ECONOMIC IMPACT OF CLIMATE CHANGE ON SMALLHOLDER MAIZE FARMERS IN SOUTHWESTERN NIGERIA: A STRUCTURAL RICARDIAN MODEL

ADEAGBO Olayinka A., Ph. D

ECONOMIC IMPACT OF CLIMATE CHANGE ON SMALLHOLDER MAIZE FARMERS IN SOUTHWESTERN NIGERIA: A STRUCTURAL RICARDIAN MODEL

ADEAGBO Olayinka A., Ph. D
Institute for Entrepreneurship and Development Studies,
Obafemi Awolowo University,
Ile-Ife, Osun State, Nigeria.

Abstract
The study analysed the economics of climate change adaptation strategies among smallholder maize farmers in Southwestern Nigeria. These were with a view to improving maize production in the study area. A multistage sampling procedure was employed to select 330 smallholder maize farmers in three states (Osun, Oyo, and Ogun States) in the study area. Primary data were collected with the aid of structured questionnaire while secondary data were collected from the Nigerian Meteorological Agency (NiMet). Data collected were analysed using descriptive statistics, and Ricardian model. The results showed that most (70.10%) of the farmers were men, married with a mean age of 47.60±10.74 years and cultivating 1.34±1.49 hectares of farmland on the average. Also, majority (80.06%) of the farmers were aware of climate change but their climate change perception intensity was low (0.27 on the average). Furthermore, dry season temperature ($p\leq0.05$), rainy season temperature ($p\leq0.01$), dry season precipitation ($p\leq0.1$), rainy season precipitation ($p\leq0.05$), dry season maize farming ($p\leq0.05$), soil types (Lixisols ($p\leq0.01$), Luvisols ($p\leq0.01$), and Nitisols ($p\leq0.01$)), farmer's sex ($p\leq0.1$), formal education ($p\leq0.1$), access to credit ($p\leq0.01$), distance from farm to a major tarred road ($p\leq0.05$), access to climate-related information ($p\leq 0.1$), and usage of improved maize seed variety ($p\leq0.01$) influenced the net revenue of smallholder maize farmers. In conclusion, smallholder maize farmer's use of climate change adaptation strategies improves their net returns to maize production in Southwestern Nigeria.

Keywords: Maize; Ricardian model; Climate change; Southwest; Nigeria.

Introduction

Agriculture being one of the most weather-dependent of all human activities is highly vulnerable to climate change. This vulnerability to climate change is particularly felt by African countries because of their dependence on rain fed agriculture, high levels of poverty, low levels of human and physical capital, inequitable land distribution and poor infrastructure (Bamire, Abdoulaye, Sanogo and Langyintuo, 2010; Tologbonse, Auta, Bidoli, Jaliya, Onu & Issa (2010). Climate change as defined by United Nation Framework Convention on Climate Change (UNFCC, 2001; 2007; 2015) refers to a change of climate that is attributed directly or indirectly to human activity which alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. According to Harvey, Saborio-Rodríguez, Martinez-Rodrígue, Viguera, Chain-Guadarrama, Vignola and Alpizar (2018), changes in climatic conditions have already presented significant challenges to smallholder maize farmers in Africa as it is being experienced in Central America.

Nigeria, like the rest of Africa, is experiencing increasing risk from climate change, including rising temperatures and heat waves, shortfalls in water supply/increasing floods arising from shortage/excessive rainfalls, sea level rise, increasing likelihood of conflict and induced environmental and vector borne diseases. These emanating conditions have compromised agricultural production (crop, livestock, forest and fishery resources), nutritional and health statuses, trading in agricultural commodities, human settlements (especially of agricultural communities), tourism and recreation among others (Adefolalu, 2007; Fadina and Barjolle, 2018).

Statement of the Research Problem

The adverse effects of climate change have negatively impacted the welfare of millions of people, most especially small holder farmers (Intergovernmental Panel on Climate Change (IPCC), 2007).

According to Coster and Adeoti (2015), maize productivity depends on climate and nature of soil among others which are regarded as the yield potentials of a certain area. This crop survives with the mean daily temperature between 16 to 19 ºC and a consistently right amount of precipitation. However, this is being threatened with persistent and erratic climate change thus affecting farming within the predominantly rain-fed systems. Climate change has induced rainfall and temperature stresses, which reduced maize yields in Nigeria. Furthermore, empirical evidence shows that there is likelihood that yield will continue to decrease by 15% and 24% by the year 2030 and 2050 respectively compared to the baseline year 2000, implying a decline of about 1.4 million tons and 2.9 million tons respectively using an average simulated yield of 1.3 tons per hectare (Coster and Adeoti, 2015). These changes in climate will in no small measure limit maize production, thus, prospecting lowered welfare status of farming families who solely depend directly on maize cultivation as their source of food and income.

To ensure continuous production, maize cultivators are practically taking steps to mitigate against the economic losses associated with climate change, however, it is noteworthy that these coping strategies and adaptation options utilized by various maize producers do not come without costs. The effect of climate change and its cost implications on farmers have been assessed by studies in countries like Egypt and Senegal on various crops but limited studies exist on the subject matter, most especially on maize production in some areas in Nigeria (Ayinde, Muchie and Olatunji (2016). Moreover, the economic loss inventories and estimation associated with maize cultivation has not been adequately documented. It is therefore imperative to estimate the economic implications and effects that are posed by climate change specifically on maize production in Southwestern Nigeria. Therefore, this research work seeks pertinent answers to the following questions; What is the socio-economic characteristics of maize farmers in Southwest, Nigeria; does climate change affect smallholder maize farms and what is the effect of climate change on the revenue of maize farmers; The broad of objective of this research is to analyse the economic effect of climate change on the net revenue of maize using structural Ricardian while the specific objectives are to describe the socio-economic characteristics of smallholder maze farmers in southwest, Nigeria; to measure the effect of climate change on maize farms and to analyse the effect of climate change on the revenue of maize farmers in the study area.

Conceptual framework

Structural Ricardian Model

To measure the economic effect of climate change on net revenue of maize crop in the study area, the standard Ricardian method (Mendelsohn, Nordhaus & Shaw (1994) was adopted. To analyse the impact of climate change in maize production by using a Ricardian approach, the net farm revenue per hectare from maize production was used as a dependent variable against a set of independent variables.

The structural Ricardian net revenue model estimated was

$NR_{ha} = \beta_0 + \beta_1 LGPTemp + \beta_2 LGPPrec + \Sigma^{n}_{=i1} a_i\, soil + \Sigma^{m}_{=1} \mu_j Gj + \varepsilon_k$ ……............................... equation (1)

presented in equation but the net revenue equation to be estimated and the Identifying instruments are shown in equation (2) below:

$Y = + bY_1 + cX_1 + X_2 + \mu$ ………..(2)

Y	=	Net Revenue (NR/ha)
X_1 (DSMT)	=	Annual dry season mean temperature recorded in the study area
X_2 (RSMT)	=	Annual rainy season mean temperature recorded in the study area
X_3 (DSMT)	=	Annual dry season mean precipitation recorded in the study area
X_4 (RSMT)	=	Annual rainy season mean precipitation recorded in the study area
X_5 (DSMF)	=	Dry season maize farming (1 = Yes, 0 = No)

X_6 (Soil types) = Soil types in the study area (0=Lixisols, 1=Luvisols, 2=Nitisols)
X_7 (AGE) = Age of maize farmers (years)
X_8 (SEX) = Sex of maize farmer (1=Male, 0=Otherwise)
X_9 (FEDU) = Formal education of maize farmer (Years)
X_{10} (CREDIT) = Access to credit (1=Access, 0=Otherwise)
X_{11} (DSTRD) = Distance from farm to the main tarred road (Km)
X_{12} (EXTSERV) = Access of farmer to extension service (1 = Access, 0 = Otherwise)
X_{13} (CLMINFO) = Access to climate-related information (1=Access, 0 = Otherwise)
X_{14} (FAMEM) = Membership of farmers' association (1= Member, 0 = Otherwise)
X_{15} (MAINOCC) = Main occupation (1= farmer, 0 = Otherwise)
X_{16} (HHSIZE) = Household size (number)
X_{17} (DSTMKT) = Distance from farm to the nearest major market (Km)

Methodology

The study was carried out in Southwestern Nigeria, which is one of the six geopolitical zones in the country. The zone consists of Ekiti, Lagos, Ogun, Ondo, Osun, and Oyo States.

The three states that were selected are Oyo, Osun and Ogun as the three highest producers of maize in the region. The major source of occupation and income in the study area is agriculture. Agriculture provides income and employment for about 75% of the population and they produce both food and cash crops. In all, a total number of 330 smallholder maize farmers were selected and analysed. Multistage sampling procedure was employed to select these smallholder maize farmers in three states (Osun, Oyo, and Ogun States) in Southwest Nigeria. Primary data were collected with the aid of structured questionnaire while secondary data were collected from the Nigerian Meteorological Agency (NiMet). Data collected were analysed using descriptive statistics and Ricardian model analysis.

Results

Descriptive statistics

Table 1: Distribution of maize farmers by socio-economic characteristics

Variables	Description	Percent	Mean	S.D.
Sex	Male	70.10		
	Female	29.90		
	<21	0.64		
Age	21 - 40	23.79		
	41 - 60	63.99		
	>60	11.58	**47.60**	**10.74**
Marital Status	Single	5.47		
	Married	86.17		
	Divorced	2.57		
	Windowed	5.79		
Household Size	1 - 3	9.32		
	4 - 6	64.95		
	7 - 9	20.26		
	10 - 12	5.47	**5.62**	**2.06**
Dependency Ratio	=0.1	22.51		
	0.11 - 1.0	63.02		
	1.1 - 2.0	11.58		
	>2.0	2.89	**0.66**	**0.73**

Variables	**Description**	**Percent**	**Mean**	**S.D.**
Sex	Male	70.10		
	Female	29.90		
	<21	0.64		
Age	21 - 40	23.79		
	41 - 60	63.99		
	>60	11.58	**47.60**	**10.74**
Marital Status	Single	5.47		
	Married	86.17		
	Divorced	2.57		
	Windowed	5.79		
Household Size	1 - 3	9.32		
	4 - 6	64.95		
	7 - 9	20.26		
	10 - 12	5.47	**5.62**	**2.06**
Education level	None	21.86		
	Pry Edu.	39.23		
	Sec. Edu.	29.26		
	Tert. Edu.	9.65		
Education (years)	0	21.86		
	1 - 6	39.23		
	7 - 12	29.26		
	>12	9.65	**7.00**	**4.91**
Primary occupation	Farming	61.09		
	Others	38.91		
Member of association	Yes	37.62		
	No	62.38		
Credit	No access	67.52		
	Access	32.48		
Extension access	Access	24.12		
	No access	75.88		
Number of extension contacts	0	77.81		
	1 - 5	12.86		
	6 -10	4.82		
	>10	4.50	**1.39**	**3.49**
Climate change awareness	Aware	80.06		
	Not aware	19.94		
Climate Information	Access	24.44		
	No access	75.56		
Climate variation	Variation	79.74		
	No Variation	20.26		
Climate change perception intensity	0	18.97		
	0.1 - 0.4	64.31		
	0.41 - 1.0	16.72	**0.27**	**0.23**

Variables	Description	Percent	Mean	S.D.
Farming experience	1 - 10	31.19		
	11 - 20	35.37		
	21 - 30	20.90		
	31 - 40	7.40		
	41 - 50	2.57		
	>50	2.57	**20.12**	**12.56**
Maize variety	Local	77.17		
	Improved	22.83		
Dry season farming	No	9.32		
	Yes	90.68		
Farm size (hectares)	=1.0	57.88		
	1.1 - 2.0	19.94		
	2.1 - 4.0	13.50		
	4.1 - 5.0	8.68	**1.33**	**1.82**
Farm distance (Km)	=5	60.77		
	6 -10	24.44		
	11 - 15	10.93	**5.52**	**4.48**
	>15	3.86		
Market distance (Km)	=5	60.77		
	6 -10	24.44		
	11 - 15	10.93	**10.77**	**9.55**
	>15	3.86		
Maize output (Kg)	=1000	48.55		
	1001 - 5000	29.58		
	5001 - 10000	8.68		
	100001 - 15000	6.43		
	>15000	6.75	**3581.23**	**519.44**

Source: Field survey, 2019

The sex of farmers can be a strong determinant of their access to productive assets such as land. As this crop enterprise is dominated by male maize farmers, however this does not preclude females from cultivating the crop. As shown in Table 1, the mean age of the sampled respondents for this study was 47.85±10.26 years. This indicates that most of the maize farmers in the study area were young and have the potential for productive activities on the farm. The results bring to view the marital status of the maize farmers. On the aggregate, majority (86.17 per cent) of the farmers were married and 5.79, 5.47 and 5.67 per cents were widowed, single and divorced, respectively. This finding is in line with the report of Girei *et al*. (2018) who opined that married farmers are likely to be committed to increase yield on their farms as it is critical to the sustenance of their family. Household size can have influence on the household expenditure on food, clothing and shelter. However, in most agrarian communities, it is seen as an advantage to the household head as it signifies the availability of farm labour. The results in Table 1 showed that the average household size of the sampled farmers was 5.62±2.06. The average dependency ratio of 0.66±0.73 among the farmers shows that they have few members that are non-productive.

Also, the results on Table 1 showed that the average farm size of the farmers for this study to be 1.34±1.49 hectares, indicating that the farmers were mainly smallholders (Lamba *et al.*, 2016).

Effect of climate change on revenue of maize farmers

Table 2: Estimates of Ricardian analysis of climate change on maize

Variables	Coefficients	Std. Erros	t-values
Dry season temperature	-186.629**	(87.365)	-2.14
Rainy season temperature	270.353***	(76.160)	3.55
Dry season precipitation	-17.534*	(10.588)	-1.66
Rainy season precipitation	-40.316**	(18.525)	-2.18
Dry season maize farming	69.170**	(30.313)	2.28
Soil types (Lixisols=base cate)			
Luvisols	-214.476***	(85.501)	-2.51
Nitisols	-152.949***	(56.769)	-2.69
AGE	0.539	(0.867)	0.62
SEX	34.428*	(19.538)	1.76
FEDU	3.704*	(2.063)	1.79
CREDIT	74.58***	(25.088)	2.97
DSTRD	-9.564**	(4.020)	-2.38
EXTSERV	-2.621	(25.663)	-0.10
CLMINFO	36.785*	(25.663)	1.63
MEMFA	-16.795	(23.391)	-0.72
MAINOCC	-0.243	(19.540)	-0.01
HHSIZE	2.271	(4.642)	0.49
DSTMKT	2.085	(2.135)	0.98
IMSV	115.546***	(20.570)	5.62
_Constant	1367.179	(3498.6)	0.39
R^2	0.466		
Adj. R^2	0.434		
F (18, 292)	14.21***		

Source: Data Analysis, 2019

*, **, and *** indicate statistical significance at the 10%, 5% and 1% alpha levels, respectively. Figures in parentheses are the standard errors.

This section presents the estimates of a Ricardian model on the effect of climate change on net revenue of small-scale maize farming in the study area. The net revenue (in Naira) from small-scale maize production was used as the dependent variable while climate data (dry season, rainy season and annual temperature and precipitation), soil types (Lixisols, Luvisols, and Nitisols) as well as socio-economic variables were used as the independent variables. The R-squared for the regression is 0.466 and the adjusted R-squared is 0.434. The R-squared implies that 46% of variation in the net revenue from small-scale maize farming in the study area is explained by independent variables included in the model. The adjusted R-squared implies there is no over-fitting in the model. The F-statistics (14.21) is significant at 1% statistical level. This suggests that the independent variables included in the model are jointly significant.

Table 3: Marginal impact of climate change on maize net revenue across the three states

Climate variables	Osun (₦)	Oyo (₦)	Ogun (₦)	Pooled (₦)
Dry season mean temp. (DSMT)	-7,192.22	-19,503.70	-35,404.88	-20,783.29
Rainy season mean temp. (RSMT)	20,861.52	54,840.87	101,317.69	59,238.58
Dry season mean precipitation (DSMP)	-328.85	-624.24	-1,306.89	-755.64
Rainy season mean precipitation (RSMP)	-3,179.32	-7,925.12	-15,923.15	-9,043.20

Also, the results on Table 3 showed the impact of changes in climate variables on net revenue of maize per hectare in the study area. A marginal increase in dry season mean temperature (DSMT) will reduce maize net revenue per hectare by ₦7,192.22, ₦19,503.70, and ₦35,404.88 in Osun, Oyo, and Ogun States respectively, while maize net revenue for whole sample will be reduced by ₦20,783.29.

A marginal increase in rainy season mean temperature (RSMT) will increase maize net revenue per hectare by ₦20,861.52, ₦54,840.87, and ₦101,317.69 in Osun, Oyo, and Ogun States and as well increase maize net revenue by ₦59,238.58 for the whole states pooled together.

More so, a marginal increase in dry season mean precipitation (DSMP) will decrease maize net revenue per hectare by ₦328.85, ₦624.24, and ₦1.306.94 in Osun, Oyo, and Ogun States and as well decrease maize net revenue by ₦755.64 for the whole study area.

Furthermore, a marginal increase in rainy season mean precipitation (RSMP) will decrease maize net revenue per hectare by ₦3,179.00, ₦7.925.12, ₦15,923.15, and ₦9,043.20 for Osun, Oyo, and Ogun States as well as for the whole sample, respectively.

Simulated impacts of climate change on maize net revenue were carried out using different climate change scenarios (2.0 °C increase in DSMT and RSMT, and 7% decrease in DSMP and RSMP). The results on Table 4 showed that if the dry season mean temperature (DSMT) increases by 2.0 °C it would result in 6.75% (₦520.91/ha), 6.60% (₦1,379.09/ha), 6.67% (₦2,530.63/ha), and 6.65% (₦1,482.71/ha) reduction in net revenue for maize farmers in Osun, Oyo, and Ogun States and also for the whole states respectively. The results also showed that if there is 2.0 °C increase in rainy season mean temperature it would result in 6.21% (₦1,382.31/ha), 7.07% (₦4,174.87/ha), 7.03% (N7,660.81/ha), and 7.04% (N4,488.52/ha) increase in net revenue for maize farmers in Osun, Oyo, and Ogun States and also for the whole states respectively.

Table 4: Predicted impacts of different climate scenarios on maize net revenue by state

Climate scenario	Osun (₦)		Oyo (₦)		Ogun (₦)		Pooled (₦)	
	? NR	%?	? NR	%?	? NR	%?	? NR	%?
DSMT (+2.0 °C)	-520.91	6.75	-1,379.09	6.60	-2,530.63	6.67	-1,482.71	6.65
RSMT (+2.0°C)	1,382.31	6.21	4,174.87	7.07	7,660.81	7.03	4,488.52	7.04
DSMP (-7%)	-10.69	3.14	-23.24	3.58	-78.01	5.63	-29.94	3.81
RSMP (-7%)	-115.46	3.50	-61.10	0.76	-73.22	0.45	-203.42	2.19

Also, the results on Table 4 further revealed that if there is a decrease in dry season mean precipitation by 7% it would result in 3.14% (₦10.69/ha), 3.58% (₦23.24/ha), 5.63% (₦78.01/ha), and 3.81% (₦29.94/ha) reduction in net revenue for maize farmers in Osun, Oyo, and Ogun States as well for all the states together respectively; while a decrease in rainy season mean precipitation (RSMP) would result in 3.50% (₦115.46/ha), 0.76% (₦61.10/ha), 0.45% (₦73.22/ha), and 2.19% (₦203.42/ha) reduction in maize net revenue for farmers in Osun, Oyo, and Ogun States as well for all the states together, respectively.

Discussion of Findings

This result reveals that many of the household members were within the economically active age range while the infants and aged were few in number. The result in Table 1 showed that the mean number of years of formal education of the farmers in the area was 7.0±4.9. This result is in consonant with the findings of Kaine (2016) that many of the maize producers in southern Nigeria can basically read and write and thus, relatively educated.

Membership of farmers' group or association is a form of social capital to farmers not only in term of accessing credit and other farm inputs but also in term of marketing and provision of opportunities to share vital information. Access to credit by smallholder maize farmers can enhance their capacity to purchase improved agricultural inputs which in turn can result in increased farm-level productivity and as such improve net revenue generated from their maize farms. According to Feder et al. (1989) and Petrick (2004), access to credit may affect farm productivity because farmers facing binding capital constraints would tend to use lower levels of improved farm inputs in their production activities compared to those are not constrained.

Farmers' access to extension service serves as a vital human capital that keeps them informed on changes and modern agricultural practices in the farming system. Access to extension service can provide farmers with quality information on how to best tackle climate change and its effects on their farms. The more the contacts of extension agents with farmers, the more updated they are on farm management, planning, practices and new agricultural technologies geared towards improving their yield and profitability of their farming activities. The experience of farmers in any agricultural enterprise can enhance their level of productivity on their farms. Maize farmers who are more experienced will know how best to combine agricultural inputs in order to maximize outputs from their farms. The results showed that an average farmer in study area is well experienced as each of them have more than 12 years of maize farming experience.

The results of the Ricardian analysis shows that the relationship between dry season mean temperature and maize net revenue is negative and statistically significant at 5% level. This implies that an increase in dry season mean temperature will decrease net revenue from maize farming. The possible explanation for this is that when there is an increase in temperature during the dry season without adequate irrigation facility it makes the soil dryer and as well exposes the maize crop to stress that can reduce its yield. This finding corroborates Ayinde *et al* (2011) who also reported similar result in their study on agricultural production and climate change in Nigeria.

The coefficient of rainy season mean temperature shows it has a positive and statistically significant (1% level) with maize net revenue. This implies that an increase in rainy season mean temperature will increase net revenue from maize farming. This finding is in agreement with Coster and Adeoti (2015) who posited that adequate sunlight intensity provided maize farmers the possibility to make their grains well-dried on the field in order to get better market value from agro-allied industries that pay premium for maize of such quality for further processing into useful bye products and livestock's feeds.

The coefficients of dry season and rainy season mean precipitation are negative and statistically significant with net revenue from maize farming at 10% and 5% level respectively. This suggests that an increase in both the dry season and rainy season mean precipitation will reduce the net revenue from maize farming. This finding is supported by Ali (2012) who reported similar result in their different studies on climate change with respect to agricultural production.

The coefficient of dry season maize farming has a positive relationship with maize net revenue at 5% level of significance. This implies that cultivating maize during dry season will increase maize net revenue in the study area. This is because maize output in the dry season commands higher market value than in the rainy season.

The coefficient of luvisols (one of the dominant soil types in the study area) has a negative relationship with maize net revenue at 1% significance level. This implies that when compared to another dominant soil type (lixisols) in the study area cultivation of maize of luvisols soil type will decrease maize net revenue. This finding agrees with the result by Coster and Adeoti (2015) that the luvisols soil type reduces the net revenue from maize farming in Nigeria.

The coefficient of nitisols (one of the dominant soil types in the study area) has a negative relationship with maize net revenue at 1% significance level. This implies that when compared to another dominant soil type (lixisols) in the study area cultivation of maize of nitisols soil type will decrease maize net revenue.

The coefficient of sex has a positive relationship with maize net revenue at 10% significance level. This implies that when compared with their female counter-parts maize farmers who are male will generate more net revenue from maize farming in the study area. This could be because male farmers often have access to productive resources than their female counterparts in Nigeria (Ibrahim et al., 2011; Coster and Adeoti, 2015). This finding is in agreement with the findings by Kurukulasuriya and Ajwad (2004), Kabubo and Karanja (2007), and Ajetomobi et al. (2011).

The coefficient of years of formal education (FEDU) shows that it has a positive relationship with net revenue from maize farming and that the relationship is statistically significant at 10% level. This suggests that smallholder maize farmers who are more educated will generate higher net revenue from maize production. This is because farmers who are more educated are better equipped to adopt new and improved technologies that can enhance revenue generated from their farms. This finding from this study is in line with that of Ibrahim et al. (2011).

The coefficient of maize farmer's access to credit shows that it has a positive relationship with net revenue from maize farming and that the relationship is statistically significant at 1% level. This suggests that smallholder maize farmers who have access to credit will generate more net revenue from maize farming when compared with their counterparts who do not have access to credit. This is because farmers who have better access to credit are more likely to afford investments needed to better adapt the effects of climate change on their farms in order to optimize maize yield.

The coefficient of distance from farm to a major tarred road shows that it has a negative relationship with maize net revenue at 5% level of significance. This implies that an increase in the distance between a maize farm and a major tarred road will decrease maize net revenue in the study area. This is because the farther away from a major tarred road a farm is located the more the costs a farmer will incur to get inputs to the farm. This result agrees with the findings of Deressa (2009), Fonta et al. (2011) and Coster and Adeoti (2015) that market distance has a negative impact on net revenue per hectare.

The coefficient of maize farmers' access to climate information has a positive relationship with maize net revenue at 10% level of significance. This implies that maize farmers who have access to climate information will have more net revenue from maize farming than their counterparts who do not have access to climate information. This is because timely and adequate information on the climate will help the farmers to plan their farm operations and adaptation strategies very well.

The coefficient of improved maize variety has a positive relationship with maize net revenue at 1% level of significance. This implies that cultivation of improved maize variety will increase the net revenue from maize farming in the study area. In other words, maize farmers who cultivate improved maize variety will generate more net revenue compared to those who do not cultivate improved maize variety.

Conclusion

The result of the descriptive statistics revealed that factors like sex, age and even years of farming experience has appositive effect on the production of maize even with the change in climate. Also, the findings from the structural Ricardian model lend credence to the conclusion that climate change had both positive and negative impacts on small-scale maize production. Climate change in terms of increasing dry season temperature, increasing dry season precipitation and increasing rainy season precipitation had negative effect on net revenue from maize production. However, an increasing rainy season mean temperature increased net revenue generated from maize production. Since an increase in both dry season and rainy season mean precipitation has negative and significant impact on net revenue from smallholder maize production in the study area.

Recommendation

This study recommends that smallholder maize farmers should be empowered in order to cope adequately with impacts of climate on their maize yield. More so, smallholder farmers should be properly trained and educated on how to adapt to excess precipitation on their farms since majority of the farmers in southwestern part of Nigeria are smallholder this will go a long way in coping with the change in climate.

References

AAC (Africa Agriculture Climate), (2002). Africa Agriculture Climate. Accessed on 16/12/17.

Abdoulaye, T., Bamire, A. S., Wiredu, A. N., Baco, M. N. and Fofana, M. (2012). Characterization of Maize-Producing Communities in Benin, Ghana, Mali, and Nigeria West Africa Regional Synthesis Report. Drought Tolerant Maize for Africa (DTMA), 18 pp, IITA, Nigeria.

ACTSA, (2009). (Action for Southern Africa). ACTSA Briefing paper. Climate change in Southern Africa.

Adams, R. M., Rosenzweig, R. M., Peart, J. T., Ritchie, B. A., McCarl, J. D., Glyer, R. B., Curry, J. W., Jones, K. J., Boote, L. H., and Allen, J. (1990). Global climate change and U.S. agriculture. Nature, 345, 219-224.

Adefolalu, D. O. (1986). Rainfall trends in Nigeria. Theoretical and Applied Climatology 37, 205-219.

Adefolalu, D. O. (2007). Climate Change and economic sustainability in Nigeria. Paper 141 presented at the International Conference on Climate Change and Economic Sustainability held at Nnamdi Azikiwe University, Enugu, Nigeria.

Adejuwon, S. A. (2004). Impact of climate variability and climate change on crop yield in Nigeria. Contributed Paper to Stakeholders Workshop on Assessment of Impact and Adaptation to Climate Change (AIACC): 2-8

Adekanye, T. A. (2014). Assessment of Mechanization Problems of Peasant Farmers in Irepodun Local Government Area, Kwara State of Nigeria. Advances in Agriculture, Sciences and Engineering Research Journal. 4(6): 1665-1672.

Adger, W. N., Agrawala, S., Mirza, M. M. Q., Conde, C., O'Brien, K., Pulhin, J., Pulwarty, R., Smit, B., and Takahashi, K. (2007). Assessment of adaptation practices, options, constraints and capacity: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and Hanson, C. Eds., Cambridge University Press, Cambridge, UK, 717-743.

Adger, W. N., Saleemul, A. B., Huq, C. and Brown, K. (2003). Declan Conway and Mike Hulme, Adaptation to climate change in the developing world, Progress in Development Studies, 3(3):179–195.

Ajetomobi, J. O. Ajiboye, A. and Rashid, H. (2010). Economic Impact of Climate Change on Irrigated Rice Agriculture in Nigeria. Paper Presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, South Africa.

Ajzen, I. (1991). The Theory of Planned Behavior. Organizational Behavior and Human Decision Processes. Scientific Researcher, 50, 179-211.

Akinnagbe, O. M., Ezeuzo O. P. and Onwubuya E. A. (2017). Challenges of Extension Workers in Reaching Rural Women Farmers in Enugu State Nigeria. Journal of Agricultural Extension, 21(3):22-36.

Ayinde, O. E. Muchie, M. and Olatunji G. B. (2016). Effect of Climate Change on Agricultural Productivity in Nigeria: A Co-integration Model Approach. Journal of Human Ecology, 35(3): 189-194.

Bamire, A. S., Abdoulaye, T., Sanogo, D., and Langyintuo, A. (2010). Characterization of maize producing households in the dry Savanna of Nigeria (46). Ibadan: IITA.

Barrios, S., Bertinelli, L. and Strobl, E. (2010). Trends in rainfall and economic growth in Africa: A neglected cause of the African growth tragedy. The Review of Economics and Statistics, 92(2), 350-366.

Becker, G. S. (1965). "A Theory of the Allocation of Time," Economic Journal, 75493-5 17.

Chappell, A., and Agnew, C. (2004). Modelling climate change in West African Sahel rainfall (1931-90) as an artifact of changing station locations. International Journal of Climatology, 547-554.

Chi-Chung, C., McCarl, B., and Schimmelpfennig, D. (2004). Yield Variability as Influenced by Climate: A Statistical Investigation. Climatic Change, 66(1-2): 236-261.

Christensen, J. H., Hewitson, B. A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W.-T. Kwon, J. Räisänen, Rinke, A. Sarr, A. and Whetton, P. (2007). The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge United Kingdom and New York, NY, USA.: Cambridge University Press.

Clark, H., Kelliher, M. K., and Patino, C. S. (2011). Reducing CH4 Emissions from Grazing Ruminants in New Zeland: Challenges and Opportunities. Asian Australasian Journal of Animal Sciences 24(2).

Coster, A. S. and Adeoti, A. I. (2015). Economic Effects of Climate Change on Maize Production and Farmers' Adaptation Strategies in Nigeria: A Ricardian Approach. Journal of Agricultural Science, 7(5):1916-9752.

Cragg, J. G. (1971). Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods. Econometrica, Econometric Society, 39(5) :829-844.

Crosson, P. (1997). Impacts of Climate Change on Agriculture. Climate Issues Brief 4. Resources for the Future, Washington, D.C.

Deresa, T.T. (2006). Measuring the Economic Impact of Climate Change on Ethiopian Agriculture: Ricardian approach. CEEPA DP25, University of Pretoria, South Africa.

Deressa, T. Hassan, R. & Poonyth, D. (2005). Measuring the economic impact of climate change on South Africa's sugarcane growing regions, Agrekon, 44(4):524-542.

Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T., and Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global Environmental Change 19, 248–255.

Deressa, T. T., Ringler, C., and Hassan, R. M. (2010). Factors Affecting the Choices of Coping Strategies for Climate Extremes: The Case of Farmers in the Nile Basin of Ethiopia. IFPRI Discussion Paper 01032.

Di Falco, S., Yesuf, M., Kohlin, G. and Ringler, C. (2011). Estimating the Impact of Climate Change on Agriculture in Low-Income Countries: Household Level Evidence from the Nile Basin, Ethiopia. Environ Resource Econ. DOI 10.1007/s10640-011-9538-y

Dim, C., and Ezenekwe, U. (2013), Does agriculture matter for economic development empirical evidence from Nigeria. Journal of Finance and Economics, 1(1), 61-77.

Fadina, A. M. and Barjolle D. (2018). Farmers' Adaptation Strategies to Climate Change and Their Implications in the Zou Department of South Benin. Environments Journals, 5(15)

FAO (1995). Food and Agriculture Organisation (FAO). Irrigation in Africa in Figures. Rome http://www.fao.org.

FAO (2003). Food and Agriculture Organisation (FAO). World Agriculture: Towards 2015/2030 - An FAO Perspective. Rome and Earth scan. London.

FAO (2006). Food and Agriculture Organization (FAO). Food and Agriculture Organization Production Year Book. Retrieved from www.fao.org/ES/ESC/common/ecg/54/en/Maize Profile.pdf.

FAO (2007). Food and Agriculture Organization (FAO). Climate change and food security. FAO, Rome, Italy.

FAO (2009). Food and Agriculture Organization (FAO). Hunger on the Rise. Retrieved from http://www.fao.org/newsroom/EN/news/.

FAO (2017). Food and Agriculture Organization (FAO). 3.02 billion people hungry. News release. Available at: http://www.fao.org/news/story/en/item/20568/icode/

FAO (2018): Food and Agriculture Organization (FAO). Available from http://www.fao.org/3/i8514en/I8514EN.pdf

Girei, A. A, Saingbe, N. D., Ohen, S. B. and Umar, K. O. (2018). Economics of small-scale maize production in Toto Local Government Area, Nasarawa State, Nigeria. Agrosearch 18(1):90 – 104.

Harvey C. A., Saborio-Rodríguez M., Martinez-Rodríguez M. R, Viguera B. , Chain-Guadarrama A., Vignola R., and Alpizar F. (2018). Climate change impacts and adaptation among smallholder farmers in Central America. Agriculture and Food Security, 7:57.

Ibrahim, S. B. Afolami, C. A. Ayinde, I. A., and Adeofun, C. O. (2011). Modelling arable crop farmers' decisions on climate change and adaptation strategies: A multinomial logit analysis in Ogun State. Proceedings of the Environmental Management Conference, Federal University of Agriculture, Abeokuta, Nigeria, 23-41.

Kabubo-Mariara, J., and Karanja, F. K. (2007). The economic impact of climate change on Kenyan crop agriculture: A Ricardian approach', Global and Planetary Change, 57(3 – 4): 319 – 30.

Kurukulasuriya, P. and Ajwad, M. I. (2004). Ricardian Study of Sri Lankan Farmers. In R. Mendelsohn, A. Dinar,A.Baist, P. Kurukulasuriya, M. I. Ajwad, F. Kogan C. Williams (Eds.), Cross sectional Analyses of Climate Change Impacts (World Bank Policy Research Working Paper 3350).

Lamba C., Taru V.B., Otitujo MA and Tumba A. (2016). Profitability of Maize production in Yola North Local Government Area of Adamawa State. Scientia Agriculturae, 13(3): 119-125.

Mendelsohn, R., Nordhaus, W., & Shaw, D. (1994). The Impact of Global Warming on Agriculture: A Ricardian Analysis. American Economic Review, 84, 753-771.

Nhemachena, C., Hassan, R., and Kurukulasuriya, P. (2010). Measuring the economic impact of climate change on African agricultural production systems. Climate Change Economics, 1: 33-55.

Nichola, T, (1996). The decision to adopt and the intensity of adoption of technology: A double hurdle model application in the adoption of a sorghum hybrid. Journal for Studies in Economics and Econometrics 20: 49–57.

Nicholson, S., Some, B., and Kone, B. (2000). An analysis of recent rainfall conditions in West Africa, including the rainy season of the 1997 El Niño and the1998 La Niña years. Journal of Climate, 2628-2640.
Nigeria using ARIMA model. National Horticultural Research Institute, Jericho Idi Ishin, Ibadan, Nigeria, Asian Journal of Agricultural Sciences 3(3): 171-176

Nigerian Environmental Study Team (NEST), (2004). Regional Climate Modelling and Climate Scenarios Development in Support of Vulnerability and Adaptation Studies: Outcome of Regional Climate Modeling Efforts over Nigeria, NEST, Ibadan, Nigeria

Niles, M. T., and Mueller, N. D. (2016). Farmer perceptions of climate change: Association with observed temperature and precipitation trends, irrigation and climate beliefs. Global Environmental Change 39, 133-142.

NRC (2010). NRC (National Research Advancing the Science of Climate Change). Washington, DC, USA.: The National Academics Press.

Nwankpa, N. N. (2017). Sustainable agricultural development in Nigeria: A way out of hunger and poverty. European Journal of Sustainable Development, 6 (4):175-184.

O'Brien, K., Eriksen, S., Nygaard, L. P., and Schjolden, A. (2007). Why different interpretations of vulnerability matter in climate change discourses. Climate Policy, 7, 73–88.

Obasi, G. (2005). The impacts of ENSO in Africa. In Climate Change and Africa :218-230. Cambridge: Cambridge University Press.

Oduniyi, S. (2013). Climate change awareness: A case study of small scale maize. University of South Africa. Published M. Sc. thesis from Faculty of Agriculture.

Ofori-Sarpong, E. (2001). Impact of climate change on agriculture and farmers coping strategies in the Upper East Region of Ghana. West African Journal of Applied Ecology, 2:21-35.

Ogundari, K. (2006). Determinants of profit efficiency among small scale rice farmers in Nigeria. A profit function approach. Research Journal of Applied Sciences. 1(1-4): 116-122.

Ogundari, K., Ojo, S. O., and Ajibefun, I. A. (2006). Economies of scale and cost efficiency in small scale maize production: empirical evidence in Nigeria. Journal of Social Sciences 13(2): 131-136.

Ogunniyi, L.T. (2004). Resource use efficiency in maize production in Oyo State, Nigeria. Journal of Sustainable Development, 1(2): 12-19.

Ogunniyi, L. T. (2011). Determinants of profit efficiency among small scale maize farmers in Oyo State, Nigeria. ARPN Journal of Agricultural and Biological Sciences, 6(1): 11-17

Ojo, T., and Baiyegunhi, L. J. S. (2018). Determinants of adaptation strategies to climate change

Okoroh, J. P. (2011). Knowledge of climate change among farmers in Okigwe Senatorial zone of Imo state, Nigeria. Nsukka, Enugu: University of Nigeria.

Tologbonse, E.B., Auta, S. J., Bidoli, T. D., Jaliya, M. M., Onu, R.O & Issa F.O. (2010). Farmers' Perception of the Effects of Climate Change and Coping Strategies in Three Agro-Ecological Zones of Nigeria. Journal of Agricultural Extension ,14 (1) :125.

Wigley, T. Pearman, G. and Kelly, P. (1992). Indices and indicators of climate change: issues of detection, validation and climate sensitivity, pp.85-96 in, Confronting Climate Change (ed.) Mintzer, I.M. Cambridge: Cambridge University Press.

Winship, Christopher; Mare, Robert D. (1992). Models for Sample Selection Bias. Annual Review of Sociology. 18: 327–350.

WMO, (2002). World meteorological organization (WMO). Scientific Assessment of Ozone Depletion: Global Ozone Research and Monitoring Project–Report No. 47, World Meteorological Organization), Geneva, Switzerland. CSI 013: 052.

World Bank. (2008). World Bank Development Report: Agriculture for Development. Washington, DC: World Bank.

World Water Forum, (2000). The Africa Water Vision for 2025: Equitable and Sustainable Use of Water for Socioeconomic Development. UN Water/Africa, 34 pp.

Zhai, F. and Zhuang, J. (2009). ADBI Working Paper 131. Retrieved from Asian Development Bank Institute:

Zuluaga, C. M., Serrato, J. M., and Quicazan, M. C. (2015). Chemical, nutritional and bioactive characterization of Colombian