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Effect of Extreme Weather on Rice Production in Nigeria (1991-2012)

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This study was carried out to determine the effect of extreme weather on rice yield in Nigeria "Between" (1991-2012). Data for climate was collected from Nigeria meteorological agency (NIMET) while data for yield was collected from Agricultural development agency (ADP). The relationship between rice yield and weather variables in Nigeria were examined using Production function. Cobb Douglas function was used because it incorporates climate variables and any of the approaches reviewed in the literature. The results showed that increase in rice yield is subject to rainfall and temperature change in Nigeria which is; increase in temperature with decrease in rainfall decreases rice yield while decrease in temperature and increase in rainfall increase rice yield in Nigeria. Temperature and rain95 are negatively significant to rice production while Growing Degree Days (GDD) is positively significant to rice in yield in Nigeria. Emphasis should be made on the use of irrigation to boost rice production in Nigeria

Keywords: Productivity, Unit-Root, Rainfall, Time-Series, Production, Bayesian

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INTRODUCTION

Extreme climate or weather event is defined as “the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable” (IPCC, 2012). But what is called an extreme weather or climate event will vary from place to place in an absolute sense (e.g. a hot day in the tropics will be a different temperature than a hot day in the mid-latitudes).

According to Powell and Reinhard (2016), weather, whether in terms of averages or events, is an important determinant of yields and extreme weather events are expected to increase worldwide. Swaminathan and Rengalakshmi (2016) also assert that extreme weather events have significant impact on agriculture and food security which is the main source of income to a large section of the rural populations. Pena and Hughes (2007) in their assessment of the impact of climate change on tropical agriculture also concluded that a significant change in climate on a global scale will impact agriculture and consequently affect the world's food supply.

Weather variability if not properly handled is one of the several factors that are likely to affect global food production. According to Dersa et al ,we cannot over emphasize the correlation between weather variability and its effects in the agricultural sector of the Nigerian economy especially on rice production. In agriculture, productivity is based on the presence of some weather variability which must be present in adequate amount. The limitation or excess of these basic factors will adversely affect our crop production.

The intergovernmental panel on climate change (IPCC, 2007) predicts that by 2100, the increase in global average surface temperature may be between 18°C and 24°C with increase of 1.5°C to 2.5°C with approximately 20 to 30 percent of plant and animal species are expected to be at the risk of extinction with severe consequences for food security in developed countries.

Weather events have observed to be rare while some extreme weather events have actually been attributed to human induced global warming. According to IPCC (2011) estimates of annual losses have ranged since 1980 from a few billion to above 200 billion USD in 2010 with the highest value for 2005 (the year of Hurrican Katrina). Heat waves can often have severe effects upon the landscape, causing famine, destruction of vegetation, and possible deaths of livestock and wildlife. A cold wave can cause death and injury to livestock and wildlife. Cold-waves that bring unexpected freezes and frosts during the growing season in mid-latitude zone can kill plants during the early and most vulnerable stages of growth. This results in crop failure as plants are killed before they can be harvested economically. Such cold waves have caused famines. Cold waves can also cause soil particles to harden and freeze, making it harder for plants and vegetation to grow within these areas.

The latest IPCC report, confirming previous findings, attaches high confidence to the probability that extreme weather events will reduce food production (Porter *et al*, 2014). Extreme events are expected to effect the volatility of yields and are seen as the principle immediate threat to global crop production (Meehl etal.,2000; Lobell et al.,2013).

The form, frequency and increasing intensity of extreme events like drought, heat waves or floods are largely attributed to changes happening in earth's climate. As indicated earlier, the socio- economic cost due to extreme events is increasing sharply and it has been notably high in the last decade of the twentieth century.

Rice has become a structural component of Nigerian diet with share of rice in cereals consumption increasing from 15% in 1970s to 26% in the early 1990s (Akpokodje *et al*, 2001). The growth of rice in Nigeria as a developing country is faced with the challenge of climate change and global warming due to increase rate of poverty, erosionand burning of firewood and farm residues. Rice is cultivated virtually in all the agro ecologicalzones in Nigeria. About 90% of rice produced in Nigeria is grown by the average subsistence farmer while the remaining 10% is cultivated under improved production methods scale and other farmers (Filani 1982). Change in weather through adverse temperature, drought, salinity and frequent flooding has become a subject of debate globally. Rice is grown in more than 70% of the states in Nigeria, despite of the availability of good land for cultivation. Presently in Nigeria the demand for rice is about 5 million metric tonnes which is more than double the quantity produced (2.2 metric tones). Hence Over 5 million tonnes annually are imported in Nigeria which is equivalent to $US 800 million in scarce foreign exchange. Nigeria is the second largest importer of rice in the world, owing to the fact that she has not been able to produce enough quantity and quality required by her citizens to compete with those ones imported from exporting countries like China and Thailand.

The growing incidence and severity of droughts, floods, hailstorms and other extreme weather events severely affect the livelihood options for small-scale farmers therefore, anticipating and calculating their effects on crop outputs is important for topics ranging from food security to the economic viability of biomass products.

METHODOLOGY

Study Area and its Climatic Structure

The study is carried out in Nigeria. She shares borders with the republic of Benin in the west, Chad and Cameroon in the east and Niger in the North, its coast lies on the gulf of Guinea in the south and it borders Lake Chad to the northwest. Nigeria stands between southern Coast of West Africa with longitude of 2° and 15°E, and 5° and 15° N latitude.

Nigeria weather varies from a fairly wet coastal area with annual rainfall greater than 3500M to the Sahel region in the north western and north eastern regions with annual rainfall less than 600MM (Ajetomobi 2010). The country's mean maximum temperature ranges from 30°C and 32°C and 36°C and 38°C in the south and north respectively. Although, mean minimum temperature is between 20°C and 22°C and below 13°C in the north and south. Nigeria has a mean temperature between 27°C and 29°C. Surface water resources total about 193 billion cubic meters based on annual flow of Nigerian rivers and streams. It is estimated that about 95% of surface water in the Northern states can be controlled 1.4 million hectares are presently under irrigation, most of which are the northern states of Nigeria (Fabiyi et al, 2011).

Nigeria is found in the tropics, where the weather is seasonally damp and very humid. She is affected by four weather types; these weather types are distinguishable as one move from the southern part of Nigeria to the northern part of Nigeria through Nigeria's middle belt. This study was carried out using secondary collected from the 34 major rice- producing states in the country and the Federal Capital Territory (FCT). These are; Kano, Kwara, Edo, Taraba, Niger, Benue, Yobe, Kaduna, Anambra, Zamfara, Jigawa, Borno, Adamawa, Ondo, Ogun, cross River, Ekiti, Ebonyi, Kebbi, Abia, AkwaIbiom, Edo,Enugu, Imo, Lagos, Osun, Bauchi, FCT, Gombe, Katsina, Nasarawa, Plateau, Sokoto and Kogi state.

Data Description and Sources

Data for the study are secondary data (time series data) which covers a period of 21 years (1991-2012). The secondary data used consist of two parts. The yield data which are obtained from the official records of each state Agricultural Development Programme. The data are available for all states in the country from 1991 to 2012. This is because about half of the states in the country were created in 1991. The other data set is the climate data from National Meteorological Agency in Lagos Nigeria for all the 32 weather stations across all the states in the country. The data consist of daily observations of maximum temperature (Tmax), minimum temperature (Tmin), and precipitation from January 1, 1981 to December 31, 2012.

Analytical Techniques

Panel Unit root-test

It is often assumed in many production models that the variables used are stationary. However, deterministic and stochastic trends in variables can introduce spurious correlations between the variables, because the errors in the data-generating-processes for different series might not be independent (Granger and Newbold, 1974). In order to avoid these problems, the first thing we need to do is to test for stationarity of the variables. Non-stationary variables can be differenced once and retested. If the differenced versions are stationary, the variables are said to be integrated of order one or I(1). If they are Stationary at levels, then the time series are integrated of order zero or I(0). Regressions on stationary variables may satisfy ideal conditions, and inferences on a deterministic time trend can be made safely. Im et.al (1997) panel unit root test was adopted in this study in this study. We applied the test to each variable, taking the whole panel at once. This particular approach show that the test has a better finite sample performance than other approaches. The test is valid when region regressions are serially uncorrelated and normally and independently distributed across regions. As long as the number of regions is large relative to the number of time period, the test statistic is normally distributed.
The test is briefly demonstrated with the equation below. If we have that the yield or weather variable is a stochastic first order auto regressive process for region i in time t,

$$\Delta Y_{it} = \alpha_i + \rho_i Y_{i,t-1} + \varepsilon_{it} \quad i = 1, \ldots, N;\ t = 1, \ldots, T; \qquad (1)$$

Where ΔY_{it} and ε_{it} are independently and identically distributed across region i and time t. The null hypothesis of a unit root in (1) is tested as

Ho: $\rho_i = 0$ for all *i.*
The unit roots and MLE models were estimated for rice in Nigeria. Since the specified production function is the linearized Cobb-Douglass function, the coefficient estimates showed the elasticities of rice yield in Nigeria with respect to the respective input factors.

Model Specification

In order to examine the effects of weather extremes on rice yield in Nigeria, this study adopted the Robertson (2012) techniques. The researcher provides a detailed review of partial equilibrium modeling of the short term and localized effect of climate. Robertson (2012) uses the production model to capture the marginal impact of temperatures modeled in three ways, namely, monthly average, GDD and SR. This study adopted the GDD method. In Robertson (2012), the general model which takes the form shown in equation (2), where the natural log of yields, y, for crop i in year t, is a function of temperature (TEMP) in ºC, total seasonal rainfall in mm (RAIN), a vector of district dummies, D,(which are the rice-producing-states in this case) and a time trend, T. The climate variables and the district dummies are vectors.

$$\ln Y_{it} = \ln \alpha_i + \beta_{ikt} \ln TEMP_{kt} + \gamma_{it} RAIN_{it} + \delta_{ij} D_j + \theta T_i + \ldots$$

She hypothesized that temperatures in the mid-30s (ºCelsius) have a different marginal impact than temperatures in the mid-20s (º Celsius).

At present, little empirical evidence exists on crop yield variation in response to the alterations in climatic conditions in sub-Sahara Africa. Further, none of the previous studies assess the effects of the major climatic factors (temperature and precipitation) on mean and variance of crop yield in Nigerian states despite regular newspapers' reports of weather-based disasters affecting crop yields.

Variable Measurement

Extreme Temperature

In this paper, heat index is used as the indicator of extreme temperature. The heat index is defined as the number of days per month with maximum temperature exceeding a certain threshold T^*, e.g. $T_{max} > T^*$ while heat-wave is defined as a continuous period (2 days or more) with daily maximum temperature exceeding 30°C.

For this study, all the approaches will be tried to find out which one explain changes in crop yield in Nigeria.

Extreme Precipitation

Precipitation (P) was measured as the accumulated total over the crop growing season, measured in centimeters. To compute extreme events for precipitation the number of days which have 95-percentiles of the daily precipitation was used.

Growing Degree Days

A derivative of extreme temperature commonly used by agronomists to measure the number of heat units crops are exposed to during growing seasons is Growing Degree Days (GDD). The traditional way to calculate GDD is to measure the difference between mean daily temperature and a predetermined threshold (Robertson, 2012). If T_h is maximum temperature, T_i minimum temperature, T_b a given baseline temperature (usually between 8 and 10°C) and Tm a given upper bound (typically 30-32°C), then, over all days, growing degree days can be calculated as

$$GDD = \left\{ \frac{T_h + T_i}{2}, T_m \right\} - T_b \quad \text{......................} \quad (3)$$

In this study, the baseline was assumed to be 10°C while the upper bound of 32°C was chosen. The use of mean daily temperature alone does not consider the fluctuation between daily maximum and minimum temperature. For example, 35 and 25 degrees have the same mean temperature (30 degrees) as 40 and 20 degrees, which is within the optimal temperature range (Lee, 2011). This study Follows Robert et. al (2012) in order to account for harmful growing degree days (HDD). In defining HDD, the lower bound is assumed to be 29°C and no upper bound. In multiple regression analysis, GDD is expected to influence yield positively while coefficient of HDD is expected to be negative.

Analytical Techniques

The data was analyzed using Cobb Douglas model using econometrics estimation of approach. This approach is similar because they both incorporate temperature variables any of the approaches reviewed in the literature. Weather is an explanatory variable if the impacts of weather variability are to be captured ideally. The approach should capture the marginal impacts of temperature at high level.

The method of analysis of data in this work is production function. In this production functions yields is a function of weather. This analyzes the effect of exposure to dry season temperature on crop yields. The model takes the form of natural log of yields, Y , for rice in year t, is a function of temperature (TEMP) in C, total seasonal rainfall in mm (RAIN), a vector of district dummies, D and a time trend, T.

RESULTS AND DISCUSSION

This section consists of the results and findings of the work which includes the relationship between weather and rice production in Nigeria, the result of the analysis and the test of the hypothesis.

Descriptive Statistics

In other to estimate the impacts of extreme weather variables on rice yield in Nigeria. Pooled time-series cross-sectional data are collected. The rice yield data includes time-series average yields of rice in each state. The data on precipitation and temperature are obtained from Nigeria Meteorological Agency (NIMET) day to day activities. Temperature data contains daily minimum and maximum outcome over the growing season of rice. The basic summary for descriptive statistics of the dataset for relevant variables used in the estimation of the statistical model of this study over the period of 1991 to 2012 for the 34 states producing rice in Nigeria is presented in the tables below.

Summary of statistics yield, GDD and rain95 of rice varieties in the Southern Nigeria

From Table 1, the production of rice in south has maximum and minimum yield of 4.979 tons/ha and 0.620 tons/ha which is recorded for Delta and Imo states respectively. Delta experienced GDD of 16.818 and rain95 of 12.272. Maximum rainfall for Delta state is 12.272. Delta state is situated in the south- south of Nigeria, which is a rain forest zon. The high rate of rainfall and Growing degree days (GDD) of rice in Delta state may be responsible for the high yield of rice in the state since rice requires adequate rainfall for proper growth. On the other hand Imo state had the lowest yield of rice in Nigeria. Imo state has GDD level of 18.022 as obtained in our result with maximum rainfall of 7.318. Imo state has high level of GDD but very low level of rain95. This may be considered as the reason behind its low yield of rice. This result from the south - south region of Nigeria, it may be concluded that rainfall affects rice yield in Nigeria. This suggest that since rainfall level may not be predicted or even when predicted may not be sufficient in achieving maximum rice yield in all the states in the country, I will recommend that we can employ irrigation method of fanning to improve rice production in all the states in Nigeria that has high GDD of rice production.

Summary of statistics yield, GDD and rain95 of rice varieties in Northern Nigeria

In Table 2, the production of rice in north has maximum and minimum yield *of 2.224* and 0.95tons/ha is recorded for Kaduna and Sokoto states respectively, kaduna state experienced

GDD of 17.5 and rain95 of 12.181. Maximum rainfall for Kaduna state is 12.181. Kaduna stateis situated in the northern part of Nigeria, which is a sudan savannah with average temperature level and high rainfall level. There is a high GDD level and high rain95 level in Kaduna state of Nigeria which can support the growth of rice in the state. On the other hand Sokoto state had the lowest yield of rice in the northern states of Nigeria 0.950. Sokoto state has GDD level of 17.955 as obtained in our result with rain95 level of 8.818. Sokoto state has high level of GDD but very low level of rain95. This may be considered as the reason behind its low yield of rice. From this result gotten from the northern part of Nigeria, it may be concluded that rainfall affects rice yield in Nigeria. This suggest that since rainfall level may not be predicted or even when predicted may not be sufficient in achieving maximum rice yield in all the states in the country, I will recommend that we employ irrigation method of farming to improve rice production in all the states in Nigeria that has high growing degree days of rice.

Yield Index

Table 3 showed that Delta state has the highest yield of rice (Mean= 4.979) among all the state in Nigeria. It has maximum and minimum yield of 17.083 and 0.837. The high yield of rice experienced in Delta state may be probably due to high rainfall that normally characterized the state (Delta) which is located in the rain forest zone of Nigeria which seems to favour rice production since rice requires adequate rainfall to grow properly and produce high yield. The growth and the high yield of rice in the state could also be attributed to favourable annual temperature that support the growth of most commonly consumed crops in Nigeria especially the cash crops like cocoa, kolanut, palm tree, and rubber production. However, the result also revealed that Imo state has the lowest (Mean= 0.621) yield of rice. Imo state has lowest rice yield, this may be due to the extreme rainfall and temperature that seem to be more hazardous to the growth of most crops and even livestock production. The heavy rainfall often times leads togreat loss in crop production as large acres of land are often been washed away by heavy erosiondue to excessive rainfall. The average rice yield in Nigeria was found to stands at about 1.942tons/ha which implies that for most states in Nigeria, yield of rice could be assumed to be very low as this yield cannot be depended upon and this therefore call for importation of rice from abroad to supplement the local production in order to meet the demand of the consumers in most states of the federation.

GDD Index

Table 4 showed the descriptive analysis on GDD office in Nigeria. It showed that Lagos state has the highest growing degree days (GDD) of 19.886 with maximum of 12 and minimum of 17 GDD in rice production in Nigeria. The high GDD of rice experienced in Lagos state may be probably due to high rainfall that normally characterized the state (Lagos) which is located in the rain forest zone of Nigeria which seems to favour rice growth on daily basis since rice requires adequate rainfall to grow properly and produce high yield. The growth and the high GDD of rice in the state could also be as a result of low temperature condition experienced in the state (lagos). In like manner, the result also revealed that Benue state has the lowest (Mean= 14.863) GDD of rice. Benue state has lowest rice GDD, this may be due to the low rainfall and very high temperature that seem to be more hazardous to the growth of rice in the Nigeria. The high temperature most times act as a limiting factor to crop production as most of the basic nutrient and organism that are essential to the growth of crop is often killed by the intensity of the heat and the inability of crops to get the required moisture for growth affects the growing t degree days in Benue state of Nigeria. The average rice GDD in Nigeria was found to stands at about 16.924 which implies that most states in Nigeria GDD of rice could be assumed to be on the average but because the population of Nigeria is not on the average but very high it therefore imply that the production of rice in Nigeria on daily basis may not satisfy the requirement of rice by the masses it is then necessary that other method be used to provide for the rice requirement of the citizens of Nigeria.

Rain 95 Index

Table 5 showed the summary of descriptive analysis of rain95. Table 5 showed that Kano state has the highest rain95 of rice (Mean= 20.681) among all the states in Nigeria. It has maximum and minimum rain95 of 47 and 10 respectively. However, Adamawa state has the lowest

Table 1: Summary of statistics yield, GDD and rain95 of rice varieties in the south

State	Yield	GDD	Rain95
Abia	1.886 (0.470)	19.568	9.772 (4.196)
Akwa Ibom	3.295 (2.244)	18.659	5.318 (4.705)
Anambra	2.275 (0.173)	18.113	10.409 (5.828)
Cross River	1.414 (0.451)	16.772	15.455 (3.972)
Delta	4.979 (4.253)	16.818	12.272 (4.671)
Ebonyi	2.467 (0.458)	15.818	12.181 (4.656)
Edo	2.691 (0.170)	16.136	11.772 (4.058)
Ekiti	2.283 (0.310)	16.022	5.590 (3.787)
Enugu	3.128 (0.870)	16.022	7.318 (5.240)
Imo	0.620 (0.271)	18.022	12.090 (4.406)
Lagos	1.734 (0.339)	19.886	5.772 (4.618)
Ogun	1.395 (0.564)	19.863	6.011 (4.730)
Ondo	2.332 (0.498)	18.454	5.590 (3.787)
Osun	1.374 (0.445)	17.386	5.455 (3.390)

Source: Data Analysis, 2017

Table 2 Summary statistics yield and climate of rice north varieties

State	Yield	GDD	Rain95
Adamawa	1.581 (0.565)	15.977	8.636 (3.331)
Bauchi	1.596 (0.454)	15.681	13.818 (3.594)
Benue	2.058 (0.172)	14.863	13.046 (3.258)
Borno	1.178 (0.479)	15.590	10.590 (3.172)
Fct	1.073 (0.498)	16.477	11.181 (3.390)
Gombe	2.224 (0.166)	16.204	8.636 (3.331)
Jigawa	1.156 (0.356)	18.045	7.272 (2.640)
Kaduna	2.685 (1.230)	17.500	12.181 (4.737)
Kano	1.608 (0.432)	17.136	18.818 (10.192)
Katsina	1.388 (0.621)	16.795	10.546 (8.517)
Kebbi	1.712 (0.537)	15.115	9.363 (3.659)
Kogi	2.023 (0.323)	5.431	12.500 (5.910)
Kwara	2.447 (0.789)	5.590	11.955 (3.709)
Nassarawa	2.030 (0.361)	16.431	11.181 (3.390)
Niger	1.665 (0.702)	16.909	13.136 (3.059)
Plateau	2.547 (1.017)	17.386	10.500 (3.173)
Sokoto	0.950 (0.372)	17.954	8.818 (3.935)
Taraba	2.065 (0.318)	16.454	7.272 (2.640)
Yobe	1.087 (0.491)	15.977	7.272 (2.640)
Zamfara	1.091 (0.291)	15.840	10.272 (4.949)

Source: Data Analysis, 2017

Table 3: Summary of descriptive analysis of yield of rice in Nigeria

State	Mean	Max	Min	Sd
Abia	1.886	2.841	0.983	0.470
Adamawa	1.580	2.221	0.180	0.564
Akwa Ibom	3.295	10.379	1.667	2.244
Anambra	2.275	2.599	1.971	0.173
Bauchi	1.596	2.333	0.801	0.454
Benue	2.058	2.522	1.838	0.171
Borno	1.178	1.832	0.461	0.479
Cross River	1.414	2.212	0.821	0.451
Delta	4.979	17.083	0.837	4.253
Ebonyi	2.467	2.895	1.612	0.458
Edo	2.691	2.898	2.303	0.170
Ekiti	2.283	2.858	1.901	0.309
Enugu	3.128	5.134	2.302	0.870
F.C.T.	1.072	1.975	0.235	0.497
GOMBE	2.224	2.617	1.795	0.165
Imo	0.620	1.169	0.251	0.270
Jigawa	1.156	2.151	0.812	0.356
Kaduna	2.679	6.815	1.514	1.299
Kano	1.608	2.160	0.685	0.432
Katsina	1.388	3.512	0.751	0.621
Kebbi	1.712	2.994	0.675	0.536
Kogi	2.022	2.500	1.147	0.323
Kwara	2.446	3.575	0.808	0.784
Lagos	1.734	2.122	1.112	0.339
Nassarawa	2.030	2.535	1.186	0.361
Niger	1.665	2.864	0.693	0.702
Ogun	1.395	2.798	1.176	0.564
Ondo	2.332	3.560	1.761	0.497
Osun	1.374	2.687	0.725	0.445
Plateau	2.547	5.499	1.014	1.017
Sokoto	0.949	1.609	0.459	0.372
Taraba	2.065	2.652	1.512	0.318
Yobe	1.087	1.806	0.347	0.491
Zamfara	1.091	1.712	0.877	0.291
Total	1.942406	17.083	0.18	1.257

Data Analysis, 2017

Table 4: Summary of Descriptive Analysis on GDD of Rice in Nigeria

State	Mean	Max	Min	Sd
Abia	19.568	21	16.5	1.167
Adamawa	15.977	18	13.5	1.040
Akwa Ibom	18.659	20	16	0.943
Anambra	18.113	20	14.5	1.153
Bauchi	15.681	16.5	14	0.627
Benue	14.863	15.5	14	0.467
Borno	15.590	16.5	14	0.781
Cross River	16.772	18.5	14.5	0.984
Delta	16.818	18.5	14	1.097

Table 4: Continues

Ebonyi	15.818	17.5	14.5	0.994
Edo	16.136	18	14.5	1.114
Ekiti	16.045	18	14.5	1.022
Enugu	16.022	18	14	1.199
F.C.T.	16.477	18.5	14.5	1.051
Gombe	16.204	17.5	14.5	0.868
Imo	18.022	21.5	14.5	2.259
Jigawa	18.045	20	13.5	1.580
Kaduna	17.795	19.5	13.5	1.250
Kano	17.136	19	14.5	1.346
Katsina	16.795	20.5	13	1.875
Kebbi	15.113	17.5	11	1.639
Kogi	15.431	17.5	13	1.217
Kwara	15.590	18	14	1.064
Lagos	19.886	21	17	1.317
Nassarawa	16.431	18	14.5	0.876
Niger	16.909	18.5	16	0.750
Ogun	19.863	22	17.5	1.135
Ondo	18.454	20.5	15.5	1.184
Osun	17.386	19	15	1.422
Plateau	17.568	18.5	17	0.470
Sokoto	17.954	20	15.5	1.396
Taraba	16.454	18	14.5	1.111
Yobe	15.977	17.5	14.5	0.931
Zamfara	15.840	17.5	12.5	1.050
Total	16.923	22	11	1.750

Source: Data Analysis, 2017

Table 5: Summary of Descriptive Analysis on Rain95 of Rice Production

State	Mean	Max	Min	Standard dev.
Asia	*13.121*	27	2	5.435
Adamawa	5.954	10	1	2.458
Akwa Ibom	13.545	29	5	7.242
Anambra	13.5	27	3	7.229
Bauchi	13.818	19	8	3.594
Benue	13.045	21	9	3.258
Borno	13.681	23	7	3.859
Cross River	13.681	21	9	3.784
Delta	13.772	25	5	5.209
Ebonyi	14.045	33	5	7.791
Edo	13.318	22	5	4.602
Ekiti	17.954	38	5	8.014
Enugu	13.454	33	5	7.890
F.C.T.	17.772	26	8	5.013
Gombe	8.636	16	4	3.331
Imo	18.590	40	7	7.048

Table 5: Continues

Jigawa	7.272	13	3	2.640
Kaduna	17.5	27	5	5.334
Kano	20.681	47	10	9.751
Katsina	7.227	35	1	6.858
Kebbi	9.363	19	4	3.658
Kogi	6	12	0	3.903
Kwara	18	24	8	4.364
Lagos	17.590	33	5	8.203
Nassarawa	17.772	26	8	5.013
Niger	18.318	26	13	3.708
Ogun	17.818	39	10	9.027
Ondo	17.954	38	5	8.014
Osun	18	37	5	7.584
Plateau	17.909	28	10	4.607
Sokoto	18.227	23	9	3.663
Taraba	5.954	10	1	2.458
Yobe	17.5	31	5	4.857
Zamfara	17.681	35	4	7.226
Total	14.390	**47**	**0**	**7.116**

Source: Data Analysis, 2017

TABLE 6. Panel Unit Root Test Results

	Yield	Heat	Rain 95
No correlation	-2.659*	-3.946*	-3.772*
Serial correlation	-3.556*	-2.556*	-9.699*
Across group	-2.659*	-3.940*	-3.460*

Source: Data Analysis, 2017

*Note: This table report three versions of Im et al.'s LM-bar test statistics. "Serial correlation" statistics are robust to error term serial correlation, while "correlation across groups" statistics are robust to serial correlation in the cross-section dimension Key: * Null hypothesis of non-stationary is rejected with 99% confidence.*

rain95 of mean 5.954 with minimum and maximum rain95 of 29 and 5 respectively. In kano state we experience average yield of rice in the state. This may be as a result of the high rainfall that allows the growth of rice in the state. On the contrary Adamawa state record a low yield of rice which may be attributed to the low 95% of rain experienced in the state. The yield of rice experienced in the state is on the average which may be as a result of the high rain95 witnessed in kano state of Nigeria. The average rain95 witnessed in the state is 14.39037 which implies that rain95 in all the state may be at the average and rice being a crop that require adequate rainfall for its trivial will do most of the states in Nigeria with high rainfall degree than those states with high temperature. With the present rain95 level in kano state it may be predicted that in the nearest future there may be high level of yield production of rice in the state with increased rainfall.

Time series property

The LM bar test is based on the mean of the individual unit root statistics. The test is valid when the errors in the region regression are serially correlated, and normally and independently distributed across region. Under these circumstances LM-bar is distributed as standard normal as long as the number of region is large relative to the number of time periods. Under the assumption of serially uncorrelated errors, the LM-bar statistics used to test this nullhypothesis is define by $_L$ = «/N< LM^ - E(n_T)\l. LM-bar is the simple average of region Lagrange Multipliers.

Table 7: Rice Estimation Result			
Variable	**Coefficient**	**Standard error**	**Z**
Temperature	-0.0137	0.186	-1.74*
Rainfall	-0.129	0.310	-1.42
Rain95	-0.005	0.303	-2.17**
GDD	0.151	0.185	1.82*
Trend	0.0113	0.002	5.42***
Constant	0.151	0.609	0.25
States			
Adamawa	-0.129	0.117	-1.10
Bauchi	0.359	0.102	3.52***
Benue	0.224	0.101	2.21**
Borno	-0.204	0.112	-1.82*
FCT	0.192	0.116	1.65
Gombe	-0.595	0.127	-4.68***
Jigawa	-0.223	0.111	-1.99*
Kaduna	0.504	0.112	4.50***
Kano	0.360	0.113	3.18***
Katsina	0.402	0.106	3.76***
Kebbi	0.228	0.107	2.14**
Kogi	0.489	0.106	4..59***
Kwara	-0.483	0.111	-4.32***
Nassarawa	0.239	0.113	2.10**
Niger	-1.213	0.097	-12.54***
Plateau	-0.458	0.119	-3.83***
Sokoto	0.484	0.110	4.39***
Taraba	-0.211	0.110	-0.191
Yobe	-0.252	0.126	-2.00**
Zamfara	-0.066	0.122	-0.55
Abia	0.097	0.116	0.84
AkwaIbiom	0.195	0.108	1.80*
Anambra	-0.100	0.092	-1.09
Cross river	0.150	0.107	1.40
Delta	-0.118	0.105	-1.13
Ebonyi	-3.661	0.094	-3.87***
Edo	0.202	0.098	2.06**
Ekiti	-0.326	0.098	-3.31***
Enugu	0.387	0.153	2.52**
Imo	-0.816	0.118	-6.90***
Lagos	0.099	0.125	0.79
Ogun	-0.722	0.128	-5.60***
Ondo	-0.558	0.111	-5.02***
Log likelihood	*-245.803*	*AIC- 581.606*	
Wald Chi-square	*1135.54*	*No of observations*	*703*
Source: Data Analysis, 2017 NB: *** Significant at 1%, ** Significant at 5%, * Significant at 10%			

This avoids possible spurious correlation between variables and allows the establishment of validrelationship.

The table above shows the results from applying the panel unit root test procedure to all individual variables of rice yield, heat and 95 percentiles of rainfall. The table shows that rice is stationary as a panel, or integrated order zero 1(0), thereby rejecting the null hypothesis of a unit root test. Several variation of the Im test was also performed due to the modified test described by Im *et al* that is robust to serial correlation. The test gives a stationary result i.e. non serial correlation and serial correlation and since the test is robust to correlation across groups, it is therefore concluded that there are no correlation across group affecting the model results. These panel time series features of this data are used in formulating the estimation model. It might be plausible that some of the temperature and rainfall variable have a long term trend with some of the yield variables. The interest of the study is that stationarity of all the variables are used in the panel production function model to avoid possible spurious correlation between variables and allows valid result.

Relationship Between Rice Yield and Weather Variables in the States.

The specification of the production function adopted for this study is Cobb Douglas (C-D) production functions. The value of Akaike and Bayesian Information Criterion (AIC and BIC), Wald and Log likelihood obtained from Cobb Douglas were very good; hence the C-D results are discussed. The Cobb Douglas production function was estimated using MLE. The optimization procedure in STATA program was employed to obtain the estimates. The results show the effects of weather change on the average and the variability of crop yield. We did not consider Regional dummies in the equation because we assume that yield variability among regions is not quite different. The time trend variable is included to describe the technological process. The estimation results for the function are represented in table 4. As we report that Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) are used to select proper functional forms. In this sense, the CD-CD functional form behaves better. We also calculated elasticity for weather variables.

In Table 7 Rain95 is negatively significant to average rice yield. The rain95 of rice is computed as 0.005 which implies that rise in rain95 by 1% will decrease rice yield by 0.005%. Temperature is negatively significant to average rice yield in Nigeria. The elasticity of temperature of rice production is computed as 0.14 which implies that 1% increase in temperature may increase rice yield by 0.14%. GDD on the hand has positive influence on rice yield. The elasticity of GDD of rice production is computed as 0.15 which means that an increase by 1% on GDD will increase rice yield by 0.15%. Time trend, which represents technology, was modeled with the series as represented by the time variable serving as a proxy for the impact of technology change on rice yield, i.e. to capture technical progress, productivity, and high-yielding varieties appears to be the most important determinant of rice yield in Nigeria. It has a coefficient of 0.0113 and it is significant at 1%. This result further justifies the position that acreage increase of crops cultivated and price factors are not sufficient to increase the food supply in Nigeria; it takes a good combination of price and structural factors, one of which is technology.

Temperature is negatively significant to average rice yield in the following states; Borno, Gombe, Jigawa, Niger, Kwara, Plateau, Taraba, Yobe, Ebonyi, Ekiti, Imo, Ogun, and Ondo. The elasticity for temperature in Borno state is computed as -0.20. In Gombe, the elasticity for temperature is -0.60 while for Jigawa, Taraba and Yobe states, the elasticity of temperature is -0.22, -0.21 and -0.25 respectively. Ekiti, Imo, Ogun and Ondo have temperature elasticity of -0.33, -0.81, -0.72 and -0.56 respectively while, Niger and Ebonyi has the elasticity of temperature of -1.2 and -3.66 respectively. Temperature also affect rice yield positively in the following states; Bauchi, Benue, FCT, Kaduna, Kano, Katsina, Kebbi, Kogi, Nassawawa, Sokoto Edo and Enugu with elasticity values of -0.35, -0.22, -0.20, -0.50, -0.36, -0.40, -0.23, -0.49, -0.23, -0.49, -0.20 and -0.39 respectively. Rain95 is negatively significant to rice yield. Temperature and rainfall has likely effect on rice production in the states, but rainfall is negatively significant in six states. The elasticity values of rainfall with respect to rice yield in those states are -0.13, -0.07, -0.10, -0.15, -0.11, -0.99 respectively for Adamawa, Zamfara, Anambra, Cross River, Delta, and Lagos. GDD has positive impact on rice yield. GDD is positively significant in some of the states like; Bauchi, Benue, FCT, Kaduna, Kano, Kebbi, kogi, Nassarawa, sokoto, akwaibiom, Cross river, and Enugu, with values of 0.40, 0.22, 0.19, 0.50, 0.36, 0.22, 0.48, 0.23, 0.48, 0.19,0.15, 0.39 respectively. It was also observed that GDD of rice is negatively significant in these states; Adamawa, Borno, Gombe, Jigawa, Niger, Plateau, Taraba, Yobe, Zamfara, Anambra, Delta, Ebonyi, Imo, Lagos, Ogun and Ondo states of Nigeria with the values -0.13, -0.20, -0.59, -0.22, -1.2, -0.25, -0.25, -0.66,-0.100, -1.11, -3.66, -0.81,0.09, -0.72, and -0.53 respectively.

CONCLUSIONS AND POLICY RECOMMENDATION

The empirical results from this study provide certain evidence that climate change is significant to rice agriculture in Nigeria. The results showed that increase in rice yield is subject to rainfall and temperature change in Nigeria which is; increase in temperature with decrease in rainfall decreases rice yield while decrease in temperature and increase in rainfall increase rice yield in Nigeria. This result is consistence with Bimpong et al 2011 that climate change affects rice yield negatively due to rising temperature and declining rainfall.

Within the limitation of this study and in realization of the effect of extreme weather in rice production in conjunction with the global importance of rice, the following recommendations were made:

- Government should encourage irrigation ofrice production so as to reduce the harmful effect of extreme weather hi rice production in Nigeria.
- Government should encourage farmers to use irrigation method of farming by providing irrigation equipments at subsidized rate for the farmers.
- Extension agents should be mobilized in order to introduce irrigation farming methods to rural and small scale rice farmers so as to increase rice yield in the country and reduce excessive importation ofrice in Nigeria.
- The challenge of extreme weather and global warming is enormous in Nigeria due to widespread poverty, prevailing slash and burn agriculture, erosion and burning of firewood and farm residues, in order to annihilate this government should improve the standard of living of the masses and public education of the people concerning the effect of these negative practices on our eco system.

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