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Analysis of the Effect of Climate Change on Rice Production in Nigeria

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ABSTRACT

The Nigerian economy largely depends on agriculture which is vulnerable to unfavorable climatic conditions. Consequently, rice is a very important staple crop, widely cultivated and consumed by millions of people in the country. Nigerian government policy heavily protects rice to stimulate its local production. There is still scanty empirical evidence on the effect of climate change on rice production in Nigeria. This study was carried out to fill this gap. This study specifically examined the effect of climate change on rice output in Nigeria. This study utilized climate data (rainfall and temperature) from the Nigerian Meteorological Center, Carbon dioxide data from FAOSTAT, and information on the country's` milled rice from USDA (1970-2016). The analytical tools employed in the data analysis were Descriptive, Trend analysis, Unit root test, Co-integration and Regression model. The findings of the study revealed that there is variation in the trend of the climatic factors and also variation in rice output throughout the study. The result also shows that annual rainfall, and temperature contribute significantly to rice output in Nigeria. Rainfall had a positive coefficient and significant 5%, temperature had negative coefficient and significant at 1%. The area of land cultivated had positive coefficient and significant at 1%. The study concluded that climate change significantly influences rice output in Nigeria. The study recommended that consideration be given to climate change in the formulation of agricultural policies for the attainment of food security and national aspiration for sustainability in the production of rice production in Nigeria.

Keywords:
Effect; Climate Change; Rice Production; Nigeria

1. Introduction

The concern of climate change is increasingly now an issue among both scientists and policy makers since the early 1990s. Climate change through extreme temperature, erratic rainfall, water scarcity, land degradation, desertification, frequent flooding, drought and increased salinity of water supply used for irrigation has become a recurrent subject of debate globally, as well as in Nigeria (Ajetomobi *et al.*,2010). In similar vein, just like other developing countries, the challenge of climate change is enormous in Nigeria due to the widespread of poverty. Though climate change pose serious threat to other sectors of the economy, agricultural sector appears to be the worst hit. The sector is more sensitive to climate change. This is because the sector depends strongly on climate making it more vulnerable compared to other sectors (IPCC 1990, & Ajetomobi *et al.,*2010).

Furthermore, Climate change and agriculture are closely linked and interdependent. According to IPCC (1996), though increasing evidence suggests that developing countries are more likely to be susceptible to climate change than the developed, the vulnerability of Nigerian agricultural sector to climate change is of particular interest to policy makers because agriculture is a key sector of the economy accounting for between 60-70% of the labour force and contributing between 30-40% of the nation's GDP. The sector also supplies the source of raw materials used in several processing industries as well as a source of foreign exchange earnings to the country. Adedeji *et al.,*(2017), posit that the adverse effect of climate change will have great implications for food production and by extension food security particularly in Nigeria where smallholder farmers with low capacity to cope and adapt to these challenges dominate the sector.

Additionally, rice is the world most important staple food crop consumed by more than half of the world population as represented by over 4.8 billion people in 176 countries with over 2.89 billion people in Asia, over 150.3million people in America and over 40 million people in Africa (Bruntrup,2006 and IRRI, 2004). It has been an important food commodity for most people in Sub-Saharan Africa particularly West Africa where the consumption of cereals mainly Sorghum and Millet has decreased from 61% in the early 1970s to 49% in the early 1990s while that of rice has increased from 15-26% over the same period (Rosegrant *et al.,*2002). Further, Rice (Oryza sativa) is a major staple food for millions of people in West Africa and the fastest-growing commodity in Nigeria's food basket (Akande & Akpokodje, 2003). The demand for rice has been increasing at much faster rate in Nigeria, as well as it cultivation. In spite of this, self-sufficiency in rice production has eluded Nigeria for a long time despite over 36 years of efforts by the Government of Nigeria towards its realization (Umeh and Ataborh,2007). The government of Nigeria has therefore not relented in her effort to develop the rice sub-sector.

Subsequently, rice is a major cereal in Nigeria in terms of its output and land area. In Nigeria, rice grown on 1.77 million hectares ranks fifth after sorghum (4.0m ha), millet (3.5m ha.) cassava (2.0m ha) and yam (2.0m ha), but if placed on a social scale, it can well be ranked first because it is no longer just a mere festival meal as in the past, but the staple of most homes in urban, and rural area (Longtau, 2003). It is important to mention that, Nigerian farmers may have responded to the increased demand for rice. Nigeria currently doubles as the largest rice producing nation in West African sub-region and the second largest importer of rice in the world. This anomaly is attributed to the inability of its local production to meet up with its demand which has been soaring at a very fast rate over the years (Oyinbo et al., 2013). Despite successive government effort, Nigerian rice production remains insufficient to fill its demand. Increase in Rice production in Nigeria therefore has the capacity to help reduce drastically the foreign exchange spending on rice importation and more importantly help save the country`s economy from losing it`s hard earned currency on importation. Significant progress in rice production output has great implication for food security and poverty alleviation in Nigeria.

Recent research has shown that rice can be used to offset the major impacts of climate change because of its potentials and unique properties as a food crop for urban poor and rural rice-growing populations (Manneh *et. al.,* 2007). The need to analyse the effects of climate on rice production in Nigeria has become paramount because climatic factors in the form of rainfall and temperature are part of the major factors associated with it production. These factors are responsible for the drought, flooding, salt stress and extreme temperatures, all of which are expected to have a significant effect on rice output. Extreme changes in rainfall patterns and rise in temperatures will lead to unfavorable growing conditions. Conversely, the extent to which climate conditions could be held responsible for the changes in rice output in Nigeria, is still an emerging subject of empirical research. Ajetomobi *et al.* (2011), examined the impact of climate change on rice production in Nigeria using Ricardian model, the data used was merely a cross sectional data of one farming season. Adedeji et al. (2017), in a separate study examined the effect of climate change on rice production in Adamawa State, Nigeria. Ayinde et al. (2013) carried out an evaluation of the effects of climate change on rice production in Niger State, Nigeria. Both studies were carried out in a state each, hence, the result cannot be generalized for the entire country. Since climate change deals with long term change, time series data is expected to give better evidence of climate change on rice production in the Nigeria. That was the motivation for carrying out the study. The overall objective of this study was to examine the effects of climate change on rice production in Nigeria. A clear understanding of the effects of climate change on rice output in Nigeria forms a major issue that can guide policy formulation. Pertinently, such understanding is needed if the government efforts to achieving self-sufficiency in rice production would become a reality. This is because; the Nigerian governments have invested more to increase rice production than other cereals. The general objective of the study is to examine of the effects of climate change on rice production in Nigeria. The specific objectives of the study are to: examine the trend of climate change in the study area from 1970-2016, describe rice production trend in Nigeria; examine if there exist long-run relationships among the variables in the study area; and, analyse the effect of climate change on rice production in Nigeria.

2. Materials and Method

The annual data used for the study were sourced from the Nigerian Meteorological Agency, USDA, and FAOSTAT database. The series spans over four decades (1970-2016). The choice of the time lag was due to availability of data. The variables used in the model specified are rainfall, temperature, and carbon emission, area of land used for rice cultivation and Rice Output which is the dependent variable while Rainfall, Temperature, Carbon emission and area of land put to rice cultivation are the explanatory variables.

Rice output - Annual Rice output (MMT)

Rainfall – average annual rainfall was used for the variable (mm);

Temperature – average annual temperature (Degree Celsius);

Carbon emission – average annual carbon-emission (ppt);

Land area – average area of land put to rice cultivation annually (hectare);

2.1 Methodology

The study adopts Fully Modified Least Squares (FMOLS) regression model in order to examine the impact of climate change on rice output in Nigeria between 1970 and 2016. Rainfall, Temperature, Carbon emission and area of land put to rice cultivation in the country represents the study independent variables (X_i), while Rice output represents the dependent variable (Y_t). The data was analyzed using E-View 10.0 software package. The statistical analysis was conducted using t-statistics, unit root test, co-integration test and regression model. These tests are essential in testing the reliability of the parameter estimates.

2.2 Analytical Technique

Trend analysis of the climate variables in the study (temperature, rainfall and carbon dioxide) as well as the trend analysis of both milled rice output and area of land used for rice cultivation in Nigeria was also described through the graph to establish the trends of the variables. The study carried out unit root test using Augmented Dickey-Fuller (ADF) test, ADF F-ratio critical value was used to arrive at the decision on the unit root of the variables. Co-integration test was also carried to test for co-integration of the variables in the model. Fully-Modified least squares Co-integration regression was used to estimate the effects of climate change on rice output, to see how much of rice output is attributable to changes in the climate variables.

2.3 Model Specification

The regression model in implicit form is;

$Y = f(X_1, X_2, X_3, X_4 \text{ err.})$

The equation is better put as;

$$LY_t = \beta_O + \beta_1 LX_{1t} + \beta_2 LX_{2t} + \beta_3 LX_{3t} + \beta_4 LX_{4t} + U_t$$

Y_t = Rice output (MMT)

X_1 = Average annual Rainfall (mm)

X_2 = Average annual Temperature (^{O}C)

X_3 = Carbon emission (ppm),

X_4= Area of land used for rice cultivation (ha)

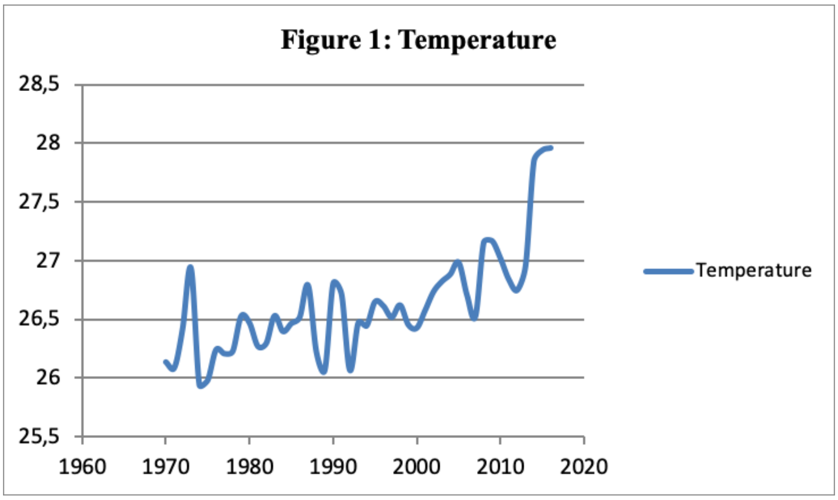
t = Years, $U_t = Error\ term$

3. Results and Discussion

3.1. Trend Analysis

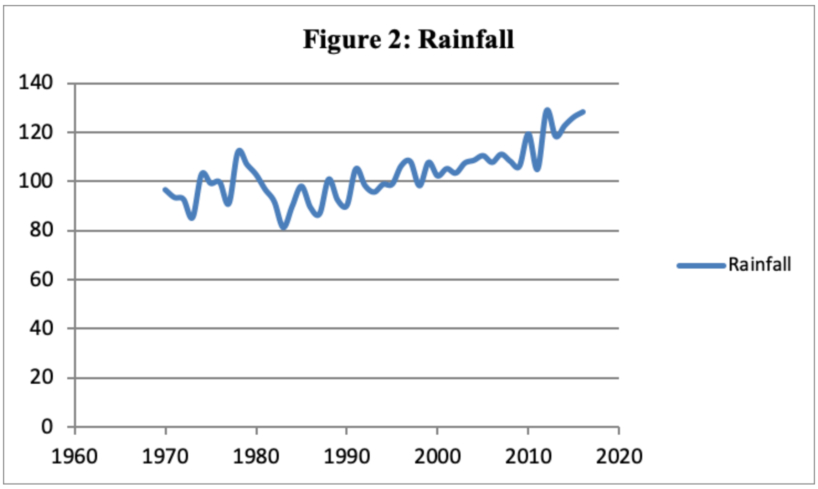
3.1.1 Temperature trend

To establish the temperature trend in the study area between 1970-2016. Time Series analysis was carried out using average air temperature (1970-2016) to determine the variations in temperature in Nigeria. Figure (1), shows a rising trend with highest trend in the year 2015 and lowest in 1974. The highest value of temperature recorded was 27.96^{o}C while the lowest value recorded was 25.94. The mean and standard deviation of temperature over the period of study from 1970-2016 are 26.62°C and 0.45°C respectively. The temperature rose steadily from 1970 until it attained a peak in the year 1973 (26.74°C), thereafter, temperature maintained a pattern of rise and fall (up and down) till 2012. Ever since, temperature had been on a rise.



3.1.2 Rainfall trend

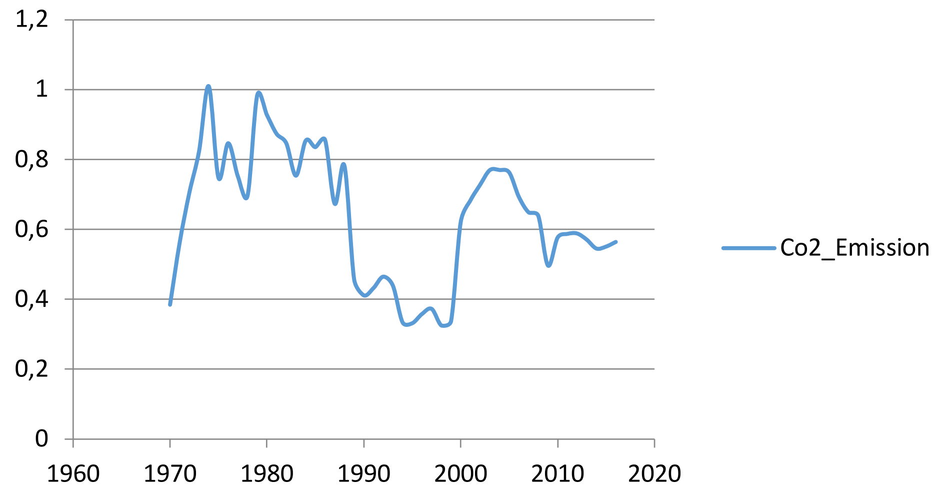
The trend analysis was used to determine the trend in average annual rainfall over the period of study in Nigeria. From figure (2), the statistical information of rainfall in Nigeria (1970-2016), shows a rising trend with highest trend in 2012 and lowest in 1983. The value of the highest rainfall was recorded as 128.93mm while the lowest recorded as 81.44mm. The mean and standard deviation of rainfall in the country over the period of study (1970-2016) are 103.05mm and 10.97mm respectively. The standard deviation shows that there is a large variability in rainfall. There was a sharp increase after 1974, 1978, and 2010 in the study area. The rise in rainfall peaked in 2012, followed by gradual decline in 2013. However, there appears to be a rise till 2016. Within this period there was fluctuation in rainfall pattern within the period.



3.1.3 Carbon emission trend

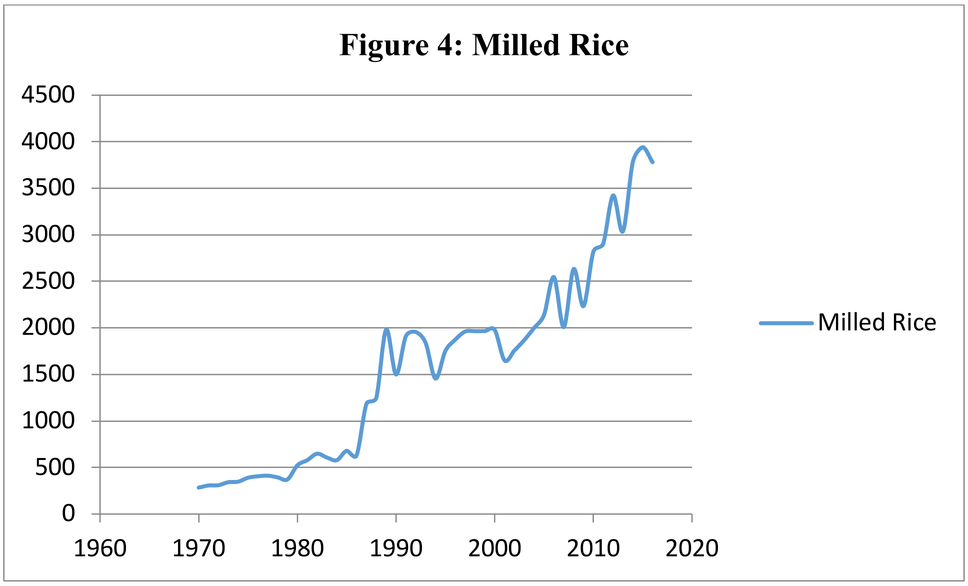
Figure (3), the trend analysis of carbon emission in Nigeria within 1970-2016 shows a fluctuating trend with the highest trend in the year 1974 and lowest in 1998. The highest value of Carbon Emission was 1.01ppm while the lowest recorded was 0.33 ppm. The result of the trend analysis for carbon emission in Nigeria shows an initial increase from the beginning of the period of study, after which the pattern became unstable. Carbon emission showed a dwindling pattern all through the period under study. The mean and standard deviation of Carbon emission in the country over the period of study from 1970-2016 are 0.64 ppm and 0.19 ppm respectively.

Figure 3: Co_2_Emission



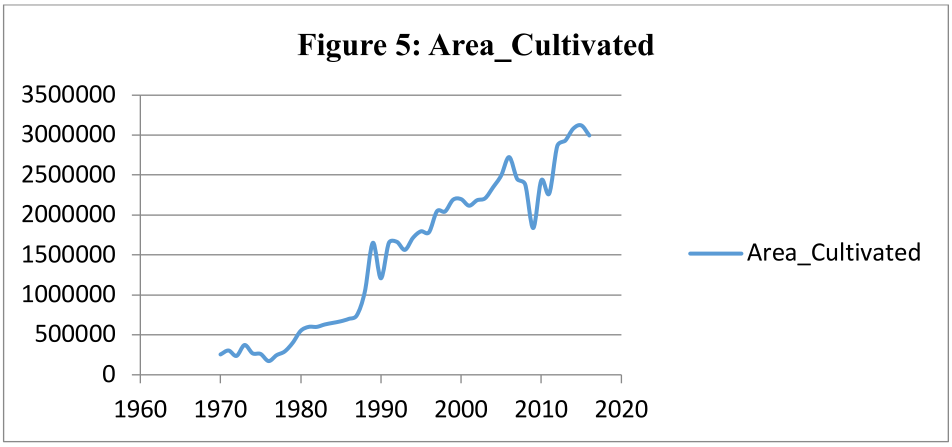
3.1.4. Milled Rice trend

Figure 4 indicates that there is an increase in the rice output steadily from 1970 until it reached an initial peak in the year 1989. The steady increase could be as a result of sustained government policy on the need to become self-sufficient in rice production in the country. Rice production after the peak in 1989, declined in 1990. There appeared to be an increase in milled rice output in Nigeria from 1991, this could again be as a result of government policy. Rice production output increased steadily from 2016 till date. In general, though rice output recorded a fluctuating trend, the pattern indicated increase in rice production in the country. The observed fluctuation in the pattern of rice production in Nigeria over four decade was largely due to the instability in government policy in the subsector (Umeh and Ataborh, undated). Thus rice fields in Nigeria are bound to contract with attendant income, employment, foreign trade and food self-sufficiency implications.



3.1.5. Land area used for rice cultivation

Figure 5 shows the area of land put to the production of rice in Nigeria increased steadily over the period of Study (1970-2016). The area of land put to rice production moved slowly from 1970 till about 1976. The area of land increased steadily from 1977 to 1987, thereafter, the area of land rose steadily until it peaked at 1989. The area of land cultivated for rice production dropped till 1990. Ever since the area of land put to rice production had been on increase except for 2008 and 2009 which indicated decline. This must have been due to sustained government policy in this direction.



3.2 Other empirical results

3.2.1 Unit Root Test

The unit root test indicates whether the included variables are stationary. The result of the Augmented Dickey-Fuller Test is contained in (3.2.1). The above table shows the stationarity test using Augmented Dickey Fuller unit root test, it reveals that all the data are stationery at first difference. The stationarity was determined at 5% level of significance. Milled rice quantity, which is used as the measure of rice output contains unit root at first difference. Also, the first difference is stationary even at the 95 per cent confidence level for Area of land used for rice cultivation, rainfall, temperature and

Carbon emission. The tests were conducted using the Augmented Dickey-Fuller estimates.

Table 1. Augmented Dickey Fulley (ADF) unit root test

Variables	ADF Statistics	Critical Value at 5%	Order of Integration	probability	Decision
Area Cultivated	-4.877627	-2.935001	I(1)	0.0003	
Co_2 Emission	-7.633533	-2.928142	I(1)	0.0000	Stationary
Milled Rice	-11.91034	-2.928142	I(1)	0.0000	Stationary
Rainfall	-7.527793	-2.929734	I(1)	0.0000	Stationary
Temperature	-8.106992	-2.929734	I(1)	0.0000	Stationary

Source: Authors Compilation 2020, E-views 10.

Co-integration Using Trace Statistic

3.2.2 The Cointegration test results

Table 2 presents the co-integration test for the variables in the models to verify if there exists a long run relationships among the variables. The test states a null hypothesis that no long run relationship exist among the variables. The result indicates no co-integration at the 0.05 level, the null hypothesis for the study was rejected at the 0.05 level. A Conclusion was then reached that there exist no long run relationship among the variables.

Table 2. Co-integration results for rice output

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Engel value	Trace Statistic	0.05 Critical Value	Prob.**
None	0.547233	68.19124	69.81889	0.0669
At most 1	0.330894	32.53426	47.85613	0.5826
At most 2	0.151321	14.45268	29.79707	0.8143
At most 3	0.100130	7.069314	15.49471	0.5696
At most 4	0.050283	2.321592	3.841466	0.1276

Source: Computation from E-views 10

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Engel value	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.547233	35.65698	33.87687	0.0304
At most 1	0.330894	18.08158	27.58434	0.4884
At most 2	0.151321	7.383364	21.13162	0.9373
At most 3	0.100130	4.747722	14.26460	0.7733
At most 4	0.050283	2.321592	3.841466	0.1276

Source: Authors computation

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis p-values

3.2. Fully Modified Least Squares (FMOLS)

This section presents the regression analysis explaining the effect of climate change on rice produ The Fully-Modified Least Squares regression was used to estimate the parameters of the models. technique was used because of the behavior of the variables which were all integrated at order o reported R-squared of the model shows that the model explains about 93.8% of the variations in variables contribution to rice output in Nigeria. The Durbin-Watson statistics illustrate (1.01) the correlation. Consequently, the interpretation of the results of the regression indicates that 5% inc will result in 1% increase in rice output in Nigeria. The regression estimate indicates that 1% incr temperature results in 2% decrease in rice output in Nigeria. The result further shows that 1% in land cultivated will result in less than 1% (0.7) increases in rice output in Nigeria. The result of th consistent with the findings from a study carried out by Ayinde *et al.,*(2013), where rainfall had p on rice output. The result of the study was however, inconsistent with the earlier mentioned stud

Table 3. Regression Result for Effect of Climate Change on Rice Production

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Rainfall	1.048913	0.393102	2.668296	0.0108
Temperature	-2.711577	0.481497	-5.631554	0.0000
Co2_Emission	-0.151297	0.120005	-1.260757	0.2144
Area Cultivated	0.795003	0.052145	15.24591	0.0000
R-squared	0.938639	Mean dependent var		7.126269
Adjusted R-squared	0.934256	S.D. dependent var		0.802180
S.E. of regression	0.205684	Sum squared resid		1.776845
Durbin-Watson stat	1.010109	Long-run variance		0.044989

temperature had positive relationship with rice output. However, the study was carried out in Niger State but not on the entire country.

4. Conclusion

This paper set out to assess the effect of effect of climate change on rice production in Nigeria. The study was carried out with a view to providing a clear understanding between climate change and rice production in the country. The empirical results from this study provide empirical evidence that climate change is significant to rice production in Nigeria. Based on the findings of the study, we established increasing temperature, dwindling rainfall and carbon emission pattern throughout the period under study in the country. The study also showed that rainfall and temperature has significant effect on rice production in the country, following the statistical significance of the variables. Hence, the study concluded that climate change significantly influenced rice production in Nigeria. Of crucial importance here will be the need to broaden the policy thinking, at all levels, to consider options that can help maximize the benefits of climate change to enhance the local production of rice in the country. Also important will be the measures to take to help cushion the effect of the negative effects of climate change so as to reduce its harmful effects on rice production in the country.

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