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ECONOMIC IMPACT OF CLIMATE CHANGE ON COCOA PRODUCTION AMONG SOUTH-WESTERN STATES, NIGERIA: RESULTS FROM RICARDIAN ANALYSIS

EDET E.O., UDOE P.O. AND A. E. EKONG

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ABSTRACT

The study was carried out to determine the economic impact of climate change on cocoa producing states in south western states, Nigeria using Ricardian analytical procedure. The specific objectives were to: analyze the economic impact of climate change on cocoa production, estimate the marginal impact of climate change on net cocoa farm revenue in the areas of study, find out whether there is a significant mean difference in climatic variables among the cocoa producing states in the south-west Nigeria and make useful recommendations based on findings. Data were sourced from CBN bulletin, Federal Ministry of Agriculture and Nigeria Meteorological Agency (NIMET), spanning 1981 - 2015. Model specification was based on Ordinary Least Square (OLS) multiple regression technique using Ricardian framework on net revenue. Data obtained were analyzed using both descriptive and inferential statistics. Results show that 11, 47 and 77% of the variations in net revenue from cocoa production were explained by rainfall and temperature for Oyo, Ondo and Osun states respectively. The study also affirms that the climatic (rainfall and temperature) and non climatic (area, producer price, yield and technology) variables accounts for 98%, 97% and 96% of the variations in net revenue per hectare of cocoa production respectively in Oyo, Ondo and Osun states. The study further showed that there was a significant difference in climate change over time across the cocoa producing states at 1% level of probability. The study indicated that climatic changes culminated in economic losses/benefits of about ₦27.63million (₦3.50million), ₦5.6million (₦14.90million) and ₦1.3million (₦5.8million) respectively across the states amidst varying marginal economic losses of ₦1billion (Ondo) and benefits of ₦10.08 and ₦270.48million (Oyo and Osun States) in the study area. Based on these, it was concluded that climatic changes over time are not the only parameters that accounted for economic losses and benefits, other factors also contributed. It was recommended that low-yielding cocoa trees, which have exceeded optimum production ages be replaced with the high-yielding ones alongside farmers should cultivate cocoa varieties that are tolerant to climate change in the area of consideration, *ab initio*.

KEY WORDS: **Climate change, Cocoa, Ricardian, Production, Economic impact.**

INTRODUCTION

The Primacies of agriculture to African economies have never been in doubt. Its role in the provision of foreign exchange and development of economies cannot be overstated, as it remained for a long time, the main source of foreign exchange earnings (Nkamleu *et al.,* 2010; Adeniyi and Ogunsola, 2014). In terms of foreign exchange earnings, no single agricultural export commodity has earned more than cocoa (Nkang *et al.,* 2007). The contributions of cocoa to the nation's economic development are vast and have been reported by many authors (Nkang *et al.*, 2007). With respect to employment, the cocoa sub-sector still offers quite a sizeable number of people employments, both directly and indirectly. Climate is the effect of weather over a long period of time, usually twenty five years (Oluyole and Adebiyi, 2007). It is a major determinant of both the location and productivity of agricultural activities. Climate can be understood most easily in terms of annual and seasonal changes of temperature and precipitation. Several studies have examined the impact of climate change on agriculture using case studies, statistical analysis and simulation models (Oluyole, and Usman, 2006). The variability of these climatic elements, however, determines the suitability of a place to grow cocoa and even the overall output from the crop. The Nigerian cocoa economy has a rich history which is well documented in literature. There are fourteen states producing cocoa in the country, namely: Ondo, Cross River, Osun, Ekiti, Ogun, Oyo, Edo, Delta, Kwara, Kogi, Abia, Taraba, Adamawa and Akwa Ibom States (Oluyole

Edet E.O., Department of Agricultural Economics (Environmental Economics unit), Faculty of Agriculture, Forestry & Wildlife Resources Management, University of Calabar, Calabar-Nigeria
Udoe P.O., Department of Agricultural Economics (Environmental Economics unit), Faculty of Agriculture, Forestry & Wildlife Resources Management, University of Calabar, Calabar-Nigeria
A. E. Ekong, Department of Geography and Environmental Sciences Faculty of Social Sciences

and Sanusi, 2009). However, cocoa production in Nigeria has witnessed a downward trend after 1971 season, when its export declined to 216,000 metric tonnes (MT) in 1976, and 150,000 metric tonnes in 1986, therefore reducing the country's market share to about 6 % and to fifth world largest producer to date.
(Folayan, Daramola, and Oguntade, 2006). Presently, Nigeria is the fourth largest producer of cocoa worldwide, after Cote d'ivoire, Ghana and Indonesia. Statistics from the Federal Produce Inspection Service (2015) showed that, cocoa production dropped considerably in Nigeria, between 2010 and 2014. Studies show that while 199, 651.2595 MT of the product was exported in 2013, 2014 witnessed a sharp decline with an export figure of 131, 115.9365 MT (FAO, 2015). Reasons elicited for the reduction in production included; less emphasis on agriculture, inadequate government program on agricultural input subsidy such as chemicals and planting materials, small farm sizes, inadequate capital, inadequate labour availability and most importantly, change in global climate (Oduwole, 2004). Given its inherent link to natural resources, cocoa production is at the mercy of uncertainties driven by climate variation, including extreme events such as flooding and drought. Over the last fifteen years, climate change (in terms of long-term changes in mean temperature or precipitation, cum an increased frequency of extreme climate effects) has gradually been recognized as an additional factor which, with other conventional pressures, will have a significant weight on the form, scale, spatial and temporal impact on agricultural productivity. According to FPIS, Nigeria lost over $15IM (about ₦30bn) as a result of this drop (FPIS, 2015).. This paper attempts to: analyze the economic impact of climate change on cocoa production, estimate the marginal impact of climate change on net cocoa farm revenue in the areas of study, find out whether there is a significant mean difference in climatic variables among the cocoa producing states in the south-west Nigeria and make useful policy recommendations based on findings.

Some theoretical issues

Related studies that have examined the impact of climate change on crop made use of either the production function approach (Ajayi, Afolabi, Ogunbodede and Sunday 2010; Abayomi, 2012) and Ricardian approach (Gbetibouo and Hassan, 2005; Mano and Nhemachena, 2006; Deressa and Hassan, 2009; Ajetomobi, Abiodun and Rashid, 2011; Fonta, Ichoku and Urama 2011; Coster and Adeoti, 2015). In the Production function approach, the production function is specified and the yields of different species of crops are examined under different climatic conditions (Reinsborough, 2003). The model assumes that the different species of crops do not have any means of adapting to the changing climatic condition (Reinsborough, 2003). This makes the model to under estimate the agricultural benefits of the changing climatic conditions. Ricardian model on the other hand measures the impact of climatic factors through their contribution to farmland-prices and have been extensively used for incorporating farm level adaptation (Mendelsohn, Nordhaus and Shaw, 1994). The approach has been used to evaluate the contribution of environmental measures to farm income (Mendelsohn, Nordhaus and Shaw, 1994).There are four major theories that underpin climate change and crop production; namely, the Ricardian theory, crop yield response theory, the Agricultural Investment Portfolio Model (AIPM) and the Metaeconomics Theoretical Model (MTM). The Ricardian theory was adopted for this study. This theory is founded on Ricardo's original observation that the value of land reflects its productivity. It is modeled in a cross-sectional fashion such that, the technique enables the measurement of the determinant of farm revenue. The general model, is specified as:

$$z = \sum i \left[\sigma_i T_i + \beta T_i^2 + \gamma_i + \delta_i P_1^2 \right] + K \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where *z* is the measure of agricultural productivity (net revenue per hectare), *T* is the average temperature, *P* is average monthly rainfall, *i* refers to the season, and *K* is a composite variable that reflects the regression constant as well as the influence of other control variables in the particular model estimated (Adeoti, 2015).
According to Coster and Adeoti (2015), the theory proceeds on the assumption that farmers maximize net revenues per hectare (NR).

$$hus,\ MaxNR = P_i^* Q_i(R, E) - C_i(Q, R, E) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Here P_i and Q_i are respectively the price and quantity of good *i; C_i* (.) is the relevant cost function; *R* is a vector of inputs, and *E* reflects a vector of environmental characteristics of the farmer's land including climate. Given that the farmer chooses inputs, *R,* to maximize *NR,* the net revenue function *NR* can be expressed in terms of *E* alone as:

$$NR = f(E) \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad (3)$$

To cater for the welfare value of a change in the environment from state *A* to *B* the model becomes:

$$W = \Sigma f(E_{iB}) * Li - \Sigma f(E_{iA}) * L_i \quad - \quad - \quad - \quad - \quad - \quad (4)$$

Where L_i is the amount of land of type *i* (Seo, Mendelsohn and Munasinghe, 2005). Equation (4) enables Cross-sectional observations across different climates to reveal the climate sensitivity of farms. The merits of this model are that, it does not only allow for the direct effect of climate on productivity, but also the adaptation response by farmers to local climate. Studies carried out over the years reveal that, many crops have preferred temperature and precipitation zones. Temperatures and precipitation levels either below or above such optimal ranges reduce productivity (Coster and Adeoti (2015). Consequently, Dinar, Hassan, Mendelsohn and Benhin. (2008) suggest the quadratic functional form of the Ricardian model as:

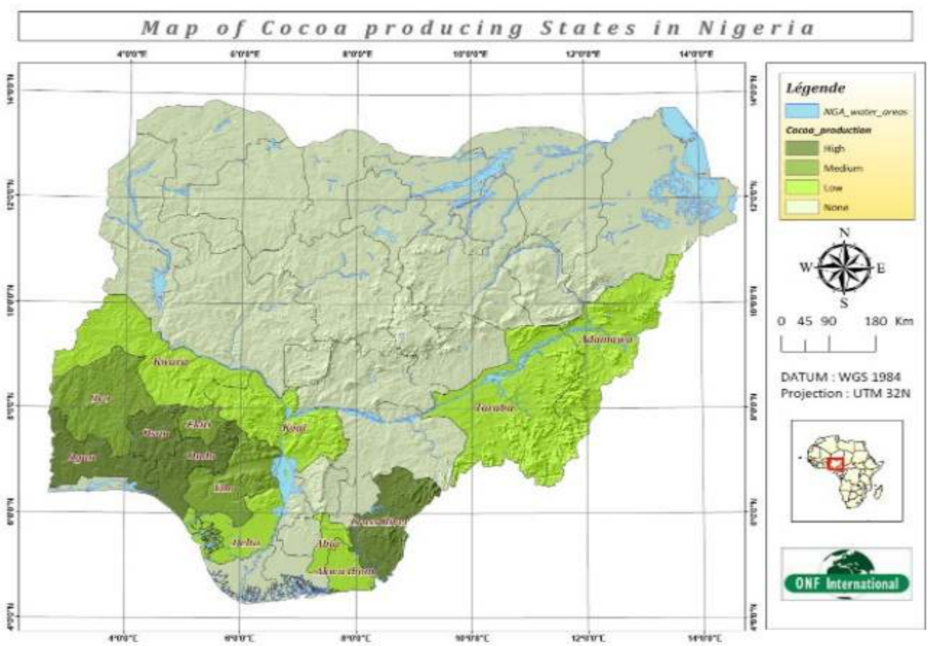
$$NR_i = \alpha_0 + \Sigma(a_s T_s + b_s T^2{}_s + C_s P_s + d_s P_s) + \Sigma f_c + Z_c + \varepsilon \quad - \quad - \quad (5)$$

Where *Ts* and *Ps* represent normal temperature and precipitation variables in each season; and Z_c represent relevant socio-economic variables

Methodology

Study Area

The study was carried out in the southwestern part of Nigeria. The states chosen were Oyo, Ondo and Osun State. Ondo State is well endowed with abundant human and natural resources and has an estimated land area of about 15,500 square kilometers. The state is bordered on the north by Ekiti and Kogi States, on the west by Ogun and Osun States, on the east by Edo and Delta States, and to the south by the Bight of Benin and the Atlantic Ocean. The state is made up of eighteen local government areas and lies between latitudes 7.088923°N and longitudes 4.7990935°E of the Greenwich Meridian . The estimated population of the state was 3,441,024 (NPC, 2006). The state is the leading cocoa producing state in Nigeria. Ondo State is rated as the largest cocoa producing state in Nigeria (Oluyole, 2005; ICCO, 2009). Oyo State is an inland state, with its capital at Ibadan. It is bounded in the north by Kwara State, in the east by Osun State, in the south by Ogun State and in the west partly by Ogun State and Republic of Benin. The state is located between latitudes $8^{0}00^{II}$N and longitudes $4^{0}00^{1I}$E of the Greenwich Meridian. The state has a population of 5,591, 589, with an estimated land area of about 28,454km^2. Osun State is rich in human and material resources. It covers an area of approximately 14,875 square kilometres. It lies between latitudes 7°30′N and longitudes 4°30′E . It is bordered by Ogun, Kwara, Oyo, Ondo, and Ekiti States in the south, north, west and east respectively. The state lies in the tropical rainforest. It has a population of 3,423, 535 (NPC, 2006). Cocoa is the main export crop grown in the state and it is second to Ondo in terms of cocoa production (Ogunsola, Olugbire, Oyekale and Aremu, 2015; Popoola, Ogunsola and Salman, 2015).



Source: ICCO (2009)
FIG.1: Map of the Nigeria showing cocoa producing States

Sources of data

The study made use of secondary data. Data on climate variables were sourced from NIMET, while data on cocoa output and producer prices of cocoa were sourced from various issues of Central Bank of Nigeria (CBN) statistical bulletins and Federal Ministry of Agriculture and Natural Resources from the States under study. The study covered the period 1981-2015.

Model specification

The econometric approach used in this study was based on the Ricardian method. This method was used to estimate the economic impact of climatic changes and allows for capturing farmers adaptations in response to climate change. Traditionally, Ricardian Model (RM) is explicitly indicated in equations 6 and 7, while equation 3 indicated the vector of climatic variables where the interest of the farmers lies:

$NR/Ha = F (PQ (W, X, Y, Z) - (TFC+TVC)$ (6)
$=PQ (W, X, Y, Z) – TC$ (7)
$NR/Ha = F (Z)$ (8)
Where NR/H is the net revenue per hectare, P is the market price of cocoa, Q is the quantity of cocoa, W is a vector of land size; X is a vector of producers' price, Y is the vector of technology, Z is a vector of climate variables. TVC + TFC = TC is a vector of input prices. The standard Ricardian model relies on a quadratic formulation of climate:

$$NR/Ha = \beta_o + \beta_1 RNF + \beta_2 RNF^2 + \beta_3 TM + \beta_4 TM^2 + \beta_5 H + \beta_6 PP + \beta_7 T + \beta_8 Y + U \quad (9)$$

NR/Ha = net revenue per hectare
RNF = vector of rainfall (millimeters)
TM = vector of temperature (Degree Celsius)
H = vector of land size (hectare)
T = Technology (time)
PP = producers price
Y = yield
U = error term (Mano and Nhemachena, 2006)
Two models were expressed differently for the three cocoa producing states of the south west, Nigeria. The first model captured the economic impact of climate variables on the net revenue per hectare on cocoa production. This model was expressed for the three different states.

$$NR/Ha = \beta_o + \beta_1 RNF + \beta_2 RNF^2 + \beta_3 TM + \beta_4 TM^2 \quad (10)$$

The second model captured the economic impact of climate and non climate variables on the net revenue per hectare on cocoa production. This model was also specified for the three different southwestern states.

$$NR/Ha = \beta_o + \beta_1 RNF + \beta_2 RNF^2 + \beta_3 TM + \beta_4 TM^2 + \beta_5 H + \beta_6 PP + \beta_7 T + \beta_8 Y + Ui \quad (11)$$

The expected marginal impact of a single climate variable on the land value and farm net revenue evaluated at the mean are:

$$MI = \partial NR/\partial RNF = \beta_1 + 2\beta_2 RNF \quad (12)$$

$$MI = \partial NR/\partial TM = \beta_3 + 2\beta_4 TM \quad (13)$$

Where MI is marginal impact,
$\partial NR/\partial RNF$= 1st order derivative of net revenue w.r.t rainfall
$\partial NR/\partial TM$ = 1st order derivative of net revenue w.r.t temperature

Analytical technique

Descriptive statistics such as graphs and tables were used in describing the trends(equations 14 and 15), while inferential statistics such as Analysis of Variance (ANOVA) and multiple regression were used. Precisely, the Ricardian Model (RM) was used to measure the economic impact of climate change on cocoa production in the areas of study.

$$CY_t = \beta o + \beta_{ir} + \beta_i T_i + \mu_i \quad (14)$$

$$CY_t = \beta o + \beta_{it} + \beta_i T_i + \mu_i \quad (15)$$

Where CY_t = actual cocoa yield(tones/hectares); βo = intercept; β_{ir} = rainfall(millimeters);
β_{it} = temperature(degree Celsius); $\beta_i T_i$ = (1981 – 2015); μ_i = error term (Mano and Nhemachena, 2006).

Results and Discussion

Trend in climatic variables on cocoa yield in southwestern States

The trend of climate variables on cocoa yield are presented in figures 2 - 4. The trend of climate variables on cocoa yield shows that temperature in Ondo, Osun and Oyo were fluctuating during the period under consideration. Specifically, Ondo state recorded the highest temperature in 1998 (27.5^0C), while the lowest was in 2009(25.73^0C). The highest temperature for Osun state was recorded in 2011(28.41^0C), while the least was in 1981(26.50^0C). Similar result was obtained in Oyo state, with a highest temperature (28.41^0C) and lowest temperature (26.61^0C) recorded in 2011 and 1981 respectively. Also, temperature exhibited an increasing trend in Ondo and Osun state, while that of Oyo state was decreasing. However, rainfall exhibited similar trend (fluctuating and dwindling) as shown in figures 5 - 7. The highest and lowest rainfall were recorded in 2010 (169.18mm) and 1983 (90.52mm), 2010 (170.26mm) and 1983 (104.79mm), 2011 (159.08mm) and 1982 (63.35mm) for Osun, Ondo and Oyo States respectively. Despite this fluctuating and dwindling trend in temperature and rainfall, the yields of cocoa across the southwestern states were on the increase by 25.43 tonnes per hectare per annum. Oluyole, Emaku, Aigbekaen and Oduwole (2013) obtained similar fluctuating trend in their studies

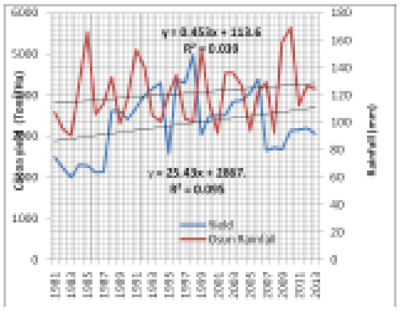


Fig.2: Trend of cocoa yield and rainfall in Osun State

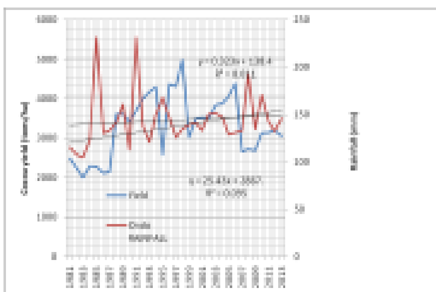


Fig.3: Trend of cocoa yield and rainfall in Ondo State

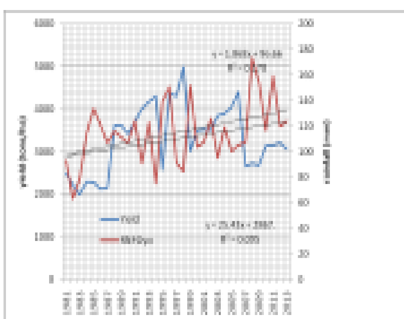


Fig.4: Trend of cocoa yield and rainfall in Oyo State

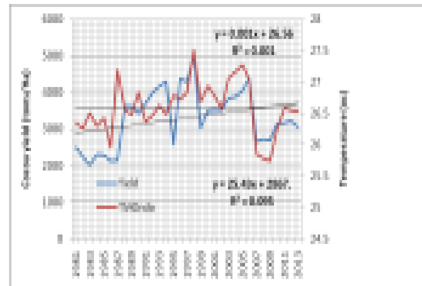


Fig.5: Trend of cocoa yield and temperature in Ondo State

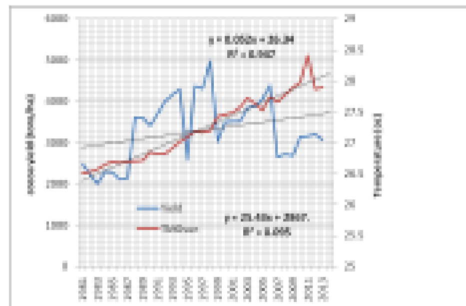


Fig.6: Trend of cocoa yield and temperature in Osun State

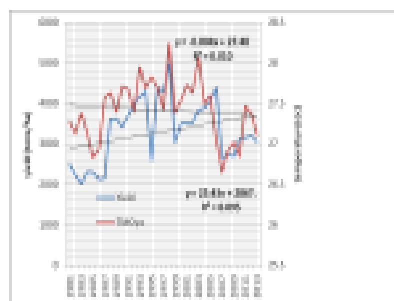


Fig.7: Trend of cocoa yield and temperature in Oyo
Ondo State

Economic impact of climate change on net revenue per hectare on cocoa production in the South - western states, Nigeria

The result showing the economic impact of climate change on net revenue per hectare on cocoa production in the southwestern states is presented in Table 1. The result shows that rainfall and its square term had opposite signs. The coefficient of rainfall and its square term were (16.872, -1.391), (281.969, -27.663) and (53.500, -5.619) for Oyo, Ondo and Osun states respectively. However, the impact of rainfall and its square term on the net revenue per hectare on cocoa production was only significant in Ondo State. Both rainfall and its square term were significant at 1 % in Ondo State. Moreso, the result of the rainfall square term was negative across the three states and this implies that an increase in rainfall reduced the net revenue per hectare of cocoa production in the study area. Similarly, the coefficient of temperature and its square term was (-73.221, 5.840), (-55.051, 3.501) and (148.938, 14.903) for Oyo, Ondo and Osun States respectively. Temperature and its square term were both positive and significant at 1% in Osun State. Temperature square term was positive across the three states and these imply that, an increase in temperature will increase the net revenue per hectare of cocoa production in the study area with significant impact being observed in Osun State.

Table 1: Economic impact of climate change on net revenue per hectare on cocoa production in the South - western states, Nigeria

Variable	Model 1(Oyo) Coefficient	t-value	Model 2(Ondo) Coefficient	t-value	Model 3(Osun) Coefficient	t-value
Constant	-92.668	-0.809	-734.854	-5.171***	-269.948	-2.143**
LnRNF	16.872	0.353	281.969	4.906***	53.500	1.022
LnRNFsq	-1.391	-0.272	-27.663	-4.859***	-5.619	-1.031
LnTM	-73.221	-1.112	-55.051	-1.399	148.938	9.049***
LnTMsq	5.840	1.460	3.501	1.297	14.903	10.339***
Diagnostics						
R^2	0.196		0.519		0.794	
Adj R^2	0.113		0.470		0.773	
F-ratio	2.359**		10.447***		37.366***	

Notes: ** = 5% level of significance; *** = 1% level of significance

Source: Field Survey Data (2017)

The estimate of the economic impact of climate and non-climate change variables on net revenue per hectare on cocoa production in the southwestern states is presented in Table 2. The result shows that for the climate change variables, the coefficient of rainfall and its square term were 64.420 and -6.327, 19.930 and -2.059, and 33.944 and -3.520 for Oyo, Ondo and Osun states respectively. The impact of the coefficient of rainfall and its square term was statistically significant at 1 % and 1 %, 5 % and 10 % and 10 % respectively. The negative coefficient of rainfall square term implies that an increase in rainfall significantly reduced the net revenue of cocoa production. Similarly, temperature and its square term also had both negative and positive impact on the net revenue per hectare on cocoa production. The coefficient of temperature (square term) was -1.185(2.205), 13.739(2.092), 75.174(3.818) and was statistically significant at (1%), (10%) and 1%(10%) for Oyo, Ondo and Osun respectively. The result of the temperature square term suggests that an increase in temperature increased the net revenue per hectare of cocoa production across the three states. However, the inclusion of non-climate variables shows that area cultivated, producer price, yield of cocoa and technological change all had a positive impact on net revenue per hectare on cocoa production in the study area. This implies that a 1% increase in area cultivated, producer price, yield of cocoa and technological change, *ceteris paribus*, increased the net revenue per hectare on cocoa production by (1.966, 0.619, 0.945 and 0.043), (1.998, 0.667, 1.145 and 0.059), (0.522, 0.600, 1.413 and 0.058) for Oyo, Ondo and Osun States respectively. The coefficient of these variables were significant at various levels of significance except area cultivated in Osun State which had a positive but not significant impact on net revenue per hectare on cocoa production. The adjusted R^2(0.98, 0.97 and 0.96) was high and shows that 98%, 97% and 96% of the variation in net revenue per hectare from cocoa production was jointly explained by the independent variables for Oyo, Ondo and Osun States respectively. The F-ratio which shows the intensity of the explanatory model across the three States was 197.566, 132.635 and 114.634 and was significant at 1% level. The results obtained for both Tables 1 and 2 are consistent with studies by Aboyami (2012), Owoeye and Sekumade (2014) and Oluyole, *et al.,* 2013). In their studies, the coefficient of rainfall was negative and statistically significant, while temperature had a positive and significant impact on cocoa yield. They attributed the negative impact of rainfall to cocoa output and asserted that too much rainfall affects effective spraying of cocoa pods in the region.

Table 2: Economic impact of climate and non-climate change variables on net revenue perhectare on cocoa production in the southwestern states, Nigeria (1981-2015)

Variable	Model 1(Oyo) Coefficient	t-value	Model 2(Ondo) Coefficient	t-value	Model 3(Osun) Coefficient	t-value
Constant	-209.102	-5.529	-95.594	-3.689	-129.246	-2.415
LnRNF	64.420	4.354***	19.930	2.000*	33.944	1.509
LnRNFsq	-6.327	-4.336***	-2.059	-1.928*	-3.520	-5.030***
LnTM	-1.185	0.897	13.739	1.028	75.174	3.211***
LnTMsq	2.205	3.148***	2.092	1.891*	3.818	1.751*
LnArea	1.966	4.565***	1.998	3.393***	0.522	0.621
LnPprice	0.619	8.956***	0.667	7.339***	0.600	5.750***
LnYield	0.945	2.692**	1.145	2.466**	1.413	3.232***
LnTech	0.043	2.103*	0.059	2.427**	0.058	2.214**
Diagnostics						
R^2	0.982		0.974		0.970	
Adj R^2	0.977		0.966		0.961	
SE	0.317		0.385		0.413	
F-ratio	197.566***		132.635***		114.634***	
DW	1.752		1.198		1.633	

Notes: * = 10% level of significance; ** = 5% level of significance; *** = 1% level of significance

Source: Field Survey Data (2017)

Marginal impact of climate change on net cocoa farm revenue in the areas of study

The marginal impact analysis was undertaken to observe the effect of small changes in temperature and rainfall on net revenue per hectare (NRh^{-1}) on cocoa production in south-west Nigeria. The results are reported in Table 3. For Oyo State; a 1% increase in rainfall had a negative impact on NRh^{-1} on cocoa production. There was a ₦45.23 million decrease in NRh^{-1} on cocoa production over the period. The marginal impact of temperature was 55.3168, meaning that a 1% increase in temperature increased NRh^{-1} on cocoa production during the period by ₦55.31 million. The combined impact of temperature and rainfall (climate) on NRh^{-1} on cocoa production is ₦ 10.08 million (Gain). This is in accordance with the work of Davis and Sadiq (2010). For Osun State, ₦203.89million was lost as a result of rainfall while ₦474.38million was gained during that period as a result of 1% increase in temperature. The combined marginal impact shows that ₦270.48 million was gained during the period. For Ondo State, a 1% increase in rainfall resulted in a loss of over ₦1 billion over the period under consideration. While temperature had a positive impact on NRh^{-1} on cocoa production as a result of the 1% increase in temperature. As a result, =₦20.29million was gained. The combined marginal impact shows that over ₦1billion was lost as a result of climate change during the period.

Marginal impact
Rainfall - Oyo

$$NR/\mathrm{h}a = bo + b_i\, RNF + b_2 RNF^2 + b_3\, TM + b_4\, TM^2 + e \qquad - \quad - \quad - \qquad (16)$$

1st order derivative: w.r.t RNF

$$\frac{\partial NRh^{-1}}{\partial\, RNF} = b_1 + 2\ b_2 + RNF\ ----------(17)$$

$$16.872 + (-1.391)(22.324) = NRh^{-1}$$

$$= 16.872 - 2.782\ (22.3247)$$

$$= 16.872 - 62.1073$$

$$= N45.235\ x10^6 = -N45.235 million$$

Temperate – Oyo (see equ. 16)

$$\partial NRh / \partial TM = b_3 + 2\ b_4\, TM ....(18)$$

$$= -73.221 + 2\ (5.840)\ (10.9635)$$

$$= -73.22 + 128.5368$$

$$= N55.3168$$

Table 3: Marginal impact of climate change on net cocoa farm revenue in SW Nigeria (1981-2015)

S/N	State	Rainfall	Temperate	Total(₦ Million)
1.	Oyo	-45.235	55.3168	10.0816
2.	Osun	-203.8962	474.3808	270.4845
3.	Ondo	-1077.0589	20.2975	-1, 056.7614

Source: Field Survey Data (2017)

Difference in climate variables among the cocoa producing states in the south west Nigeria

Table 4 shows the difference in climate variables among the cocoa producing states in the South West, Nigeria. The result showed that there was a significant difference in climate variables across the three States. This was due to the fact that the Fcal (379.9969) was greater than the Fcritical-value (2.2707) and a p-value of 0.0000 which was significant at 1% level. Thus, the null hypothesis was rejected in favour of the alternative hypothesis.

Table 4: Difference in climate variables among the cocoa producing states in south-western Nigeria (1981-2015).

Source of variation	SS	Df	MS	F_{cal}	F_{crit}	P-value
Periods	19439.08	32	607.4712	2.2775	1.5161	0.0004
CC variables	506777.3	5	101355.5	379.9969	2.2707	0.0000
Error	42676.34	160	266.7271			
Total	568892.7	197				

Source: Field Survey Data (2017); Note: CC = Climate change

Test of hypotheses

Hypothesis 1: The null hypothesis of no significant difference in climatic variables among the cocoa producing states in the south west, Nigeria was rejected. This was shown using the ANOVA test (Table 4). Therefore, it was concluded that there was a significant difference in climatic variables among the cocoa producing states in the south west, Nigeria. The result of hypothesis 2 showed that, climatic variables had a significant economic impact on cocoa production in the three states using the multiple regression estimates. This was due to the fact that the t_{cal} was greater than the t_{crit} across the three cocoa producing states.

Conclusion and Policy recommendations

The paper concludes that rainfall impacted negatively on the net revenue per hectare of cocoa production in the south-west Nigeria. Increase in rainfall lead to a loss of ₦4.23million, ₦203.89 million and ₦1.077 billion in Oyo, Osun and Ondo states respectively. Temperature on the other hand had a positive impact on net revenue per hectare on cocoa production in the three states. The net revenue per hectare increased by ₦55.31million, ₦474.38 million and ₦20.297 million in Oyo, Osun and Ondo states respectively as a result of temperature increase. As a result of climate change (temperature and rainfall) Osun and Oyo states gained ₦270.48 million and ₦10.0816 million in the period under consideration, while Ondo state lost ₦1,056.76 million as a result of climate change. Based on the findings, it was recommended that:

I. Cutting-edge adaptation measures should be employed by cocoa farmers in the management of cocoa to the physiological maturity stage. This can be achieved via collaboration of the extension agents.

II. Cocoa Research Institutes (CRI) should breed cocoa varieties that are capable of withstanding the vagaries of climate change specific to the region under consideration.

III. Efforts aimed at mitigating adverse climate variations through sustainable replacement of old cocoa trees with improved varieties should be pursued with policy contents by the government. This will help to ameliorate adverse climatic effects on the commodity for enhanced income for the cocoa farmers.

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