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Economic Effects of Climate Change on Maize Production and Farmers' Adaptation Strategies in Nigeria: A Ricardian Approach

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Abstract

Increasing threat of climate change is aggravating the problem of declining agricultural productivity in the face of rapid population growth. This implies that rural sustainance and food security is under threat and stress. Given that crops differ in climate requirements and economic importance, analysis of the attendant effect of climate change on specific crop remains to be adequately explored. This study uses Ricardian approach to examine the effects of climate change on maize production in Nigeria.

Multistage sampling technique was employed for the study. Data were collected on 346 maize-based farming households in three different agro-ecological zones of Nigeria.

Average age of the farmers and household size were 45years and 8 persons respectively. Average years of farming experience and years of schooling were 25.6 and 6.5 years respectively. The empirical results showed that maize net revenue is sensitive to climate change. Seasonal marginal impact analysis showed that increase in rainfall during rainy season increased Maize Net Revenue (MNR) in rainforest, guinea and montane savanna respectively. Marginal increase in rainfall during the dry season increased MNR in rainforest while it decreased MNR in guinea and montane savanna respectively. However, marginal increase in temperature during dry season has positive impacts on MNR in all AEZs. The predicted results using a range of climate scenarios confirm that climate change will have negative impact on maize net revenue in the future. Maize Farmers have taken adaptive measures against climate change which are changing the planting dates, changed land-use practices, mixed cropping and mixed farming. The major barriers to adaptation are inadequate credit or saving and inadequate knowledge of appropriate adaptation strategies suited for the local climate conditions.

Keywords: climate change, maize production, adaptation strategies, Ricardian analysis

1. Introduction

Climate change as defined by United Nation Framework Convention on Climate Change (UNFCC) refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. Succinctly put, this effect of the pursuit of livelihood and comfort leads to emission of Greenhouse gases (GHG). These gases are mainly carbon dioxide (CO_2), methane (CH_4) and nitrous oxides (NO_2) (Molua, 2002). It is now well known that climate is changing worldwide. The past two decades have witnessed globally a rapid increase in the awareness about climatic changes. This triggered widespread apprehension among scientists and governments about their global implications (Gadgil, 1996). The major environmental concern regarding increased concentration of CO_2 and other trace gases is their greenhouse potential that is ability to trap solar energy in the atmosphere. This trapped solar energy causes global warming and other changes in the world's climate (Houghton et al., 1996).

Climate change is primarily caused by the developed countries. However, it is the bitter irony of destiny that Africa contributes least (920,000 t of CO_2 each year, less than 4% of the global production) of all the continents to the climate change, but will probably suffer most from its consequences. Economists refer to this as a typical case of negative external effects, an externalisation of costs: A non-involved party bears the costs of a third party's actions (Medugu, 2008). FAO (2007) reported that up to11% of arable land could be highly affected by climatic change in the developing world. There will be a reduction of cereal production in 65 countries and retardation of about 16% of agricultural GDP. A decrease of up to 30% in world food production due to effects of climate change on agriculture is generally predicted (IPCC 2007).

In Africa estimates indicate that about 60-70 percent of the population is dependent on the agricultural sector for the employment, and the sector contributes on average nearly 34 percent to gross domestic product (GDP) per country (Adam et al., 1993). In Nigeria, Agriculture contributed 41.25 of GDP in 2005 almost the same as in 2004 (CBN 2005). Over 2006, 2007, 2008, 2009, 2010, 2011,2012 and 2013 the share of agriculture in overall real GDP amounted to 41.72%, 42.01%, 42.13%, 41.70%, 40.76 %, 40.11%, 39.26% and 38.56% respectively (NBS, 2010, 2014).

More than 60% of the working adult populations of Nigeria are employed in the agricultural sector directly and indirectly. Over 90% of Nigeria's agricultural output comes from peasant farmers who dwell in the rural area where 60% of the population live (Agricultural Report, 2007). Despite these contributions, Crosson (1997) pointed out that considering the lower technological and capital stocks, the agricultural sector in developing countries is unlikely to withstand the additional pressures imposed by climate change without a concerted response strategy.

Nigeria is experiencing adverse climatic conditions with negative impacts on the welfare of millions of people. Persistent droughts and flooding, off season rains and dry spells have sent growing seasons out of orbit, on a country dependent on a rain fed agriculture (Medugu, 2008). Nigerian agriculture is almost entirely rain-fed hence inherently susceptible to the vagaries of weather. Only about a million hectare is currently irrigated in Nigeria out of the total 30.5 millions arable hectares of land (Madu et al., 2010). As global warming accelerates, it is expected that agricultural adaptation to climate change can only be meaningful, if irrigated agriculture gains prominence. Agriculture in Nigeria is therefore particularly vulnerable to the impacts of climate change (FAO, 2008; Medugu, 2008; IFAD, 2007). The consequences are that the increasing frequency and severity of droughts are likely to cause: crop failure; high and rising food prices; distress sale of animals; de-capitalization, impoverishment, hunger, and eventually famine.

Many people and most households in Nigeria depend on cereals (most especially, maize) as a contributing, if not principal, source of food and nutrition (CBN, 2005). Maize is one of the important grains in Nigeria, not only on the basis of the number of farmers that engaged in its cultivation, but also in its economic value. Maize is a major important cereal crop being cultivated in the rainforest and the derived savanna zones of Nigeria (Iken & Amusa, 2004). Despite its high yield potential, maize production is however faced with numerous constraints. One of the major constraints is intermittent drought during the growing season, which, significantly reduce maize yield (Ayanlade & Odekunle, 2006).

Declining agricultural productivity in the face of rapid population growth as a result of climate change is worrisome and cause for a great concerned. Militating against the climate change requires understanding the impact of the change and effectiveness of the coping strategies. Given that different crops have different climate requirements necessitate the need for specific crop analysis which has not been adequately explored in Nigeria. Hence the effect of climate change on notable food crop like maize which has long term implication for food security was therefore investigated. Specifically, the study sought to analyze the effects of climate change on maize farmers' income; assess farmers' perception and adaptations to climate change and identify the barriers to adaptation to climate change.

2. Literature Review/Theoretical Framework

Previous studies that examined the impact of climate change on agriculture made use of agronomic (otherwise known as production function) studies (Mearns et al., 1997; Downing, 1992; Schulze et al., 1993; Adams et al., 1990, 1993; Parry et al., 1999) and Ricardian approach (Mendelsohn et al., 1994; Deressa & Hassan, 2009; Gbetibouo & Hassan, 2005; Sanghi, 1998; Sanghi et al., 1998; Kumar & Parikh, 1998). The agronomic models simulate a laboratory type set up and provide data on climatic factors and crop growth. Although the agronomic models provide a controlled and randomized application of environmental conditions, it does not take adaptive behavior of an optimizing farmer into account. Ricardian model on the other hands measure the impact of climatic factors through their contribution to farmland-prices and have been extensively used for incorporating farm level adaptation (Mendelsohn et al., 1994). However, availability of land prices as well as non-existence of efficient land markets are two major obstacles in applying the Ricardian method to most of the developing countries, hence Semi-Ricardian model using data on annual net revenue per hectare instead of land prices, since land value is the present value of a future stream of net revenue (Seo & Mendelsohn, 2007).

The Ricardian approach estimates the importance of climate and other variables on the capitalized value of farmland. The method utilized the typical economic measure of farm performance: net revenue or net farm income. The approach has been used to evaluate the contribution of environmental measures to farm income. By regressing land value on a set of environmental inputs, one can measure the marginal contribution of each input to farm income. Ricardian model has been extensively criticized on the ground that; it fails to fully control for the impact of variables that could also explain the variation in farm incomes, it assumes prices will remain constant, failure to take account of water supply and failure to account for the effect of factors that do not vary across space such as carbon dioxide concentrations that can be beneficial to crops.

Despite its shortcomings, Ricardian model has been extensively applied to a number of countries such as United States (Mendelsohn et al., 1994, 1999), Brazil (Sanghi, 1998) China (Liu et al., 2004) and India (Sanghi et al., 1998; Kumar & Parikh, 1998, 2001). Similar approach has been applied in Africa: Cameroon (Molua, 2002, Molua & Lambi, 2006), Senegal (Sene et al., 2006), Kenya (Kabubo & Karanja, 2007), Srilanka (Seo et al., 2005; Kurukulasuriya & Ajwad, 2004), Ethiopia (Deressal et al., 2005) South Africa (Gbetibou & Hassan, 2005), Egypt (Eid et al., 2005) and Nigeria (Ajetomobi et al., 2011; Fonta et al., 2011).

2.1 Theoretical Framework

The theoretical basis of the Ricardian method is deeply rooted in the famous theory of economic rents by David Ricardo (1817). However, much of its application to climate-land value analysis, draws extensively from the work of Mendelsohn et al. (1994).

Mendelsohn et al. (1994) propose an alternative economic approach, which makes use of cross-sectional data to capture the influence of climatic as well aseconomic and other factors on land values (or farm income). The technique has been named the Ricardian method because it is based on the observation made by Ricardo (1817), that land values would reflect land productivity at a site under perfect competition. It is possible to account for the direct impact of climate on yields of different crops as well as the indirect substitution among different inputs including the introduction of different activities, and other potential adaptations to different climates by directly measuring farm prices or revenues by using the Ricardian model. The Ricardian technique captures the flexibility of farmers better than the agronomic method. The method examines how land values (or rents) shift with climate and other control variables. Because farmer adaptations are reflected in land values, the approach accounts for the costs and benefits of adaptation.

To measure the economic effect of Climate change on maize crop in Nigeria, the standard Ricardian method (Mendelsohn et al., 1994) was adopted. However, the specification follows Seo et al. (2005) due to its simplicity.

Assuming that the revenue maximizing function of maize farmers in Nigeria is derived from the cost function, production (output function) and the cost of land as follow.

$$C_i = C_i(Q_i, P_x, E) \tag{1}$$

Where Q_i represents the quantity of maize, $C_i(.)$ is the relevant cost function associated with maize production, P_x represents the vector of prices of inputs associated with maize production except land, and E reflects a vector of environmental characteristics of the farmer's land including climate (i.e., temperature and precipitations). Given the cost function in Equation (1), under the assumption of perfect competition in the market for maize crop production, the farmer will maximize net revenue as:

$$Max\ NR = P_i * Q_i(R, E) = C_i(Q_i P_x, E) - P_L L_i = 0 \tag{2}$$

Where NR represents the net revenue per hectare proxies for farm land value, R is a vector of inputs, P_L is the rent and L_i the land. If we assume that a maize farmer chooses inputs, R, to maximize NR, then we can express the resulting outcome of NR in terms of E alone as:

$$NR = f(E) \tag{3}$$

And, the resulting welfare value of a change in the environment from state A to B is:

$$W = \sum f(E_{iB}) * L_i - \sum f(E_{iA}) \times L_i \tag{4}$$

Where, L_i is the amounts of land of type i (Seo et al., 2005). Equation (4) indicates that the welfare value of change in environment is equal to the difference in the net revenue given the two states of nature. However, since maize crop grow and develop very well under preferred temperatures and rainfall, thus, levels far above or below the optimal ranges would obviously reduce productivity. This suggests that the relationship between NR and these climate variables should be hill-shaped as has been extensively discussed in the literature (Mendelsohn et al., 1994; Kurukulasuriya & Mendelsohn, 2006; Seo et al., 2005). To capture this hill-shaped relationship, NR for maize crop production in Nigeria is specifying using the model of Equation (3) as:

$$NR = \sum(\beta_0 + \beta_1 T_1 + \beta_2 T_2^2 + \beta_3 R_3 + \beta_4 R_4^2) + \sum \gamma_i S_i + \sum \alpha_i X_i + \varepsilon \tag{5}$$

Where T_i and R_i represent normal temperature and rainfall in each season, S is the set of soil variables, X is the set of economic and social variables like access to market and capital and other relevant social characteristics and erepresents the error term. Equation (5) represents the empirical model to be estimated for Nigerian maize farmlands

2.2 Marginal Impact Analysis

The marginal impact analysis was undertaken to observe the effect of an infinitesimal change in temperature and rainfall on net maize revenue.

From Equation (5), the mean marginal impact of a climate variable on maize farm revenue will be derived. The expected marginal impact of a climate variable on net revenue, the proxy of farm value, evaluated at the mean is:

$$E\left[\frac{\partial NR}{\partial T_i}\right] = \beta_1 + 2 * \beta_2 T_2 * E[T_i] \tag{6}$$

$$E\left[\frac{\partial NR}{\partial R_i}\right] = \beta_3 + 2 * \beta_4 R_4 * E[R_i] \tag{7}$$

3. Methodology

3.1 Study Area

The study area is Nigeria. Nigeria is one of the sub-Saharan African nations in the western part of the Africa and shares land border with the republic of Benin to the west, Chad and Cameroon to the east, Niger republic to the north, and its coast lies on the gulf of Guinea (Wikipedia, 2009).

The total land area of Nigeria (923,766 km^2) is divided into seven broad ecological or land resource zones namely mangrove swampy forest, Rainforest, Montane forest/grassland, Derived savanna, Guinea savanna, Sudan savanna, and Sahel savanna (Olufemi & Ameh, 1999). The categorization is based on the similarity of climate and vegetation cover as well as the type of crops that are adapted to each land area. With the exception of the montane region, the length of wet season (days) and temperature increase from the coast to the hitherland. In this categorization no state of the federation can boast of one ecological zone. A state may have up to three ecological zones. All these zones support maize production.

3.2 Sampling Procedure

Multistage sampling technique was employed for the study. Three major maize producing states were purposively selected to represent agro-ecological zones (Niger: guinea savannah, Taraba: montane savanna and Oyo: rainforest). The second stage was the purposive selection of two Local Government Areas with records of highest maize production in each of the states. Thirdly, 5 villages were randomly selected from each LGA and lastly 400 maize-based farming households were randomly selected from the list of maize producing farmers obtained from the ADP of each zone in a proportionate sampling method.

Although a total of 400 questionnaires were administered on the respondents, 54 of these were found unsuitable for analysis and consequently, data from 346 questionnaires were analyzed for the study.

3.3 Type and Sources of Data

The study employed both primary and secondary data. Data were collected on households demographic and farm characteristics, input and output in maize production, institutional factors, perception of climate change and adaptation strategies using structured questionnaire.The questionnaire instrument was adapted and modified from the Global Environmental Fund (GEF) Regional Climate, Water and Agriculture Project of the Centre of Environmental Economics and Policy in Africa (CEEPA), University of Pretoria, South Africa (See, http://www.ceepa.co.za/climate_change/index.html).

3.4 Secondary Data

Data on climate variables that is temperature and rainfall for 41 years (1970-2011) was employed in the study. The data was obtained from the Nigerian Metrological Agency in Oshodi, Lagos State. Averages of temperature and rainfall data for the 41 years from six weather stations (Yola, Ibi, Minna, Bida, Ibadan and Saki) in the three agro-ecological zones were pooled to allow enough variation in the data set. Their averages for the two predominant seasons (Dry and Rainy season) in the country were estimated for the 41 years period. The dry season ranges from November – March while the rainy season range from April – October. It is assumed that farms within the same location experiences the same weather conditions hence the same climate data are matched to farms that are within the neighbourhood of each station.

3.5 Soil Data

The soil data for the three selected states representing each maize producing agro-ecological zone were obtained from the Food and Agricultural Organization (FAO, 2003). The FAO provides information about the major and minor soils in each location, including the slope and texture. In all, there exists 8 types of soil (Arenisols, Vertisols, Luvisols, Nitrosols, Lexisols, Fluvisols, Leptosols and Plinthosols) in the three states and the percentage share of each particular dominant soil was obtained.

3.6 Net Revenue

Maize production performance was measured using average yield as well as using gross revenue calculations based on the market valuation of output and all variable input costs including cost of labour. The real net revenue that was used for this study defined as gross revenue minus the cost of fertilizer and pesticides, hired labour (valued of median market wage rate), light farm tools (such as files, axes, cutlass, machets etc), rental on heavy machinery (tractors, ploughs, threshers etc) and household labour (valued at own wage rate).

4. Results and Discussion

4.1 Socio-Economic Characteristics of Maize Farmers

The distribution of the farmers by agro-ecological zone as presented in Table 1 shows that between 77% and 97% of maize farmers were male across the three agro-ecologies with an overall male dominance of 90.8%. Male dominance has severally been attributed to the laborious nature of peasant farming due to high dependence on manual labour. Also limited access of women to productive inputs has also made men the major actors. The comparison of socio-demographic characteristics of maize farmers across the agro-ecological zones revealed that there were significant differences in all the estimated variables, at the one percent level of significance. Farmers in the rainforest had the highest mean age of 51.54 years, followed by guinea savanna (43.48 years) and montane savanna (41.61 years). Farmers' experience in farming showed that maize farmers in guinea savanna had higher average experience of 30.64 years, which is significantly higher than rainforest (24.93 years) which in turn is higher than montane savanna (15.81 years). This implies that with the level of experience of the sampled farmers they are expected to have more knowledge and information about climate change and agronomic practices that they can use in response to climate change. According to Maddison (2006) and Nhemachena and Hassan (2007) experience in farming increases the probability of uptake of adaptation measures to climate change. The year of education attainment was found to be significantly low across the three agro-ecological zones with mean of 9.16 years, 4.58 years and 7.64 years for rainforest, guinea savanna and montane savanna respectively. The implication of this is that there would be low level of technological adoption to improve maize farming and limited exposure of farmers to warning system of climate information that can facilitate effective adaptation strategies. The household size also showed a significant difference across the three agro-ecological zones. Maize farmers in the guinea savanna had an average household size of 10 persons, montane savanna (8 persons) and rainforest (5 persons). The average distance of product and input market place to the farms varied significantly across the agro-ecological zones. In all, the average distance of product and input market to farms was about 7.90 km and 7.45 km. The number of extension visits varied among the farmers in each agro-ecological zone. The average number of visit was 2.26, 2.5 and 1.47 times in rainforest, guinea and montane savanna respectively. On the average, about 61.7%, 54.9% and 34.2% of maize farmers had access to credit in rainforest, guinea and montane savanna respectively. In terms of agricultural subsidy, average subsidy received by farmers in all the zones was N5, 837 in a year. About 67%, 89.2% and 68.4% of the maize farmers in rainforest, guinea and montane savanna respectively reported to have property right on their farmland which was acquired through inheritance and outright purchased.

4.2 Farm Characteristics

The land holding and proportion of land area allocated to maize production varied significantly across the agro-ecological zones (Table 1). The total farm size holding in guinea savanna is significant higher (6.57 ha) than total farm size holding in montane savanna (4.66 ha) which in turn is higher than total farm size holding in rainforest (3.49 ha). The proportion of land area allocated to maize production also varied significantly across the three agro-ecological zones. The average land area allocated to maize production was significantly higher in guinea savanna (1.89 ha) than montane savanna (1.56 ha) and rainforest agro-ecological zones (0.84 ha) respectively. This suggests that maize farming is still predominantly on small scale level. Maize yield in the montane savanna (4.01 ton/ha) was significantly higher than its yield in guinea savanna (3.40 ton/ha) and rainforest (2.54 ton/ha) respectively. The result is consistent with previous studies (Abiodun et al., 2011; Madiyazhagan et al., 2004) that highest maize production occurs in the savanna because these zones have the most favourable climate and soil for maize production. The distribution of the farmers by their use of inputs across agro-ecological zones shows maize farmers in guinea savanna used an average of 300 kg/ha of fertilizer in maize production. This is significantly higher than average fertilizer used by rainforest (153.56 kg/ha) and montane savanna (125.75 kg/ha) respectively. The yearly average of the sample was about 272.6 kg/ha which is lower than the recommended usage of 400 kg/ha application level for effective optimum growth and yield of maize (Law-Ogbomo, 2009).The result also shows that maize farmers in the guinea savanna used an average 12.6litres/ha of pesticides which is significantly higher than average pesticides used by montane savanna (2.98 lt/ha) and rainforest (2.87 lt/ha) respectively. The use of irrigation for maize crop production shows that majority (77.7%) of the farmers did not use irrigation for maize production while about 22.3% made use of irrigation to grow maize. Montane savanna had the highest percentage (39.2%) of farmers using irrigation than guinea (20.2%) and rainforest (11.7%) respectively.

4.3 Ricardian Analysis

4.3.1 Descriptive Statistics of Relevant Variables Used in Ricardian Analysis

1) Net Revenue

Net maize revenue varied across the three agro-ecological zones. It was found to be significantly higher for maize farmers in montane savanna (₦158,554.60) than maize farmers in rainforest (₦140,081.90) which in turn is higher than guinea savanna (₦109,237.15). The variability in maize net revenue across the agro-ecological zones can be explained by the difference in climatic condition and the level of technology.The empirical analysis therefore tried to find the climatic, soil, and socioeconomic variables that would help explain this variability.

2) Climate

The study considered two climate data namely temperature and rainfall. This is because their data were readily available in the climate model. The averages for the two predominant seasons (Dry and Rainy season) in the country were estimated for the 41 years period (1970-2011). The dry season ranges from November – March while the rainy season range from April – October. Result in Table 1 showed that rainforest agro-ecological zone recorded the highest monthly average rainfall (176.3 mm) during the rainy season followed by guinea savanna (163.4 mm) and montane savanna (147.1 mm). Rainfall pattern during the dry season was found to be very low in guinea (3.8 mm) and montane (6.8 mm) savanna than rainforest zone (24.1 mm). Results showed that Montane savanna had higher monthly average temperature during the rainy and dry season (31 ^{o}C and 33.4 ^{o}C) than guinea savanna (30.3 ^{o}C and 32.9 ^{o}C) and rainforest (29.5 ^{o}C and 32 ^{o}C).The average annual rainfall for the 41 years period of study was estimated at about 1262 mm, 1166 mm and 1062 mm for rainforest, guinea and montane savanna respectively while average annual temperature for the same period was estimated at about 31.7 ^{o}C, 32.7 ^{o}C and 32.9 ^{o}C for rainforest, guinea and montane savanna respectively.

3) Soil

In Table 1, it showed that there are eight soil samples that were dominant in the study areas based on FAO (2003) soil data classification. The percentage shares of each particular dominant soil in the soil mapping were used in the regression. Across the agro-ecological zones, rainforest farmlands were covered by three dominant soil types in respect of lixisol (50%), luvisol (50%) and leptosol (34%). Guinea savanna farmlands were located on six dominant soil types which includes; lixisol (90%), luvisol (50%), leptosol (34%), fluvisol (35%), pinthosol (70%) and nitrosol (70%). Montane savanna agro-ecological zone were located on seven dominant soil types. They are; arenisol (40%), lixisol (50%), leptosol (50%), fluvisol (35%), pinthosol (70%), veritosol (60%), nitrosol (70%). This implies that endowment of soil resources differed from one agro-ecological zone to another.

Table 1. Descriptive statistics of variables used in Ricardian Regression

Variables	Rainforest	Guinea	Montane	All zones	F-stat.
Net revenue (~~N~~)	140,081.90	109,237.15	158,554.60	128.878.87	3.95***
Dry season rainfall (mm)	24.1(11.4)	3.83(4.05)	6.8(8.91)	11.43(4.94)	
Rainy season rainfall (mm)	176.3(10.30)	163.4(19.85)	147.1(37.30)	156.7(20.75)	
Annual rainfall l(mm)	1262(573.45)	1166.7(19.85)	1062.9(254.27)	1035.21(214.25)	
Dry season temperature (°C)	32.02(2.47)	32.9(7.11)	33.4(6.54)	32.8(5.87)	
Rainy season temperature (°C)	29.5(2.24)	31.3(5.17)	31.0(5.09)	30.6(1.53)	
Annual temperature (°C)	31.7(4.04)	32.7(5.92)	32.9(5.45)	32.2(2.05)	
Arenisol (%)			40	0.09(0.17)	
Fluvisol (%)		35	35	0.25(0.16)	
Lixisol (%)	50	90	50	0.70(0.20)	
Luvisol (%)	50	50		0.39(0.21)	
Leptosol (%)	34	34	50	0.38(0.07)	
Nitrosol (%)		70	70	0.49(0.30)	
Pinthosol (%)			70	0.51(0.31)	
Veritosol (%)			60	0.14(0.10)	
Farm size (ha)	3.49(3.16)	6.57(5.38)	4.66(3.86)	5.31(5.52)	28.02***
Land area formaize (ha)	0.84(0.51)	1.89(1.12)	1.56(0.97)	1.54(0.81)	6.83***
Maize yield (t/ha)	2.54(4.64)	3.40(3.29)	4.01(2.82)	3.31(3.64)	3.69**
Fertilizer (kg/ha)	153.56(152.7)	404.6(373.7)	125.37(75.36)	272.7(284.04)	47.72***
Pesticides (lt/ha)	2.87(4.16)	12.61(20.07)	2.98(2.15)	7.76(15.12)	14.61***
Irrigation (%)	11.7	20.2	39.2	22.3	
Gender (% male)	90.4	97.1	77.2	90.8	
Age of household head (years)	51.54(11.20)	43.48(7.38)	46.61(11.91)	45.44(10.45)	29.81***
Education (years)	9.16(6.17)	4.58(6.15)	7.64(6.24)	6.46(6.47)	17.29***
Household size (number)	5.08(3.38)	10.26(3.57)	7.52(4.24)	8.33(4.27)	55.85***
Farming experience (years)	24.39(12.85)	30.64(10.79)	15.89(10.16)	25.56(12.69)	47.49***
Distance to output market (km)	7.16(8.23)	10.26(5.42)	3.61(1.89)	7.90(6.39)	36.42***
Distance to input market (km)	8.01(9.26)	8.58(5.52)	4.28(3.02)	7.45(6.59)	12.84***
Extension contact (number)	2.26(0.75)	2.5(2.13)	1.47(1.02)	2.19(1.68)	10.76***
Access to credit (%)	61.7	54.9	34.2	52	
Land ownership (%)	67	89.1	68.4	78.3	
Subsidy (~~N~~)	4581(1760.4)	6423(8567.7)	11354(15684)	5837.28(9575)	

Note. * **Significant at 1%; **Significant at 5%; Values in parenthesis are standard deviation.

Source: Computed from field data, 2012.

4.3.2 Model Estimation

Three models were estimated for the regression analysis. The first model estimates the response of maize net revenue to climate variables only. The second model integrates the soil variables into the first model and the third model added the socio-economic characteristics of the household to the second model.

1) Relationship between Maize Net Revenue and Climate Variables (Mode 1)

Model 1 shows the response of maize net revenue with climate variables only. Results (Table 2) showed that rainfall during the dry season, temperature during the rainy season and square of temperature during the dry season exhibits strong collinearity and hence were dropped from the model. The co-efficient of determination (R^2) of 0.254 indicate that 25.4% of the variations in net revenue were explained by the climate variables. The adjusted R^2 (0.243) is a little lower than R-squared but not too much suggesting that the model do not have a serious over fitting problem. The F-statistic (F = 23.137***) indicates that the overall model is significant at I percent,

Result shows that dry season rainfall has a negative relationship with net revenue and is statistically significant ($p < 0.1$). The reason for this is that low rainfall associated with dry season period reduced maize yield which decreased maize net revenue, thus weakening the purchasing power of the farmers.

The quadratic term of dry season rainfall exhibits a U-shaped relationship with maize net revenue implying that increased rainfall during the dry season may be associated with higher productivity. Adequate rain during dry season is capable of lengthening growing season for maize with greater output possible per hectare.

Rainy season rainfall, however, has a positive relationship with maize net revenue and exhibits a U-shaped relationship with it. This implies that increased rainfall during the rainy season is beneficial for maize production.

The quadratic term for rainy season temperature have a U-shaped relationship with net revenue, implying that temperature during the rainy season could be beneficial for maize production. This results show that climate exhibits a non-linear relationship with net revenue which is consistent with findings in literature (Mendelsohn et al., 1994; Kurukulasuriya & Mendelsohn, 2006; Kabubo & Karanja, 2007; Ajetomobi et al., 2011).

2) Relationship between Maize Net Revenue, Climate and Soil Variables (Model 2)

Model 2 (Table 2) shows the response of maize net revenue with climate and soil variables. The inclusion of soil variables was to capture the spatial heterogeneity across the agro-ecological zones sampled. The soil variables introduced did not in any way improved the model as the R^2 (0.254) and F- statistics (F = 23.137***) remain the same as in the first model although all the climate variables and soil variables were negatively signed and significant at $p < 0.01$, $p < 0.05$ and $p < 0.1$ probabilities level.

Results show that only two of the soil variables (luvisol and pinthosol) among the eight soil types introduced into the model are significant while the other soil types dropped because of strong collinearity. When the soil variable is negatively significant, it means the soil is poor and its spatial extension will cause a decrease in farm net revenues (Sene et al., 2006). This indicates that the dominant soil types in the three agro-ecological zones are not suitable for maize production in their present state. The reason attributed for this may be due to continuous cropping of the same land over the years for maize production with its attendant fertility depletion especially in a cropping system dominated by maize which is a high nutrient feeder.

3) Relationship between Maize Net Revenue, Climate Variables, Soil Factors and Household's Socio-Economic Variables (Model 3)

Model 3 (Table 2) show the results of maize net revenue regression with socio-economic variables combined with the first and second model. Introduction of these variables raises the co-efficient of determination (R^2) from 25.4% to 36.3%. The adjusted R^2 (0.323) suggested that the model was not over-fitted. The F- statistics (9.158; $p < 0.01$) and Durbin Watson (1.928) indicates that the overall model is significant and well behaved. The result also confirms the quadratic relationship between net farm revenue and climate variables.

Results showed an indirect relationship between dry season rainfall and net revenue and this is statistically significant ($p < 0.05$). This implies that low rainfall during the dry season tends to reduce net revenue in maize production. Also, dry season rainfall intensity is capable of increasing humidity which hinders proper drying of maize cobs on the field thereby making storage difficult. This in turn affects grain quality and consequently market price for the product. However, the second order effect of dry season rainfall exhibits a U-shaped relationship with net revenue. This implies increased rainfall during the dry season positively relates to increased maize net revenue as farmers will take advantage of rain during this period for dry season maize cropping. By implication, increased dry season rainfall is beneficial to maize if it falls between the critical growth period but could be harmful if erratic or inadequate during this period and intense at later period when higher humidity could affect the drying process.

The quadratic term of rainy season rainfall exhibits a U-shaped relationship with net revenue and is statistically significant ($p < 0.01$). This suggests that increased rainfall during the rainy season will increase maize productivity.

Also, dry season temperature has a positive and significant relationship with net revenue ($p < 0.05$). Such relationship points to the possibility of farmers capitalizing on the adequate sunlight intensity to dry their grains on the field and thus made them store better for greater market value. This explains the reason why some farmers preferred to leave the maize to dry properly on the field. The maize has to be dried until it attains a moisture level of 12% which is the recommended level for long term storage. Such maize cobs are then shelled and sold at the grain market. Dried maize, command high price than green maize and are bought in large quantity by agro-allied industries for further processing into useful bye products and livestock's feeds.

Rainy season temperature has a U-shaped relationship with net revenue and statistically significant ($p < 0.05$), implying that temperature during the rainy season could be beneficial for maize production. This is because rainy season temperature is required for seed germination, formative crop growth and enhances physiological and grain maturity (Abiodun et al., 2011).

The dominant soil variable (luvisol) has a negative relationship with net revenue and is statistically significant ($p < 0.05$). This implies that the dominant soil type in the three agro-ecological zones on which maize is grown is not suitable for increased maize production at its present state. Its continued cropping will reduce net revenue of maize annually.

Most of the households' variables have a significant impact on maize net revenue per hectare.

Gender of the household head has a positive relationship with net revenue and statistically significant ($p < 0.05$). This indicates that maize net revenue may increase with male headed household than the female headed household. This may be because of the considerable physical and tedious task involved in maize farming or because of possible discrimination faced by women when selling farm produce; which limited their access to productive input resources. This result corroborates the findings by Kurukulasuriya and Ajwad (2004), Kabubo and Karanja (2007), and Ajetomobi et al. (2011).

Household size has a positive and significant impact on net revenue ($p < 0.10$). This indicates that household members in this study were not majorly dependents and were productive people. A large household improves the potential labour position on the farm. An increase in the number of productive dependant in a household will increase net farm revenue.

Education level of the head has a positive relationship with net revenue and statistically significant ($p < 0.05$). This implies that higher levels of education attainment generally leads to higher net revenue per hectare of maize. By implication, an educated household head possessed the ability to adopt new and improved technologies and ability to better optimize on farming practices.

Based on a priori expectation, co-efficient of irrigation is expected to have a positive impact on maize net revenue because irrigation controls for rain fluctuation most especially in the dry season. However, results showed that irrigation has a negative relationship with net revenue and is statistically significant ($p < 0.05$). This result is not surprising given that maize production is rain-fed in the country and that very few farmers in the study areas cultivated maize during the dry season that required irrigation. As reported by Kurukulasuriya and Ajwad (2004) rain-fed agriculture is more profitable than irrigated agriculture because there is a cost associated with the latter than the former.

Distance to input market has a negative relationship with net revenue and statistically significant ($p < 0.05$). This indicates that farmers incurred more cost in terms of money and time if the market place becomes farther away from their farms. This result supports the finding of Fonta et al. (2011) and Deressa (2007) that market distance has a negative impact on net revenue per hectare.

Contrary to a priori expectation, extension agents' contact with farmers is negatively related to net revenue and statistically significant ($p < 0.05$). This implies that number of visit by extension agents to keep the farmers informed about new technologies and modern farming technique was inadequate. This is not surprising giving that in our sample the average number of contact between extension agent and farmer was twice per month. This result is in agreement with findings by Adeogun et al. (2008); Sabo and Zira (2009) and Saka (2011) that the frequency of contact by extension agents was found to be low among Nigerian farmers.

Household access to subsidy (cash or kind) has a positive relationship with net revenue and statistically significant ($p < 0.05$). This implies that access to farm subsidy have a significant impact in increasing farm revenue.

Land area has inverse relationship with net revenue and statistically significant ($p < 0.01$). This indicates that small farms are more productive on a per hectare basis than large farms. The possible reason for this observation is that small farms use fixed resources such as household labour and other inputs over a smaller area than large farms.

Similar results by Kabubo and Karanja (2007) and Ajetomobi et al. (2011) showed that there is inverse relationship between farm size and productivity indicating the reductive importance of small farm holding.

Table 2. Ricardian regression estimates of maize net revenue model

	Model 1		Model 2		Model 3	
	Co-efficient	T-value	Co-efficient	T-value	Co-efficient	T-value
Dry season rainfall	-0.051*	-1.537	-0.043**	-2.121	-0.065**	-2.011
Dry season rainfall square	0.002**	2.213			0.002**	2.232
Rainy season rainfall square	1.164e-5*	1.549	-9.28e-6	-1.249	2.57e-5***	3.806
Dry season temperature	0.049	0.602	-0.120*	-1.903	0.013**	2.125
Rainy season temperature square	0.003**	2.808			0.003**	2.835
Soil: Luvisol			-1.668***	-4.369	-0.588**	-2.674
Pinthosol			-1.893**	-2.841		
Gender					0.160**	2.030
Age						
Household size					0.002	0.529
Years of schooling					0.009*	1.688
Farming experience					0.001	0.545
Irrigation					-0.174**	-2.154
Ownership of land					-0.010	-0.142
Distance to output market					0.004	0.668
Distance to input market					-0.013**	2.078
Livestock ownership					-0.024	-0.425
Extension contact					-0.023*	-1.639
Received subsidy					6.237e-6**	2.618
Access to credit					0.044	1.007
Land area for maize					-0.316***	-3.744
Land area for maize square					0.091***	3.759
Constant	-0.372	-0.197	11.345***	3.734	-0.531	0.270
R – Square	0.254		0.254		0.363	
Adj – R square	0.243		0.243		0.323	
F – Statistics	23.137***		23.137***		9.158***	
Durbin Watson	1.731		1.731		1.928	

Note. Legend: * Significant at 10%; ** Significant at 5%; *** Significant at 1%.

Source: Computed from field data, 2012.

4.3.3 Marginal Impacts of Climate Variables on Maize Net Revenue

In this subsection, marginal impacts of climate on maize agriculture (Table 3) were estimated using the regression results for model 3. The marginal impact analysis was undertaken to observe the effect of small changes in temperature and rainfall on maize net revenue. Results showed that marginal increase in rainfall during the dry season significantly increases net revenue per hectare for maize farms in the rainforest agro-ecological zone by ₦ 4,398.57 while it reduces net revenue per hectare for maize farms in guinea savanna and montane savanna by ₦ 5,429.09 and ₦5,593.36 respectively. The reason may be that majority of the farmers in guinea and montane savanna cultivated maize once per year because of the unimodal pattern of rainfall in these agro-ecological zones thus leaves the maize on the field to dry properly before harvesting and storage. Any slight increase in rainfall during this period may result in diseases and pests build-up which may cause economic damage for the maize farmers. In addition, the drying process could be disturbed thereby promoting grain deterioration and consequent reduction in market value of the product. While in the rainforest agro-ecological zone maize is cultivated twice per year (early and late maize) because of bimodal rainfall distribution hence increase in rainfall during the dry season will be beneficial for maize farmers in this zone as it increased net revenue.

The rainy season rainfall has a positive impact on maize net revenue in all the agro-ecological zones. Increasing rainfall in the rainy season increases net revenue per hectare for maize farms in rainforest, guinea and montane savanna by ₦1,274.75, ₦917.59 and ₦1,205.01 respectively. During the rainy season, increasing rainfall by 1mm increases net revenue in all farms by ₦1,043.92. As noted by Durand (2006), precipitation is the most important driver of maize production. It is therefore important that farmers be encouraged to irrigate their maize farms to mitigate the impact of rainfall deficiency, all other things being equal.

Also, Table 3 shows that temperature during the dry season increase net revenue per hectare for maize farms in rainforest by ₦1,821.06, guinea savanna by ₦1,420.08 and montane savanna by ₦2,061.21. The scenario above shows that, even though maize production is rain-fed, intense sunlight is required to dry the maize cobs after it has completed its growth processes before harvesting and storage for further processing. Sowunmi and Akintola (2009) reported that savanna agro-ecological zones are found to be suitable for maize production in terms of good soil and temperature. Also, small changes in temperature during the rainy season increases maize net revenue in rainforest, guinea and montane savanna by ₦24,794.43, ₦20,514.34, ₦29,491.16.

As indicated from the result of this study, temperature is not harmful for maize production. This result did not agreed with the findings from many studies in literature (Mendelsohn et al., 1994; Kurukulasuriya & Mendelsohn, 2006; Kabubo & Karanja, 2007) who argued that temperature is harmful for crop production. The distinct point of disagreement is that these studies used the combination of different crops and aggregated revenues which are different from this study that used single crop. Moreover, one should be mindful that each crop have known climate on which it can grow best which emanated from the result of this study.

Table 3. Marginal impact of climate change on maize net revenue across the agro-ecological zones

	Rainforest (₦)	Guinea (₦)	Montane (₦)	All zones (₦)
Dry season rainfall	4.398.57	-5,429.09	-5,933.36	-3,221.97
Rainy season rainfall	1,274.75	917.59	1,205.01	1,043.92
Dry season temperature	1,821.06	1,420.08	2,061.21	1,678.65
Rainy season temperature	24,794.43	20,514.74	29,491.16	23,682.18

Source: Computed from field data, 2012.

4.3.4 Predicting the Impact of Climate Change on Maize Agriculture in Nigeria

The study simulated the impact of future climate change scenarios on maize crop across the three agro-ecological zones namely rainforest, guinea savanna and montane savanna. In this simulation, the only variable subject to change were the climate variables while other factors were constant. However, in the long run, technology, capital, consumption etc. are bound to change and these will have tremendous impacts on future maize net revenue. Therefore, we are not making a forecast of how net revenue of maize will actually change but simply isolating the effect of climate change on net revenue of maize. In this section, the regression result for model 3 was used to project the impact of global warming on maize agriculture in Nigeria. To assess the impact of different climate scenarios three General Circulation Models (GCMs) scenarios were used. They are Canadian General Circulation Model (CGCM2), Hadley Centre for Climate Prediction and Research (HADCM3), and the Parallel Climate Model (PCM). The three models predict a wide range of climate outcomes. The emphasis of the present study is to develop scenarios of near-term climate change based on the existing trend and knowledge of how climate may change in the near future. To make prediction for the impact of climate on maize agriculture in the year 2030, three scenarios were highlighted and used. These are (a) increase in temperature only by 1.5 ^{o}C (b) decrease in rainfall by 7% (c) increase in temperature by 1.5 ^{o}C and decrease in rainfall by 7%. The scenarios were applied separately for rainforest, guinea savanna and montane savanna respectively.

Results in Table 4 show that if rainfall decline by 7% it would result in 35.7% loss in maize net revenue in all the zones. However, there is a marked difference in the predicted loss across the agro-ecological zones. In rainforest, 18.3% (-₦1,056.61/ha) loss in maize net revenue, 20.2% (-₦10,923.72/ha) loss in guinea savanna and 49.7% (-₦ 12,414.83/ha) loss in montane savanna agro-ecological zones respectively were predicted. This gives an indication that maize production is rain dependent and that further decline in rainfall in the near future would result in substantial loss in maize revenue. Studies (CIMMYT, 1988; Diallo et al., 1989) reported that availability of adequate rainfall is by far the most limiting factor in maize production in sub-Saharan Africa. Kurukulasuriya and Ajwad (2004) in their study highlight the importance of precipitation relative to temperature for agriculture in tropical countries. The results from the four climate models used in their study reveal that change in precipitation levels, not temperature, drives productivity. Table 4 revealed further that increase in temperature by 1.5 ^{o}C would result in 4.6% (₦1,260.74/ha) gain in maize net revenue in rainforest zone, 4.4% (₦983.14/ha) gain in guinea savanna and 4.3% (₦1,426.99/ha) gain in montane savanna zones respectively. In all zones, a gain of 4.4% in maize net revenue was predicted. The result showed that rainforest, guinea and montane savanna agro-ecological zones are more likely to suffer economic loss in maize production from declining rainfall than from rising temperature. This is because maize is a hot season crop, with optimum productivity in the temperature range of 21-30 ^{o}C (Abiodun et al., 2011; Sowunmi & Akintola, 2009). This finding is therefore consistent with the conclusion in Mendelsohn et al. (1994) that climate change could be beneficial under some conditions. The cumulative effect of the two factors will be devastating for the maize farmers in the three agro-ecological zones under study as they were going to suffer losses in maize net revenue in year 2030. Estimated losses were 2.5%, 35.5% and 28.1% for rainforest, guinea and montane savanna agro-ecological zones respectively. In all zones, estimated loss in maize net revenue is 15.5%. This implies that climate change (rainfall and temperature) will have harmful effect on maize revenue in the future. Madiyazhagan et al. (2004) observed that high temperature (greater than 30 ^{o}C) compounded by water stress occurring at the same time decreases maize kernel planted in dry land environments. Also, Akpalu et al. (2008) reported that the impact of precipitation on maize yield is stronger than that of temperature, meaning that the impact of climate variability on maize yield could be negative if the change increases temperature but reduces precipitation at the same rate and simultaneously. This result indicate that climate change could have negative impacts on maize net revenue in the future which may pose a serious threat to household food security since maize is a staple food and widely consumed in Nigeria. Thus, effective and efficient adaptation measures should be promoted to prepare stakeholders in maize production systems to enhance their resilience and flexibility when facing adverse climatic change.

Table 4. Predicted impacts of different climate scenarios by agro-ecological zones

	Rainforest (₦)		Guinea (₦)		Montane (₦)		All Zones (₦)	
Climate scenarios	ΔNR	%Δ	ΔNR	%Δ	ΔNR	%Δ	ΔNR	%Δ
-7% rainfall	-2,050.6	-18.3%	-10,923	-20.2%	-12,414	-49.7%	-5,661.9	-35.7%
+1.5 ^{o}C	1,260.74	4.6%	983.13	4.4%	1,426.9	4.3%	1,147.01	4.4%
(-7% +1.5 ^{o}C)	-789.86	-2.5%	-9,940	-35.5%	-10,987	-28.1%	-4,513.7	-15.5%

Note. *** ΔNR = Change in net revenue per ha; %Δ = percentage change in net revenue/ha.

Source: Computed from field data, 2012.

4.4 Perception of Climate Change by Agro-Ecological Zones

Table 5 presents the farmers' perceptions of long term climate change by agro-ecological zones. Results indicate that significant number of farmers in the three agro-ecological zones; rainforest (35.1%), guinea savanna (53.2%) and montane savanna (75.9%) said that temperature has increased over the years. By contrast, 12.8%, 15% and 7.6% of farmers in rainforest, guinea and montane savanna respectively said that temperature has decreased. Farmers in montane savanna recorded the lowest percentage in terms of decreased temperature (7.6%), altered temperature change (3.8%) and no change in temperature (2.5%) than their counterpart in other agro-ecological zones.

The result for rainfall (Table 5) shows a similar pattern across the three agro-ecological zones. Majority of the farmers in the three agro-ecological zones; rainforest (59.4%), guinea savanna (68.6%) and montane savanna (77.1%) said that rainfall had decreased over the years. Also, 5.3% and 1.7% of the farmers perceived increase in rainfall for rainforest and guinea savanna respectively while none of those sampled farmers in montane savanna said that rainfall had increased. Also, 25.6% of the farmers in the rainforest and guinea savanna (22.5%) said that there had been change in the timing of rains while only 10.1% of the respondents in the montane savanna said the same. In addition, 11.7%, 8.2% and 13.9% of the farmers in rainforest, guinea and montane respectively said they had lived through a change in the frequently of droughts while 11.7%, 8.2% and 1.3% of farmers in rainforest, guinea and montane respectively said that there is no change in rainfall pattern. From the above it suggests that the farmers are perceptive to climate change which is a basic precondition for adaptation.

Table 5. Perception of climate change by agro-ecological zones (% of respondents)

Perception	Rainforest	Guinea	Montane
Increased temperature	35.1	53.2	75.9
Decreased temperature	12.8	15.6	7.6
Altered temperature change	12.8	15.0	3.8
No change in temperature	8.5	9.2	2.5
Increased rainfall	5.3	1.7	0.0
Decreased rainfall	59.4	68.6	77.1
Change in timing of rains	25.6	22.5	10.1
Change in frequency of drought	11.7	8.2	13.9
No change in rainfall	11.7	3.5	1.3

Source: Computed from field data, 2012.

4.5 Short-Term Adaptation to Climate Change

Households reported that they have used more than one type of adaptation strategies. This implies that a single strategy is not adequate in adapting to the impact of climate change as combination of several strategies is likely to be more effective than a single strategy. Table 6 reveals the analysis of adaptation made by respondents across the agro-ecological zones. Results showed that the major adaptation method adopted by maize farmers across the agro-ecological zones was changing the planting dates of maize. This was observed to have the highest percentage in all the three agro-ecological zones, that is, Rainforest (77.7%), Guinea savanna (83.8%) and Montane savanna (69.5%). Changed land-use practices such as crop rotation, shifting cultivation etc was shown to be important across the agro- ecological zones; rainforest(75.5%), guinea (65.3%) and montane savanna (48.1%) respectively. Adopting mixed cropping or multi cropping is widely practiced in rainforest zone (78.7%) compared to farmers in guinea savanna (35.8%) while it is less adopted by farmers in montane savanna (19%). Adopting mixed farming i.e planting crops and rearing livestock are more common in montane savanna (69.2%) and guinea savanna (57.6%) than rainforest (27.7%). Uses of improved maize seed are adopted by 52.8%, 48.1% and 42.7% of the farmers in rainforest, guinea and montane savanna respectively. The use of irrigation as an adaptation strategy to cushion the adverse effect of climate change was commonly practiced in montane savanna (35.3%) than guinea (10.6%) and rainforest (2.6%) agro-ecological zones. Adopting terrace or contour across the slope was universally practiced in the rainforest zone (31.7%) to guide against soil erosion. 43.2% and 25.6% of the maize farmers in montane and guinea savanna change from farming to non-farming during the hot climate but this practice is almost irrelevant in rainforest (4.3%). Changing the use of chemicals and fertilizers as an adaptation strategy was more common among maize farmers in montane savanna (43.2%) than other maize farmers from guinea (36.8%) and rainforest zones (26.6%). Prayer or ritual offering are made by farmers across the agro-ecological zones but it is more pronounced in guinea savanna (42.2%) and montane savanna zones (38.3%). Few of the maize farmers report no changes in agricultural practice across the three agro-ecological zones; rainforest (10.6%), montane savanna (7.6%) and guinea savanna (4.6%). This implies that every respondent across the agro-ecological zones have made at least one adaptation

Table 6. Short term Adaptation to climate change by agro-ecological zones (% of respondents)

Adaptation	Rainforest	Guinea savanna	Montane savanna
Mixed/Multi cropping	78.7	35.8	19.0
Changed land-use practices	75.5	65.3	48.1
Increased use of irrigation	2.6	10.6	35.3
Mixed farming	27.7	57.6	69.2
Changed time of planting	77.7	83.8	69.5
Terrace/Contour construction	31.7	1.7	16.5
Use of improved seed varieties	52.8	48.1	42.7
Change from farming to non-farming	4.3	25.6	43.2
Change use of chemicals and fertilizers	26.6	36.8	43.2
Prayer or ritual offering	11.4	42.2	38.3
No adaptation	10.6	4.6	7.6

Source: Computed from field data, 2012.

4.6 Barriers to Adaptation by Agro-Ecological Zones

The analysis of barriers to adaptation in Nigeria maize agriculture by agro-ecological zones revealed some important differences in the extent and prevalence of different adaptation measures. The possibility of these differences may be due to differences in the perception of climate change across the agro-ecological zones or due to institutional differences between the agro-ecological zones. Six major constraints to adaptation were identified by maize farmers across the agro-ecological zones. These are inadequate information on climate change, inadequate knowledge of appropriate adaptation strategies, inadequate credit or saving, no access to water/river/stream, inadequate access to improved seed variety and land tenure problem.

Results (Table 7) show that majority (67.9%) of the sampled farmers lacked appropriate knowledge of adaptation strategies. This is closely followed by inadequate credits or saving to invest in appropriate adaptation strategies (64.2%), inadequate information on climate change (63.9%), inadequate access to improved seed (18.8%) and inaccessibility to water or stream to facilitate irrigation (11.8%). However there is a marked difference in the barriers to adaptation across the agro-ecological zones. Larger percentage of farmers in rainforest (61.7%), guinea savanna (57.8%) and montane savanna (79.7%) were impeded by inadequate information on climate change. This could be attributed to the fact that research on climate change and indigenous adaptation options are still at lower ebb in the country and thus information is lacking in this area. A large number of maize farmers in montane savanna (84.8%), rainforest (62.8%) and guinea savanna (55.5%) opined that inadequate credit or saving hindered them from possessing the necessary resources and technologies that can assist them to adapt to climate change. Also, inadequate knowledge of appropriate adaptation strategies that suited the local climate conditions are considered a major barrier to adaptation in guinea savanna (75.1%), rainforest (61.7%) and montane savanna (59.5%). inaccessibility to water/river/stream were major adaptation constraint in guinea savanna (46.8%) and rainforest (30.9%) while few farmers in montane savanna (15.2%) felt they were impeded. Inadequate access to improved seed variety was anticipated to be a major barrier in adaptation but was perceived not to be a barrier except in montane savanna agro-ecological zone. Land tenure problem is a major barrier to adaptation because of the high population pressure which forces farmers to cultivate a small portion of land over the years and makes them unable to conserve from further damages. Nearly half of the maize farmers in montane savanna claimed to have been impeded by land tenure problem while very few were constrained in rainforest (27.7%) and guinea savanna (4.0%) respectively. This lack of security of property right is a major problem in technology adoption.

Table 7. Barriers to adaptation by agro-ecological zones

	Rainforest	Guinea	Montane	Pooled
Inadequate information on CC	58 (61.7)	100 (57.8)	63 (79.7)	229 (63.9)
Inadequate knowledge of appropriate adaptation strategies	58 (61.7)	130 (75.1)	47 (59.5)	235 (67.9)
Inadequate credit or savings	59 (62.8)	96 (55.5)	67 (84.8)	222 (64.2)
No access to water/river/stream	29 (30.9)	81 (46.8)	12 (15.2)	41 (11.8)
No access to improve seed	9 (9.6)	9 (5.2)	47 (59.5)	65 (18.8)
Land tenure problem	26 (27.7)	7 (4.0)	39 (49.4)	72 (20.8)

Source: Computed from field data, 2012.

5. Conclusion

The paper assesses the economic effects of climate change on maize farmer net revenue per hectare using the Ricardian estimation technique. A number of interesting findings emanating from this study showed that there is a non-linear relationship between net revenue and climate variables suggesting that climate change affect maize productivity. The study revealed further that gender, household size, education; subsidy has a positive relationship with maize net revenue while luvisols, irrigation, distant to inputs market, and land area has inverse relationship with maize net revenue. The marginal impact analysis showed that increasing rainfall marginally during dry season increases maize net revenue in rainforest zone while it decreases maize net revenue in guinea and montane savanna agro-ecological zones. However, increasing temperature marginally during dry and rainy season increases maize net revenue in the three agro-ecological zones under study. The prediction results confirm that climate change will have a substantial impact on maize net revenue, and that the impact will be more pronounced in guinea and montane savanna than rainforest zone. The results suggest that farmers in Nigeria were aware of climate change, that most of them have noticed an increase in temperatures and decrease in rainfall and that some have taken adaptive measures.

6. Policy Implication and Recommendation

Evidence from this study and available literatures has shown that climate had changed and is still changing while we continued to live with it. The climate change phenomenon is an environmentally induced factor which cannot be controlled but rather to adjust and cope with it. To ensure livelihood sustainability and food security which is being threatened on daily basis by climatic variation and changes there is need for policies framework to be developed at local farm level to counter this adverse effect.

- The study revealed that climate change affects maize production and that farmers were going to suffer losses from declining rainfall than rising temperature. It is suggested that government and private organization should assist in the provision of irrigation facilities to local farmers so as to cope with rainfall deficiency.
- Low revenue of the maize farmers significantly weaken their purchasing power hence makes it difficult for investing in irrigation technology. Policy measures directed towards strengthening financial institutions i.e Microfinance banks, Nigerian Agricultural Bank, Bank of Industry etc should be put in place to encourage them to give credit facilities to farmers at low interest rate.
- The dominant soil types in the study area are not suitable for improved maize production in their present state. Policy directed towards intensification of extension agents' technical service on soil management and conservation techniques that will help in improving soil structure and fertility for increased maize productivity should be focused. Also, government should support maize farmers in the provision of fertilizers at subsidized rate.
- Climate change information is a necessary perquisite for adapting to climate change. Nigerian meteorological agency and other meteorological agencies should be encouraged and strengthened to provide farmers with early warning signal through extension agents to enable them make informed decisions and allow them to better prepare for adverse weather conditions.
- There is preference for specific adaptation strategies among farmers based on the prevailing climatic conditions in their respective zone. Adaptation policies by government should target different agro-ecological zones based on the constraints and potentials of each agro-ecological zone instead of recommending uniform interventions.

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