EFFECTS OF RAINFALL AND TEMPERATURE ON RICE PRODUCTION IN NIGERIA

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ABSTRACT
The study was carried out to determine the effects of climate variability on rice production in Nigeria from 1970-2016. Secondary data were employed, years of study extended from 1970-2016 (47 years). Time series data were extracted from Nigerian Meteorological Agency (NIMET) and annual rice production was collected from National Bureau of Statistics. Results reveal that there were fluctuations over the period of study with alternating fall and rise. In the sub-period of 2010-2016, high mean rainfall of 799.10mm was recorded and a low mean rainfall of 641.97mm was recorded in the sub-period of 1980-1989 thereby resulting in average of 702.39mm over the period of study. High mean temperature of 26.77^0C was recorded in the sub-period of 1980-1989 and low mean temperature of 21.05^0C in 1970-1979 resulting in an average of 24.97^0C over the period of study. High output of rice production of 5,381,609 tons was recorded in 2010-2016 and a low output of 2,610,975 tons in 1970-1979 with an annual percent change of -6.58 percent over the period of study. Coefficients of annual temperature and rainfall were positive and were both statistically significant at 1 percent level which implies a direct relationship between rice production and climate variables (rainfall and temperature). Rise in annual rainfall and temperature will lead to increase in rice production. The study recommended provision of varieties that can cope with moderate and high levels of rainfall and temperature.
Keywords: Climate change parameters, Climate variability, Rice Production.

INTRODUCTION

Agriculture is the root of Nigeria's economy because it is the leading source of livelihood in Nigeria; it is the largest sector of the economy and engages two thirds of the total labour force (Food and Agricultural Organization, 2019). The rice sector in Nigeria is one of the most important remarkable agricultural developments over the decades. Rice is the most consumed staple food by Nigeria's over 174 million people across states and geo-political zones (Terungwa and Yuguda, 2014). Rice is a crop that cuts across regional, religious, cultural, national and international boundaries with very high demand. It is mainly grown in four major production ecosystems which are broadly defined on the basis of water regions; Irrigated rice, Rain field low land rice, Upland rice and deep water rice (Olagunju, 2014).

Rice is normally grown in water-flooded fields in more than 95 countries and plays a vital role in feeding large sections of the Nigeria population. Rice needs a significant amount of water, estimated to be around 500 to 600 mm, and the optimal temperature for growth was reported to be between 22^0C and 31^0C, and requires 5 to 6 hours of sunshine per day (Wang, 2018). Agricultural sector is exposed to high level of vulnerability and impact caused by climate change. Climate change across Africa is exacerbated by low level of adaptation and mitigation (Intergovernmental Panel on Climate Change (IPCC, 2015: Montpellier Panel Report 2015).

Climate variability is predicted to have impact on agriculture, economy and livelihood of the populations of under-developed countries. Rainfall variability from season to season greatly affects soil water availability to crops, and thus poses serious crop production risks.

Farming activities depend on favorable climate conditions and are at risk under changing climate (Porter, Xie, Challinor, Cochrane, Howden, Iqbal, Lobell, and Travasso, 2014). Agricultural production is at risk in countries where rainfed system of agriculture is predominantly practiced.

Since agriculture in Nigeria is largely rain-fed, any variability in climate is guaranteed to impact its productivity in particular and other socio-economic activities generally, in the country. To reduce the undesirable effects of climate change, farmers in Nigeria resort to different agricultural technologies including crop combinations, changes in planting and harvesting dates, using improved seeds and chemical fertilizers, and soil fertility management techniques.

Rainfed system of agricultural production is liable to seasonal changes which on the long run affect farmer's standard of living. One of the major problems associated with rice production is drought which is caused by climate change. Drastic changes in rainfall patterns bring about unfavorable growing condition into cropping calendar thus modifying growing season which could subsequently reduce crop productivity. Since rice has become a strategic commodity in the Nigerian economy, it is important assess the effects of annual rainfall and temperature variability on its production with a view to improve production and as much as possible reduce rice importation in Nigeria.

The main objective of the study was to determine the effects of rainfall and temperature

variability on rice production. Specific objectives of the study were to;

i. examine the trend in rice production,
ii. assess the trend in annual rainfall pattern;
iii. investigate the trend in annual temperature pattern; and
iv. evaluate the effects of annual rainfall and annual temperature on rice production in Nigeria.

The hypothesis of the study stated in null form is; there is no significant relationship between rice production and changes in rainfall and temperature pattern.

METHODOLOGY

The study area is Nigeria. Secondary data were employed so sampling procedure do not apply to this study. Time series (mean and annual rainfall in millimeters and temperature in Degree Celsius from 1970 to 2016) were extracted from Nigerian Meteorological Agency (NIMET) and annual rice production data (1970-2016) were collected from National Bureau of Statistics (NBS). Annual rice production was measured in tons and coefficient of variation was measured in percentages. Standard deviation and mean of sub-periods for rice, rainfall and temperature were calculated to get the coefficient of variation for each sub-periods. Averages, standard deviations, annual percent change, coefficient of variation were used to analyze the dataset to explain the variables. Annual rice production (in tons) in the country was used as dependent variable, annual mean temperature and rainfall as the independent variables.

Multiple regression was employed to determine the relationship that existed between the dependent variable and the independent variables.

RESULTS AND DISCUSSION

Trend of change in rice production

This sub section presents the result of the trend in analysis of annual production of rice covered by the study (1970-2016). Results in Table 1 and Figure 1 show that average rice production per annum was fluctuating throughout the period of study with alternating fall and rise. Rice production increased from 458,500 tons in 1970-1979 sub-period to 1,617,132 tons in 1980-1989 sub-period and increased to 3,034,000 tons in 1990-1999 sub-period and increased again to 3,394,825 tons in 2000-2009 sub-period and finally rose to 5,381,609 tons in 2010-2016 sub-period. Average rice production per annum ranged from a lowest of 458,500 tons in 1970-1979 sub-period to highest of 5,381,609 tons in the 2010-2016 sub-period. Average rice production per annum over the study period was 2,610,975 tons. The fluctuation might have been caused by some production factors such as (climatic, environmental, cultural, institutional) factors.

The intra sub-period annual percent change rate was positive with 6.45 percent in 1990-1999 sub-period, 8.16 percent in 2000-2009 sub-period, 9.23 percent in 2010-2016 sub-period. However, there was a negative annual percent change of -4.33 percent in rice production in 1970-1979 sub-period and a lower negative of -2.89 in 1980-1989 sub-period. The average annual percent change rate over the period of study was negative with -6.58 percent which implies that average rice production was low during the period of study.

Coefficients of variation shows instability in the average rice production per annum with coefficient of variation ranging from 30.35 percent in 1970-1979 to 40.85 percent in 1980-1989 to 10.62 percent in 1990-2000 to 13.36 percent 2000-2009 and finally to 13.90 percent in 2010-2016 with an average of 63.92 percent. Coefficient of variation shows percentage of variation in the mean of each sub-periods which implies that the rates at which changes occur in each sub-periods differ from each other which may be due to (climatic, environmental, cultural and institutional) factors. This result correlates with the result of Ayinde, Ojehomon, Daramola, and Falaki (2013) which revealed that rice production trend of the study area is not stable.

Table 1: Trend in Rice production in Nigeria (1970-2016)

Sub-period	Average Rice Production (tons) Per annum	Annual percent change	Coefficient of Variation (%)
1970-79	458500	-4.33	30.35
1980-89	1617132	-2.89	40.85
1990-99	3034000	6.45	10.62
2000-09	3394825	8.16	13.36
2010-16	5381609	9.23	13.90
All Period	**2610975**	**-6.58**	**63.92**

Source: National Bureau of Statistics, 2019

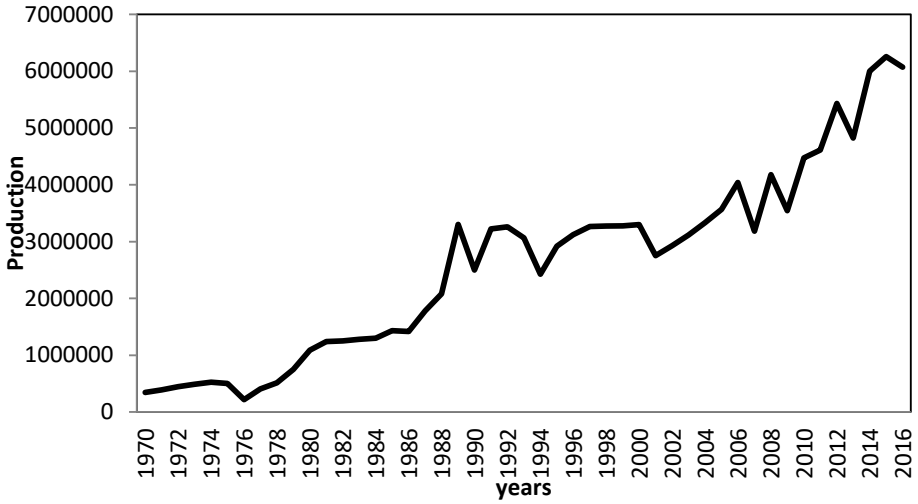

Fig 1: Nigeria Rice Production from 1970-2016
Source: National Bureau of Statistics, 2019

Trend of change in annual rainfall pattern

This sub section presents the result of the trend in analysis of rainfall in Nigeria from 1970-2016. Results in Table 2 and Figure 2 show that average annual rainfall was fluctuating throughout the study period with alternating rise and fall. Rainfall fell from 679.59mm in 1970-1979 sub-period to 641.97mm in 1980-1989 sub-period but rice production increased and rainfall later increased to 693.17mm in 1990-1999 sub-period with a higher increase in rice production, rainfall increased again to 727.11mm in 2000-2009 sub-period with a lower increase in rice production, rainfall finally increased to 799.10mm in 2010-2016 sub-period with a high increase in rice production. The average annual rainfall per annum ranged from a lowest of 641.97mm in 1980-1989 sub-period to highest of 799.10mm in 2010-2016 sub-period. Average annual rainfall per annum over the period of study was 702.39mm.

The intra sub-period annual percent change rate of rainfall was positive in all the sub-periods with 9.43 percent in 1970-1979 sub-period, 9.90 percent in 1980-1989 sub-period, 9.72 percent in 1990-1999 sub-period, 8.32 percent in 2000-2009 sub-period, 15.08 percent in 2010-2016 sub-period. The average annual percent change rate over the period of study was 1.67 percent.

Coefficient of variation shows instability in average rainfall per annum with coefficients of variation ranging from 8.98 percent in 1970-1979 sub-period to 8.44 percent in 1980-1989 sub-period to 7.58 percent in 1990-1999 sub-period to 7.87 percent in 2000-2009 sub-period to 5.15 percent in 2010-2016 sub-period with an average of 10.25 percent over the period of study. Coefficient of variation shows the percentage of variation in the mean of each sub-periods.

This result is in line with the result of Akinsanola and Ogunjobi (2014) which reported that there was rainfall anomaly over all the stations in the study area.

Table 2: Trend in Nigeria Rainfall Pattern (1970-2016)

Sub-period	Average Rice Production (tons) Per annum	Annual percent change	Coefficient of Variation (%)
1970-79	679.59	9.43	8.98
1980-89	641.97	9.90	8.44
1990-99	693.17	9.72	7.58
2000-09	727.11	8.32	7.87
2010-16	799.10	15.08	5.15
All Period	**702.39**	**1.67**	**10.25**

Source: Nigerian Meteorological Agency, 2019

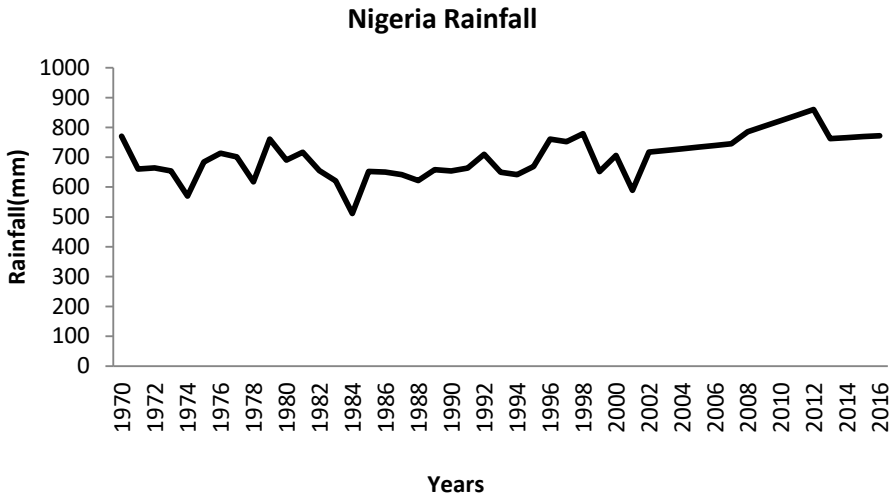

Fig 2: Nigeria Rainfall Pattern from 1970-2016
Source: Nigerian Meteorological Agency, 2019

Trend of change in annual temperature pattern

This sub section presents the trend of change in analysis of temperature in Nigeria from 1970-2016. Results in Table 3 and Figure 3 show that average annual temperature was fluctuating throughout the period of study with a fall and rise from 21.05°C in 1970-1979 sub-period to 26.14°C in 1980-1989 sub-period which increases rice production, temperature increased again to 26.77°C in 1990-1999 sub-period which led to a higher increase in rice production, temperature fell to 25.87°C in 2000-2009 sub-period which led to a lower increase in rice production and finally fell to 25.03°C in 2010-2016 sub-period with a high increase in rice production. Average temperature per annum ranges from a lowest of 21.05°C in 1970-1979 sub-period to highest of 26.77°C in 1990-1999 sub-period. Average temperature per annum over the period of study was 24.97°C.

The intra sub-period annual percent change rate of temperature was positive in all the sub-periods with 8.50 percent in 1970-1979 sub-period, 8.77 percent in 1980-1989 sub-period, 10.05 percent in 1990-1999 sub-period, 11.23 percent in 2000-2009 sub-period, 11.45 percent in 2010-2016 sub-period. The average annual percent change rate of the study period was positive with 1.29 percent.

Coefficient of variation shows instability in the average annual temperature per annum with coefficients of variation ranging from 5.68 percent in 1970-1979 sub-period to 4.24 percent in 1980-1989 sub-period to 1.86 percent in 1990-1999 sub-period to 4.63 percent in 2000-2009 sub-period to 10.23 percent in 2010-2016 sub-period with an average of 10.34 percent over the period of study. Coefficient of variation shows the percentage of variation in the mean of each sub-periods. This result agrees with the result of Ayinde, Muchie and Olatunji (2011) which revealed that there is variation in the temperature variable in the study area.

Table 3: Trend in Nigeria Temperature pattern (1970-2016)

Sub-period	Average Rice Production (tons) Per annum	Annual percent change	Coefficient of Variation (%)
1970-79	21.05	8.50	5.68
1980-89	26.14	8.77	4.24
1990-99	26.77	10.05	1.86
2000-09	25.87	11.23	4.63
2010-16	25.03	11.45	10.23
All Period	**24.97**	**1.29**	**10.34**

Source: Nigerian Meteorological Agency, 2019

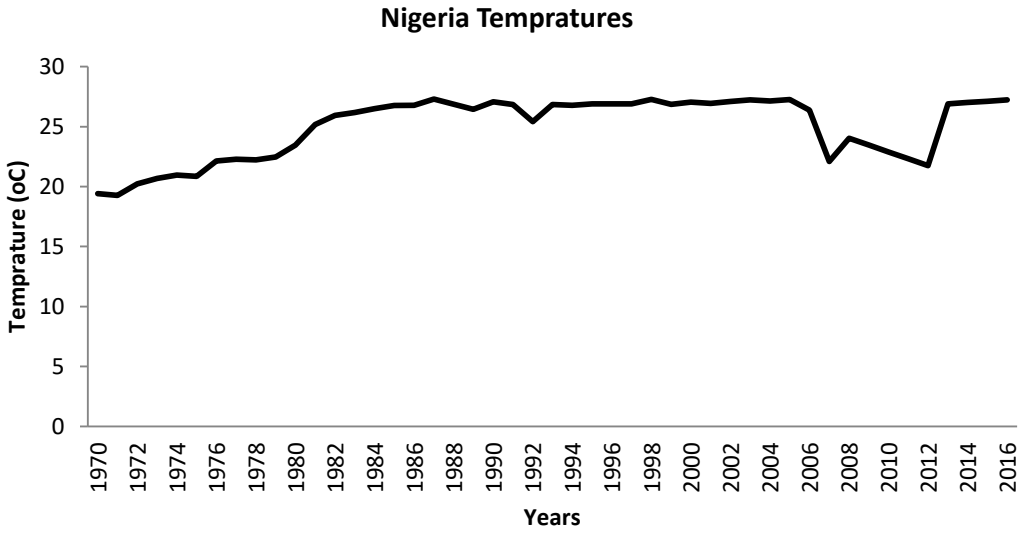

Fig 3: Nigeria Temperature Pattern from 1970-2016
Source: Nigerian Meteorological Agency, 2019

RESULTS OF REGRESSION ANALYSIS

This sub section presents the result of multiple linear regression analysis. Results in Table 4 show that the coefficient of determination (R^2) for regression of rice with rainfall and temperature is 0.669. R^2 indicates that rainfall and temperature accounts for more than sixty-six percent of the factors that determine production. The F-value is statistically significant at 1 percent level which indicates that data are fitted well.

The coefficient of annual rainfall was positive and statistically significant at 1 percent level and the coefficient of temperature was also positive and statistically significant at 1 percent level. The results show there was a direct relationship between annual rainfall and rice production. Rise in annual rainfall and temperature will lead to increase in rice production which will in turn lead to substantial increase in farmer's income from rice production.

In summary, these results show that annual rainfall and temperature positively affect the output of rice. This result is in consonance with the result of Ayinde, et al., (2013) which revealed that the higher the minimum temperature, the higher the rice production in the study area. It also correlates with the result of Adedeji, Tiku, Waziri-Ugwu and Sanusi where increase in rainfall leads to increase in rice production in the study area.

Table 4: Regression Result of Rice with Rainfall and Temperature

Variable	Coefficients	Standard error	t value	p value
(Constant)	-1.7400000	2.133000	-8.159	0.000
Rainfall	15371.820	2025.779	7.588	0.000
Temperature	369184.179	56531.045	6.531	0.000

R-squared 0.669
F – Statistics 44.517

The study concluded that climate variation exists in Nigeria. Variation in climate affected rice production. From the result of the regression analysis, it can also be concluded that the higher the rainfall and temperature, the higher the output of rice. This is because climate variables have a positive relationship with rice production. Rise in annual rainfall and temperature will lead to increase in rice production and will also lead to significant increase in farmer's income from rice production.

Based on the result of the trend and regression analysis, the following recommendations were made in order to improve rice production in Nigeria

a. That breeders should help to develop rice seeds varieties that can grow well under varying climatic conditions.
b. Also, breeders should help to develop rice seeds varieties that can grow well under high temperature and high rainfall.

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