall gave the following result in Table 4. Therefore, by applying Johansen test on Cocoa and Rainfall series we found the presence of two co-integration vectors. Therefore, by applying Johansen decision rule, we conclude that there are two co-integration vectors for the model. Hence our findings imply that there are stable long run relationships between the two variables i.e. Cocoa and Rainfall. The results for the Johansen's test are concluded in Table 4 below.

Table 4
Trend assumption: Linear deterministic trend
Series: RAINFALL COCOA
Lags interval (in first differences): 1 to 1
Unrestricted Cointegration Rank Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.418657	25.26546	15.41	20.04
At most 1 *	0.115264	4.653703	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Trace test indicates 2 cointegrating equation(s) at the 5% level
Trace test indicates 1 cointegrating equation(s) at the 1% level

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.418657	20.61175	14.07	18.63
At most 1 *	0.115264	4.653703	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Max-eigenvalue test indicates 2 cointegrating equation(s) at the 5% level
Max-eigenvalue test indicates 1 cointegrating equation(s) at the 1% level

From the Table 4, the Trace Statistic test reveals that at both 5% and 1% level of significance that at most 2 and 1 equations are co-integrated, since their absolute values are greater than the critical values of 5%

and 1% level of significant i.e.25.27>15.41 and 20.04, 4.65>3.76.

Also, from the same table, the Max-Eigen values reveal that at both 5% and 1% level of significance that at most 2 and 1 equations are co-integrated. Their absolute values are greater than the critical values of 5% and 1% level of significant i.e. 20.61>14.07 and 18.63, 4.65>3.76. This corroborated the Trace Statistics. Therefore, it was concluded that there is a long run equilibrium relationship between Cocoa and Rainfall in the study area. With all these tests, there is a long run equilibrium relationship between the dependable (Cocoa) and one of the explanatory variables (Rainfall) in the model. The results established the fact that Cocoa yield in the study area is mostly affected by rainfall variability.

From the study, it is establish that Cocoa is highly susceptible to drought and the pattern of cropping of cocoa is related to rainfall distribution. It is well established that cocoa is highly sensitive to changes in climate-to rainfall and application of water which correlate the findings of Adu-Ampomah and Frimpong (2002). Since rainfall alter stages and rates of development of coca pests and pathogens, modify host resistance and result in changes in the physiology of host-pathogen/pests interaction (Appiah, (2004). The most likely consequences are shifts in the geographical distribution of host and pathogen/pests, altered crop yields and crop loses which, will impact socio-economic variables such as farm income, livelihood and farm-level decision making.

CONCLUSION

The implication of the statistical analysis is that rainfall affects cocoa yield in the study area. Since it is establish that there is long run equilibrium relationship between cocoa and rainfall. Therefore, rainfall variability will affects cocoa yield over time. Drought management policy through information systems about changing climate conditions and patterns, preparatory practices and options to deal with eventuality of drought must be set in place. Also, irrigation is traditionally not part of the cocoa farming systems in the study, therefore, policies to promote the establishment of irrigation systems in farms through the provision of infrastructure, education and training should be considered.

References

Adejuwon, J. O. and T. O.Odekunle, (2006). Varrability and severity of Little Dry Season in South Western Nigeria. *Journal of Climate*. Vol. 5, Pp 483-493

Adegeye S. O. (1998): "An evaluation of food crop farming inside old Cocoa Groves" Nigerian *Journal of Agriculture* 14. 1.

Adu-Ampomah, Y. and E. B Frimpong,. (2002). Breeding for ease of establishment in degraded environment. Rep. Cocoa Res. Inst., Ghana, 1999/2000. p 90-91/

Akeh, L. E. and S. O. Gbuyiro, (2006). Climate Change Detection and Its Socio-economic Impacts: Nigeria Situation. *Journal of the Nigeria Meteriological Society* (NMS). No.1, Pp 82-93.

Appiah, M. R. (2004). Impact of cocoa research innovations on poverty alleviation in Ghana. Ghana Academy of Arts and Sciences Publication. 32pp

Ayoade, J. O. (2004). A Statistical analysis of rainfall over Nigeria. *Journal of Tropical Geography*. 39, 11-23.

Dennett, M. D., J. Elliston and C. B. Speed, (1981): "Climate and Cropping Systems in West Africa''. *Geoforum* 12(2): 198-202.

Emielu, S. A. (2000). *Senior Secondary Geography*. Geographical Bureau Nigeria Limited, Nigeria. Pp 71-72.

Folayan J. A. (2005): "Economic Analysis of Cocoa Marketing in Ondo and Ekiti States of Nigeria". Unpublished Ph.d Thesis, Department of Agricultural Economics & Extension, Federal University of Technology, Akure.

International Cocoa Organisation, (1994): ''Project Proposal on improvement of Cocoa Marketing and Trade Liberalizing, Cocoa Producing Countries''. International Cocoa Organization. Ex/94/6/Rev. 1 (ICCO Secretariat).

International Cocoa Organisation, (2008): Annual Statistical Report. 7, 103-106.

Imodu, P. B. (1995): ''Produce Trade and Marketing in Ondo State: Recent Trends and Implications''. A seminar Paper in at the Annual Cocoa Day in Akure, Ondo State on 24th June, 1995.

Jonathan, B., E. Abayomi, U. Gideon, and A. Julius, (2009): "An Assessment of Water Supply Potential for Crop Production: Comparative Study of River Basins Under the Jurisdiction of Two River Basin Development Authority Areas Located in Different Ecological Zones of Nigeria" *Journal of Meteorology and Climate Science* 7, 1

MARD, (1993): Ministry of Agriculture and Rural Development, Akure, Ondo State.

Mortimore, M. J. (1989). "Adopting to drought: Farmers, famine and desertification in West Africa. Cambridge University Press, Cambridge, UK.

Mayhew, D and A. Perry, (1998): Tropical and Sub-Tropical Foods; 183-193, Macmillan Publishers Limited London and Basingshoke.

NPC, (2006): National Population Commission, Nigeria Annual Censor, 2006

Olarenwaju, M. (2004). A Preliminary Study of the Impact of Climate Change on the Growth of Melon in Kwara State. *Journal of Nigerian Meteriological Society*. l5, 1-5.

Omotosho, J. B. (2001). *Prediction of Seasonal the Onset, Cessation and Length of the Rainy Season, the Monthly and Annual Rainfall Amount for the whole of Nigeria for the year 2000.* Final Report of the project Submitted to the Department of Meteorological Services, Federal Ministry of Aviation, Abuja.

Omotosho J. B. (2007). Pre-rainy Season Moisture Build-up and Storm Precipitation Delivery in the west African Sahel. *International Journal of Climatology*. DOC:10.1002/joc.1548.

Oyekale, A. S. (2009). ''The Effect of Climate Change on Cocoa Production and Vulnerability Assessment in Nigeria''. *Medwell Agriculture Journal*. 4 (2),77-85.

Parry, M. L., Rosenzweig, C., Iglesias, A., Livermore, M., and Fischer, G. (2004). 'Effects of climate change on global food production under SRES emissions and socio-economic scenarios'. *Global Environmental Change.* 14, ; 53–67.

Salako, F. K. (2006). Rainfall Temporary Variability and Erosivity in Subhumid and Humid Zones of Southern Nigeria. *Land Degradition Development*. 17, 541-555.