Climate Change and Agricultural Productivity Nexus in Nigeria

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Abstract
Since agriculture in Nigeria is mostly rain-fed, it follows therefore that any change in climate is bound to impact its productivity in particular and other socio-economic activities in the country. This study examines the impact of climate change and agricultural productivity in Nigeria. The data for this study was sourced from the Central Bank of Nigeria statistical bulletin and World Bank indicators. The data were analyzed using some econometric tools such as Augmented Dickey Fuller (ADF) test, Johansen Test and Error Correction Model. The ADF test reveals that amount of rainfall, emission of CO_2, government expenditure on agriculture and agricultural output were stationary after differencing at level 1. The results of the Johansen co-integrated test revealed that there is one co-integrating equation at 5% showing a co-integrating relationship between agricultural output and other variables. The Error Correction Model indicated that amount of rainfall positively significant at 5% to agricultural output on the short run indicating that vagaries in climate especially rainfall affected food production and output in Nigeria. The study recommends, among other things that 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.
Keywords: *Climate change, Agricultural Productivity, Nigeria*

1. Introduction

Globally, climate change is one of the environmental factors that inhibits economic development and sustainability of mankind (Adejuwon, 2004). Natural climate cycle and human activities have contributed to an increase in the accumulation of heat-trapping “greenhouse” gases in the atmosphere thereby contributing to increase in temperature in the global climate (global warming) (UNFCCC, 2007). Global warming causes unpredictable and extreme weather events which increasingly affect crop growth, availability of soil water, forest fires, soil erosion, droughts, floods, sea level rises with prevalent infection of diseases and pest infestations (Adejuwon, 2004; Zoellick & Robert, 2009). These environmental problems result to low and unpredictable crop yields, which invariably make farmers more vulnerable, especially in Africa (Ziervogel *et al.*, 2006; UNFCCC, 2007). Desertification, uncontrolled grazing, livestock migration, poaching/settlement within protected areas, bushfires and deforestation also posed threats to the environments. All these adversely affected agriculture and food supply, fresh water resources, natural ecosystems, biodiversity and human health, threatening human development and their social, political and economic survival (Zoellick & Robert, 2009).

Climate change refers to a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period typically decades or longer (IPCC, 2007). Also it is the local climate variability that people have previously experienced and adapted to, but is changing, and this change is observed in a relatively great speed (UNFCC, 2007). Similarly, Agriculture is seen as the production of food and livestock, and the purposeful tendering of plants and animals (Ahmed, 1993). As stated by Ahmed (1993) agriculture is the mainstay of many economies and it is fundamental to the socio-economic development of a nation because it is a major element and factor in national development. In the same view**,** Emeka (2007) described agricultural sector as the most important sector of the Nigerian economy which holds a lot of potentials for the future economic development of the nation as it had done in the past.

Agriculture is responsible for 14 percent of global Green House Gases (GHG) emissions and livestock plays a considerable role in climate variation in terms of their contribution to GHG emissions (Krishna, 2011). 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

(IFAD 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. The position in Nigeria is not different from this generalized position.

It is also anticipated that the climate change phenomenon will affect agriculture in a number of ways. For example, uncertainties in the onset of the farming season, due to changes in rainfall characteristics (early rains may not be sustained, and crops planted at their instance may become smothered by heat waves) can lead to an unusual sequence of crop planting and replanting which may result in food shortages due to harvest failure. Extreme weather events such as heavy winds, and floods, devastate farmlands and can lead to crop failure. Availability of agricultural products is affected by climate change directly through its impacts on crop yields, crop pests and diseases, and soil fertility. Also agricultural sector is extremely vulnerable to risk and uncertainty. Farmers and agribusiness operators closely monitor changing weather patterns, farm programs, prices, sales, etc. to reduce their exposure to risk and uncertainty (FAO, 2008). The decline in agricultural output is argued to be one of the major problems hindering the attainment of development in Nigeria. Persistent droughts and flooding, off season rains and dry spells have sent growing seasons out of orbit and led to increased conflict between farmers and herders, leading to a decline in agricultural output. This decline (partly) as a result of this climate change has hindered the growth and development of Nigerian economy.

In climate change economics literature, the 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). These studies suggest a link between climate change and agricultural productivity, though with diverse conclusions. This paper pursues the same objectives further by specifying a similar but modified model to incorporate country-specific variables peculiar to the domestic economy, with agricultural output expressed as a function of amount of rainfall, emissions and government expenditure on agriculture.

In view of the foregoing, this study probes the impact of climate change on agricultural productivity in Nigeria. The remainder of this paper is organized as follows; section 2 presents the literature review. Section 3 describes the methodology employed in the study. Section 4 discusses the results while the final section articulates the policy recommendations and concludes the study.

2. Literature Review

2.1. Conceptual Clarifications

According to Fulginiti and Perrin (1998) agricultural productivity refers to the output produced by a given level of inputs in the agricultural sector of a given economy. Specifically, it can be seen as the ratio of value of total farms outputs to the value of total inputs used in farm production (Olayide & Heady 1992 as cited in Iwala 2013). Agricultural productivity is measured as the ration of final output, in appropriate units to some measure of inputs. Singh and Dhillion (2000) as cited in Kumar and Manimannan (2014) suggested that "yield per unit" should be considered to indicate agricultural productivity. Many scholars criticized this suggestion pointing out that it considered only land as the factor of production with no other factors of production. Therefore other suggestions have been put forward that agricultural productivity should contain all the factor of production such as: labour, farming experiences, fertilizers, availability and management of water and other biological factors. As opined by Amire and Arigbede (2016) Agricultural productivity therefore refers to the increase in per capita output of agricultural produce within an economy during a given period of time. It can be monthly, quarterly or annually. Most economists and statisticians tend to use the latter (annual trends) due to its precise and articulate information it tends to offer.

Climate change has been described as a statistical variation that persists for an extended period, typically for decades or longer (Akinbobola, Adedokun & Nwosa, 2015). It includes shift in the frequency and magnitude of sporadic weather events as well as the slow continuous rise in global average surface temperature (Intergovernmental Panel on Climate Change (IPCC, 2001). The German Advisory Council on Climate Change noted that climate change is a threat already having substantial impact on human beings and the natural eco-system both in developed and developing countries but at varying degree (WBGU, 2003). For the developed countries, the impact of climate change has been perceived to be less severe due to natural advantage, high adaptation techniques, high technology, mechanised agricultural system and wealth status. The presence of these factors has enabled the developed countries to curtail the adverse effect of climate change. For developing countries (Nigeria inclusive), the impact of climate change is of great momentum given the high temperature level, poor adaptation capacity, lack of early warning system and low national income level of these countries (Akinbobola *et al.*, 2015).

2.2. Literature Review

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) who proposed an alternative economic approach, which makes use of cross-sectional data to capture the influence of climatic as well as economic 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.

Empirically, Barrios, Ouattara and Strobl (2004) examined the impact of climatic change on the level of total agricultural production of Sub-Sahara Africa (SSA) and non-Sub-Sahara Africa (NSSA) developing countries. The study utilized a new cross-country panel climatic dataset in an agricultural production framework. The findings of the study revealed that climate, measured as changes in country-wide rainfall and temperature has been a major factor influencing agricultural production in SSA while in NSSA countries agricultural production seems not to be affected by climate change. Furthermore, simulations using the estimates suggest that the detrimental changes in climate since the 1960s can account for a substantial portion of the gap in agricultural production between SSA and the rest of the developing world. In Sri Lankan, Seo *et al.* (2009) analysed the effect of climate change impact on agriculture productivity using the Ricardian method and five AOGCM experimental models. The model analysed the net revenue per hectare for four most important crops (rice, coconut, rubber, and tea) in the country. The study focused more on the precipitation effect on crop production due to the greater range of precipitation across the country although the limited range of temperature variation allowed only a simple test of temperature impacts in the study. Both the Ricardian method and five AOGCM experimental models showed that the effects of increase in precipitation are predicted to be beneficial to all crops tested and the benefit ranged from 11 % to 122 % of the current net revenue of the crops in the model.

Utilising a Co-integration model approach on time-series data from 1980 to 2000, Ayinde *et al.* (2011) estimated the effect of climate change on agricultural productivity in Nigeria. The study shows that negative climate change trend has negative effects on Nigerian agriculture. It revealed that heavy rainfall of the previous year could lead to erosion and leaching, while rainfall variability affects agric production, temperature variability seems not to have important effects on agricultural productivity in Nigeria economy. Gebreegziabher *et al.* (2011) examined the economic effect of climate change on agriculture productivity using a countrywide computable general equilibrium model. The study observed that the impact of overall climate change will be relatively benign until approximately 2030 and then worsens considerably. Further, the simulation results showed that, over a 50-year period, the projected reduction in agricultural productivity may lead to about thirty (30) percent less average income, compared with the possible outcome in the absence of climate change.

Fonta, Ichoku and Urama (2011) employed the Ricardian approach that captures farmer adaptations to varying environmental factors to analyze the impact of climate change (CC) on plantation agriculture in Nigeria. By collecting data from 280 farm households in seven different agro-ecological zones of Nigeria (Cross River, Abia, Edo, Ondo, Ekiti, Oyo and Ogun States), the quantity of crops produced over time and land value proxied by net revenue per hectares (NR), were regressed on climate, household and soil variables. The results suggest that these variables have a significant impact on the net crop revenue per hectare of farmlands under Nigerian conditions. Specifically, seasonal marginal impact analysis indicates that increasing temperature during summer and winter would significantly reduce crop net revenue per hectare whereas marginally increasing precipitation during spring would significantly increase net crop revenue per hectare.

Some other studies have equally been done to determine the effects of climate change on the production of some major food crops in some parts of the country. For instance, Henri-Ukoha et al. (2014) examined the effects of climate change in rice farmers in South East, Nigeria; Sanusi and Oladejo (2014) also looked at the impact of climate change on cocoa production in Nigeria while Akinbola and Imoudu (2014) studied the effect of climate change on cassava production in Ondo State, Nigeria. One common result reported in these studies is that climate change had adversely affected the production of these crops one way or the other prompting the need to take necessary measure to mitigate it effects.

Akinbobola, Adedokun and Nwosa (2015) probed the impact of climate change on the composition of agricultural output in Nigeria for the period 1981 to 2011. The Ordinary Least square (OLS) estimation technique revealed that with exception to fishery production, climate change had a significant and positive impact on the composition of agricultural output in Nigeria. Idumah, Mangodo, Ighodaro and Owombo (2016) investigated the impact of some of these climatic variables on food production in Nigeria from 1975 to 2010. The results of the Johansen co-integrated test revealed that there is one co-integrating equation at 5% showing a co-integrating relationship between agricultural output and the climatic variables. The Vector Error Correction Estimates indicated that rainfall was positively significant at 5% to food production on the short run indicating that vagaries in climate especially rainfall affected food production and output in Nigeria. Olayide, Tetteh and Popoola (2016) sought to investigate the differential impacts of rainfall and irrigation on agricultural production in Nigeria. Using time series data that spanned 43 years and econometric analytical technique, they quantified the differential impacts of rainfall and irrigation on aggregate production and sub-sectors (all crops, staples, livestock, fisheries and forestry). The study suggests that irrigation had positive and significant impact on aggregate agricultural production as well as all sub-sectors of agriculture.

3. Methodology

3.1. Theoretical Framework

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).

3.2. Model Specification

The fundamental and linear equation which forms the model is drawn from the theoretical and empirical literatures reviewed in the previous chapter. It is observed that there is a causal link between climate change and agricultural productivity in Nigerian economy. In this section, we pursue the same objectives further by specifying our model. The Ricardian approach adopted by Fonta et al (2011), but modified for time series estimation, will be used in this study to specify a multiple regression equation with Agricultural output as a function of amount of rainfall, emission and government expenditure on agriculture. Thus, the model is specified below:

AGRO = f (AMR, EMI, GEA) .... (1)

Where: AGRO = Total Agricultural output, AMR = Amount of rainfall, EMI = Emission of CO_2, GEA= Government expenditure on agriculture, f = Functional notation

Our model can be restated in econometric form as:

$AGRO_t = \beta_0 + \beta_1 AMR_t + \beta_2 EMI_t + \beta_3 GEA_t + \mu_t$ ....(2)

Model of equation (2) serves as a co-integrating model. It proves the stability of the long-run relationship when it is highly statistically significant (Bannerjee et al, 1998).

The general error correction model adopted for the study is specified as follows:

$\Delta AGRO_t = \alpha_0 + \alpha_1 \Delta AMR_t + \alpha_2 \Delta EMI_t + \alpha_3 \Delta GEA_t + \lambda ECM_{t-1} + \mu_t$ ....(3)

Where,

ECM = Error correction term; the residual that are obtained from the estimated co-integrating model of equation (2). It is the feedback and adjustment effects which indicated how much of the disequilibrium is being corrected. Δ = the first differenced form of the variables in the model. μ = error term

α_1, α_2, α_3, are the impact multiplier that measures the immediate impact that a change in the explanatory variables has on a change in the dependent variable. λ = the speed of the adjusted parameter. The value of the λ must be between the range $-1 \leq \lambda \leq 0$ and must be statistically significant.

With the specified equation, we intend to ascertain whether a short or long-run relationship exist between climate change and changes in agricultural productivity in Nigeria.

3.3. Model Justification and Evaluation

The Ricardian model 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. 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. In evaluation of this research work we shall employ some criteria such as the economic, statistical and econometrics criteria to analyse data for the period 1985 – 2019 to inform policy suggestions. Data on agricultural output and government expenditure on agriculture were collected from the central bank of Nigeria statistical bulletin 2019, while data on amount of rainfall and emission were collected from World Bank indicators database.

4. Result Presentation

4.1. Unit Root Test

The analytical techniques highlighted in the previous section are applied to the model of the study and the results are presented in this section. We begin with the result of the stationarity tests, since empirical analysis based on time series data would be biased if the underlying data are non-stationary. As earlier noted, the test used for observing the stationarity of the time series data used for analysis in this study is the Augmented Dickey-Fuller (ADF) test. The results are summarized in table 4.1 below.

Table 4.1. Summary of ADF unit test result

Variables	ADF statistics	Order of Integration	Remarks
D(LAGRO)	-4.083255	1(1)	Stationary at first difference.
D(AMR)	-5.551620	1(1)	Stationary at first difference.
D(EMI)	-6.430198	1(1)	Stationary at first difference.
D(LGEA)	-8.017613	1(1)	Stationary at first difference.

Source: *Researcher's compilation using E-view*

As seen in table 4.1 Total agricultural output, amount of rainfall, emission of CO_2 and government expenditure on agriculture are stationary at first difference. This however provides a necessary condition for estimating co-integration and error correction model.

4.2. Co-Integration Test

Having confirmed that the data are stationary, we then proceed to examine if the variables are co-integrated. The co-integration test is used to test for the existence or not of a long run relationship among the variables. The Johansen methodology is preferred to the Engle-Granger test because it is unbiased and allows for more co-integrating equation. Table 4.2 shows the co-integration result of our variables

Table 4.2: Summary of Johansen co-integration result

Hypothesized No. of CE (s)	Trace Statistics	0.05 Critical Value	Prob**
None*	40.32458	40.17493	0.0483
At most 1	16.98614	24.27569	0.3122
At most 2	4.999171	12.32090	0.5677
At most 3	1.219097	4.129906	0.3145

Source: Researcher's compilation using E-view

*denotes rejection of the hypothesis at the 0.05 level

As evidenced table 4.2, the result shows the existence of one co-integrating eqn(s) in the trace statistics at 5% level of significance, thereby suggesting that there is stable long-run relationship among the variables of the study. Thus the existence of a co-integrating relationship between a set of variables implies that an error correction model (ECM) exists. The significance of the error correction model (ECM) is an indication of the existence of a long run relationship between the dependent variable and the independent variable. Table 4.3 shows the estimate of the error correction model.

Table 4.3: Summary of the ECM Result: Dependent Variable-D (Lagro)

Variables	**Coefficient**	**Std. Error**	**t-statistic**	**Prob.**
C	-0.194279	0.029100	6.676135	0.0000
D(AMR)	0.065549	0.026163	2.619350	0.0421
D(EMI)	-5.796556	2.360218	-0.245594	0.8077
D(LGEA)	0.075286	0.009811	3.891063	0.0086
ECM (-1)	-0.129420	0.059993	-2.157269	0.0394
R^2 0.671463	F-Statistic 4.400368	Prob (f-stat) 0.002796	DW stat 1.842179	

Source: Researcher's compilation using E-view

Adjusted R^2 = 0.571826

From table 4.3, the value of the intercept is -0.194279 indicates total agricultural output will decrease by -0.194279 when all other variables are held constant. The estimate coefficient of amount of rainfall shows that a unit increase in amount of rainfall will subsequently increase total agricultural output by 0.065. In addition the estimate coefficient of emission of CO_2 is -5.79 indicating a negative relationship between emission of CO_2 and total agricultural output thus indicating that a unit change in the emission of CO_2 will decrease total agricultural output by -5.97. The coefficient of government expenditure on agriculture is 0.075 which indicates that a unit change in government expenditure on agriculture will increase the total agricultural output by 0.075. Finally the negative and statistically significant error correction model is an indication of a satisfactory speed of adjustment. It shows that about 12 percent of the errors are corrected each period.

4.2. Evaluation of Result

4.2.1. Economic A Priori Criteria

This shows the theorized relationship between the modeled regressors and regressand. It also serves as a basis for evaluating our estimated model to ensure conformity with economic theory. Table 4.4 below shows the a priori expectations for the variables in the model earlier specified.

Table 4.4: Apriori Expectations

VARIABLES	EXPECTED SIGN	OBTAINED SIGN	REMARKS
AMR	POSITIVE	POSITIVE	CONFORMS
EMI	NEGATIVE	NEGATIVE	CONFORMS
LGEA	POSITIVE	POSITIVE	CONFORMS

Source: Researcher's compilation (2016)

4.2.2. Statistical Criteria (First Order Test)

a. Coefficient of Determination (R^2)

The R-squared measures the overall goodness of fit of the entire regression. The values of the R-squared is 0.671463 approximately 67%, indicating that the independent variables accounts for about 67% of the variation of the dependent variable.

b. T-Statistics

This test is carried out mainly to check for the individual significance of the variables. Statistically, the t-test under consideration is interpreted based on the following statement of hypothesis:

H_0: The individual parameters are not significant
H_1: The individual parameters are significant

Decision Rule

At 5% level of significant, accept the null hypothesis if P-value > 0.05 otherwise reject the null hypothesis and accept the alternative hypothesis. The t-test is summarized in table 4.5 below:

Table 4.5: Summary of t-test

Variable (t-value)	P-value/ Decision rule	Remark
D(AMR) (2.619350)	0.0421<0.05	Significant
D(EMI) (-0.245594)	0.8077>0.05	Insignificant
D(LGEA) (3.891063)	0.0394<0.05	Significant

Source: Researcher's compilation (2016)

As shown in table 4.5; Amount of rainfall, government expenditure on agriculture is significant while emission of CO_2 is insignificant at 5% level of significant in the short run.

c. F-Statistics

The F-statistics is used to test for simultaneous significance of all the estimated parameters

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$

H_1: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$

Decision Rule

At 5% level of significance, accept the null hypothesis if P-value > 0.05, otherwise reject the null hypothesis and accept the alternative hypothesis. From our ECM result, the F-statistics is 4.400368 and the P-value is 0.002796 < 0.05. Hence, we reject the null hypothesis and accept the alternative hypothesis that our independent variables are simultaneously significant and the overall regression model is statistically significant.

4.2.3. Econometrics Criteria (Second Order Test)

a. Test for Autocorrelation

The Durbin-Watson test was used to test for autocorrelation with the following hypotheses:

H_0: There is no autocorrelation

H_1: There is autocorrelation

Decision Rule

Using the rule of thumb, at 5% level of significance, we accept the null hypothesis if the Durbin Watson statistics is approximately 2. From the result, the Durbin-Watson stat is 1.842179 Therefore there is no presence of autocorrelation in the model.

5. Policy Recommendations

This study examined the relationship between climate change and agricultural productivity in Nigeria from 1985 – 2019. The error correction model was used to test the impact of the subject of our interest. However, before applying the regression analysis, the stationarity of the various variables was stated using the Augmented Dickey Fuller test; Total agricultural output, emission of CO_2 and government expenditure on agriculture were stationary at first difference while amount of rainfall was stationary at level form. In addition the Johansen co-integration test was used to determine the presence or otherwise of a co-integrating vector in the variables. The trace statistics indicated only one co-integrating equations at 5 percent level of significance pointing to the fact that the variables have a long run relationship. More so, from our estimated results, amount of rainfall has a positive relationship but significant impact on total agricultural output; emission of CO_2 has negative relationship but insignificant impact on total agricultural output; and government expenditure on agriculture has a positive relationship and significant impact on total agricultural output.

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 proposes the following recommendations.

- 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.
- 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.
- Private organizations and NGOs should also be encouraged to sponsor radio jingles that create climate variation awareness, knowledge, and mitigating measures.
- Lastly, Farmers should equally be sensitized and trained in the area of adaptation and mitigation of the effect of climate change as this will go a long way to ameliorate large scale failure in food production in the country.

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