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INFLUENCE OF CLIMATE CHANGE ON THE GROWTH RATES AND DIRECTION OF GROWTH OF OUTPUTS OF SELECTED FOOD GRAINS IN NIGERIA (1981-2020)

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ABSTRACT
The study assessed the influence on the growth rates and direction of growth of prices of outputs of selected food grans (rice, maize and wheat) in Nigeria from 1981 to 2020. Time series data were collected from secondary sources. The data was analyzed using regression analysis. The analysis showed that, the instantaneous growth rates were 4.8%, 4.3% and 1.5% for outputs of maize, rice and wheat, respectively, per annum increase in Nigeria (1981-2020); Whereas the value of the coefficient of quadratic term (t^2) for rice (5.22), maize (0.649) and wheat (-0.62) were positive for rice and maize but negative for wheat which implies stagnated growth rates in rice and maize production and accelerated growth process in wheat production. In the same, the result revealed that the instantaneous growth rates were 15.5%, 13.2% and 13.1% for prices of maize, rice and wheat, respectively, per annum increase in Nigeria (1981-2020). Also, the value of the coefficient of t^2 for rice (13.2%), maize (15.5%) and wheat (13.1%) were all positive and significant – which implies accelerated growth process in Nigeria (1981-2020). The study concluded that, climate change, environmental degradation and stagnating yields could have catastrophic effects and reduce yields and increase prices of food grains like rice, maize and wheat in Nigeria. It was therefore, recommends that, effort should be made by government and other relevant stakeholders in agriculture towards providing irrigation facilities in order to adjust any unfavourable influence of increase or decrease in rainfall on food grains' growth and yield in Nigeria.

Keywords: Climate change, growth rate, direction, food grains, Nigeria.

INTRODUCTION
Climate change possibly affects the natural and managed systems of forests, wetlands, coral reefs, agriculture and fisheries that societies depend on to provide food, fuel, and fiber and many other services. The scenario makes it harder to produce food for the growing population of Nigeria and may also alter the timing, availability and quality of water resources.

Climate change has brought with it changes in weather patterns that can have serious repercussions for all of us, upsetting seasonal cycles, harming ecosystems and water supply, affecting agricultural farming systems and food production, and also causing sea levels to rise (Igwe *et al.*, 2014). Climate change is now a subject of worldwide concern. It has the potential of affecting all natural and human systems and may be a threat to human development as well as survival socially, politically and economically. Nigeria has a variety of ecosystems, from mangroves and rain forests on the Atlantic coast in the south to the savannah in the north bordering the Sahara. Whether dry or wet, those ecosystems are being abused by global warming or climate change. Climate change is expected to impact on the agricultural sector in multiple ways, among others through increased variability with regard to temperature, rain, frequency and intensity of extreme weather events, changes in rainfall patterns and in water availability and perturbations in ecosystem (Haider, 2019). Many countries in the tropical and

sub-tropical regions of which Nigeria is included, are expected to be more vulnerable to warming because of additional temperature increases that probably affects their marginal water balance and harm their agricultural sector (Idowu *et al.,* 2011). The problem is expected to be more severe in Nigeria, where current information is the poorest, technological change has been the slowest and the domestic economies depends heavily on agriculture.

Igwe *et al.* (2014) defined climate change as change of climate which is directly attributed or indirectly attributed to human activity that alters the composition of the global and/or regional atmosphere and which is in addition to natural climate variability observed over comparable time periods. Climate plays a dominant role in agriculture having a direct impact on the productivity of physical production factors such as soil's moisture and fertility. Climate variability and change has a direct, often adverse effect on the quantity and quality of agricultural production in Nigeria (Enghiad *et al.,* 2017). Climate change affect farming outputs at any stage from cultivation through the final harvest even if there is sufficient rain, its irregularity may affect yields adversely if rain fail to arrive during the crucial growing stages of the crops. It has been noted that temperature trend in Nigeria since 1901 shows increasing pattern – the mean air temperature in Nigeria between 1901 and 2005 was 26.6ºC while the temperature increase for the 105 years was 1.1ºC (Elisha *et al.,* 2017). This is obviously higher than the global mean temperature increases of 0.74ºC which had been recorded since 1860 when actual scientific temperature measurement started (Nzeka and Taylor, 2017). According to Library of Congress (2006), rainfall trend in Nigeria between 1901 and 2005 shows a general decline.

Within the 105 years that is between 1901 and 2005, rainfall amount in Nigeria dropped by 81mm (Library of Congress, 2006). Rainfall became worst from the early 1970s, and the pattern has continued till the period of sharp drastic rainfall decline which corresponds with the period of sharp temperature rise (Nzeka and Taylor, 2017). The trend of temperature in Nigeria is relatively constant, which can also be linked to the irregular movements of rainfall, which regulates the condition of the temperature.

Nowadays, climate change is one of the most critical environmental challenges with serious negative socio-economic consequences, although, triggered both by natural and human activities such as industrial production, agriculture and transportation which is the major contributor to the concentration of greenhouse gases (GHGs) in the atmosphere which causes climate change [Food and Agriculture Organization (FAO) of the United Nations, 2017)]. Nigeria's wide range of climate variation allows it to produce a wide variety of food and cash crops. Food shortage is consequently linked with climate change. In contrast, it has been reported that temperature has no linkage with agricultural output (Igwe *et al.*, 2014). Food shortages as a result of population increases are more obtained in Nigeria than climate change. Though, climate change can cause food shortages in the case of flood situation. Using regression analysis to examine drought as factor affecting arable crops output, it has been shown that drought causes decrease in output of food crops. Igwe *et al.* (2014) recognized that drought is a major cause of crop failure in rain-fed dependent agrarian community. FAO (2017) also established that, severe food shortages were due to drought situations. There is a knowledge gap existing between climate change, growth rates and direction of growth of outputs of selected food grains (rice, maize and wheat) in Nigeria from 1981 to 2020.

The research attempted to answer the following questions: What is the influence of climate change on the growth rates of prices of outputs of rice, maize and wheat in Nigeria (1981-2020)? What is the influence of climate change on direction of growth of prices of outputs of rice, maize and wheat in Nigeria (1981-2020)?

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The objectives of the study were to: determine the influence of climate change on the growth rates of prices of outputs of rice, maize and wheat in Nigeria (1981-2020); and assess the influence of climate change on direction of growth of prices of outputs of rice, maize and wheat in Nigeria (1981-2020).

MATERIALS AND METHODS

The Study Area

The study area is Nigeria. It lies roughly between latitudes 4°N and 14°N as well as longitudes 3°E and 15°E (Federal Government of Nigeria, 2012). It covers a landmass of approximately 923,768 km^2 representing about 14% of the land area in West Africa (Water and Sanitation Programme, 2012). The population of Nigeria stood at 211.40 million inhabitants in April 2021 (O'Neil, 2021). This makes the country the most populated nation and one of the largest countries in Africa [Central Bank of Nigeria (CBN, 2013)]. The country is bordered by the elongated territory of Benin to the west, the semi-arid country of the Niger Republic to the North, the sub-equatorial Cameroun to the East, and the Atlantic Ocean to the South (Figure 1).

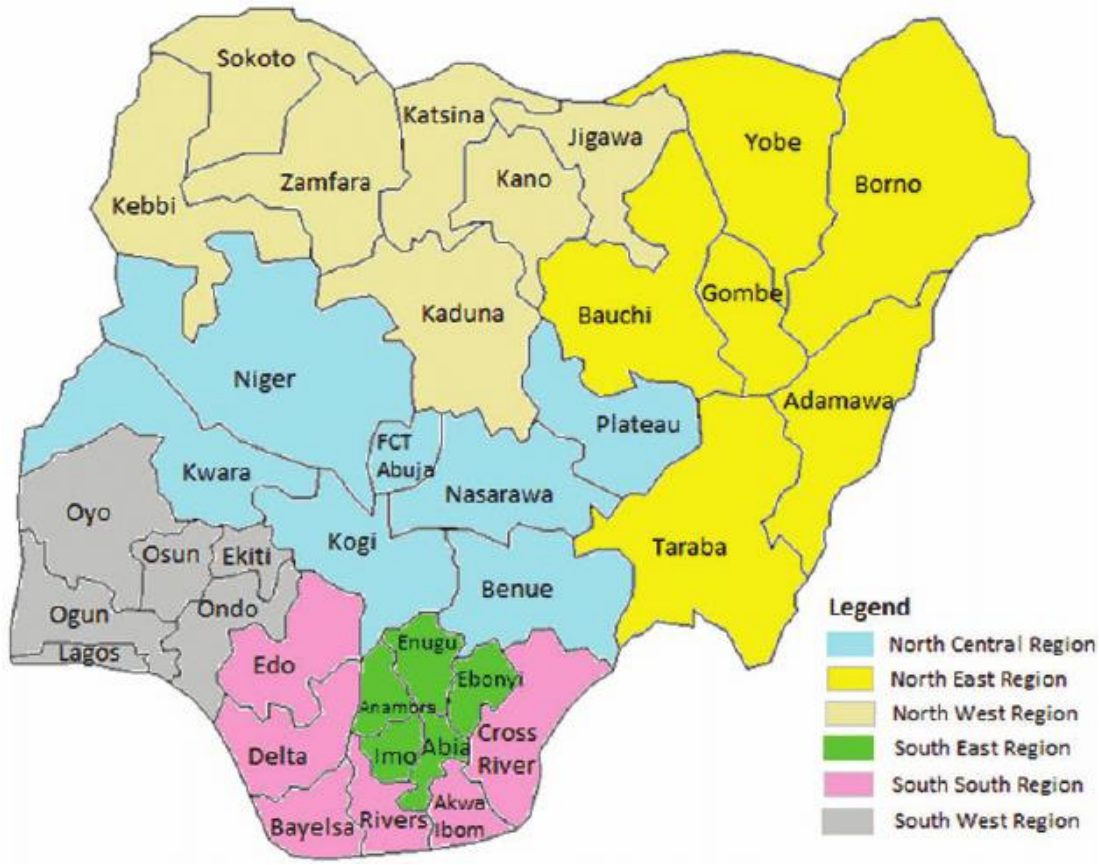

Figure 1: *Map of Nigeria showing the 36 states grouped into 6 agro-ecological zones.*
Source: Adopted from the Federal Government of Nigeria (2012).

Method of Data Collection

The data was obtained from records of the National Bureau of Statistics (NBS), Food and Agriculture Organization Statistical Database (FAOSTAT) publications, databases and annual reports. These sources were selected because of the consistency and long period of the coverage of data. The variables for which data was collected consists of production and prices of rice, maize and wheat grains in Nigeria for a period of forty years (1981-2020).

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Data Analytical Techniques

Data for this study was analyzed using regression analysis (growth model) to achieve the study objectives.

The Gordon Growth Model (GGM) was used to determine the intrinsic value of a food grain(s) output. The trend equation used to ascertain the direction and growth rates of variables of interest (rice output, maize output, wheat output, price of rice, price of maize and price of wheat) are as specified:

$\ln Y_t = \alpha + \beta_{Ry}t + \mu_t$ …(1)
$\ln Y_t = \alpha + \beta_{My}t + \mu_t$ …(2)
$\ln Y_t = \alpha + \beta_{Wy}t + \mu_t$ …(3)
$\ln Y_t = \alpha + \beta_{Rp}t + \mu_t$ …(4)
$\ln Y_t = \alpha + \beta_{Mp}t + \mu_t$ …(5)
$\ln Y_t = \alpha + \beta_{Wp}t + \mu_t$ …(6)

where;
α = the constant,
β = Vector of the trend variable μ in the econometric error term,
β_{Ry}, β_{My}, β_{Wy}, β_{Rp}, β_{Mp}, β_{Wp}, = coefficients of the trend variables for rice, maize and wheat production and prices, respectively,
t = time trend variable.

The parameter of utmost interest in the equations 1-6 were coefficients of βs and the slope of these would give the indication whether positive or negative to show the absolute change in the regressor Y. In the specification of equations 1, 2, 3, 4, 5 and 6 are the linear and quadratic time terms indicate the circular path in the dependent variable (Y). Multiplying b by 100 gave the instantaneous growth rate (IGR) at a point in time.

$IGR = \beta \times 100$ …(7)

where; β = is the least-square estimate of the slope coefficients

Taking the antilog of β subtracting 1 from it and multiplying the difference by 100 gives the compound growth rate (CGR) over a period of time. Also, the quadratic time variable (t) allows for the possibility of determining whether there was acceleration, deceleration or stagnation in the study (Maikasuwa and Ala, 2013). In determining the direction or pattern of growth, our main concern is on β_2 (that is, coefficient of t) which reveals a measure of the growth pattern following Ndubusi *et al.* (2021) and Maikasuwa and Ala (2013). In other words, if β_s are positive and statistically significant there is acceleration in growth, if β is negative and statistically significant there is deceleration in growth, if β is not statistically significant there is stagnation in the growth process.

Similarly, the compound growth rate (CGR) in percentage in each of the 6 cases can be recovered from the equations in the following manner:

$CGR = (e^{\beta i}-1)*100$ …(8)

where; β = coefficient of the trend variables in the respective cases.

If β is positive and statistically significant, there is acceleration in growth, if β is not statistically significant, there is stagnation in the growth process.

RESULTS AND DISCUSSION

Growth Rates of Output of Rice, Maize and Wheat in Nigeria

The result of growth rates and direction of growth of the variables is presented in Table 1. The exponential trend equation was done using the estimated regression coefficient of the time trend variable as contained in equations 1, 2, 3, 4, 5, 7 and 8. The coefficient of multiple determination (R^2) value of rice (0.878), maize (0.816) and wheat (0.447) implies that 87.8%,

81.6% and 81.6% of the variations in the trend of rice, maize and wheat outputs, respectively, were explained over time by the trend model. The result indicated that the coefficient for estimating the growth of rice, maize and wheat yields were positive [maize (0.048), rice (0.043) and wheat (0.0151)] and significant at 1% (table 3). The instantaneous growth rates (growth at points) were 4.8, 4.3 and 1.51 suggested 4.8%, 4.3% and 1.5% for outputs of maize, rice and wheat, respectively, per annum increase in Nigeria during the period of the study (Table 2). The compound growth rate of for maize, rice and wheat were 4.92%, 4.39% and 1.51%, respectively.

The quadratic term (t^2) in equations 4, 5 and 6 allow for the possibility of determining acceleration, deceleration or stagnation in rice, maize and wheat output growth processes. Results in Table 5 showed that the value of the coefficient of t for rice (5.22), maize (0.649) and wheat (-0.62) were positive for rice and maize but negative for wheat. Thus, coefficients of t^2 for rice and maize were insignificant – which implies that there were stagnated growth rates in rice and maize production. But, coefficient of t^2 for wheat was significant and implies that, there was accelerated growth process in wheat production. This is consistent with the findings of Food and Agricultural Organization (FAO) of the United Nations, Rome (2016) who posited that, climate change, environmental degradation and stagnating yields could have catastrophic effects and reduce yields of wheat in Nigeria by 20%.

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Table 1: Estimated growth models of rice, maize and wheat outputs in Nigeria (1981 – 2020)

Variable	Crops	Model	Determinant	Co-efficient	t-stat	F-stat	R^2	AIC
Output	Rice	Linear	Trend	157,616.8	12.79	163.64	0.811	30.31
			Constant	712,897.3	2.55			
		Quadratic	Trend	29,405.36	0.79	151.96	0.80	29.80
			$Trend^2$	4,975.44	5.22			
			Constant	2,178,121	3.77			
		Exponential	Trend	0.043	16.56	274.51	0.878	0.422
			Constant	14.16	238.67			
	Maize	Linear	Trend	224,256.5	12.913	166.75	0.814	30.99
			Constant	19,060.2	4.84			
		Quadratic	Trend	181,291.8	2.64	82.32	0.816	31.03
			$Trend^2$	1,101.66	0.649			
			Constant	2178121	3.78			
		Exponential	Trend	0.048	8.45	71.45	0.65	1.137
			Constant	14.54	112.35			
	Wheat	Linear	Trend	597.60	1.38	2.90	0.447	23.63
			Constant	55,845.21	5.69			
		Quadratic	Trend	1,632.44	0.96	3.12	0.0557	23.64
			$Trend^2$	-26.53	-0.62			
			Constant	49291.26	3.43			
		Exponential	Trend	0.015	2.45	6.03	0.437	1.21
			Constant	10.73	79.82			

Source: Data analysis (2021).

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Table 2: Growth rates and direction of growth of rice, maize and wheat prices

Variable	Crops	IGR (%)	CGR (%)	Direction of Growth
Price	Rice	13.2	14.11	Acceleration
	Maize	15.5	16.76	Acceleration
	Wheat	13.1	13.99	Acceleration

Note: IGR = Instantaneous growth rate; CGR = Compound growth rates; % = Percentage.
Source: Data analysis (2021).

Direction of Prices of Rice, Maize and Wheat in Nigeria

The result of growth rates and direction of growth of the variables is obtained in Table 2. The exponential trend equation was done using the estimated regression coefficient of the time trend variable as captured in equations 7 and 8. The coefficient of multiple determination (R^2) value of rice (0.88), maize (0.915) and wheat (0.80) means that 88%, 91.5% and 80% of the differences in the trend of rice, maize and wheat prices, respectively, were explained over time by the trend model. The result indicated that the coefficient for estimating the growth of prices of rice, maize and wheat were all positive [maize (0.155), rice (0.132) and wheat (0.131)] and significant at 1% (Table 6). The instantaneous growth rates (growth at points) were 15.5, 13.2 and 13.1 suggested 15.5%, 13.2% and 13.1% for prices of maize, rice and wheat respectively, per annum increase in Nigeria during the period of the study (table 4). The compound growth rate of for maize, rice and wheat were 16.76%, 14.11% and 13.99%, respectively.

The quadratic term (t^2) in equations 1, 2, 3, 4, 5, and 6 allow for the possibility of acceleration in prices rice, maize and wheat growth processes. Results in Table 6 revealed that the value of the coefficient of t^2 for rice, maize and wheat were all positive and significant. This implies that the pattern of growth for rice and maize and wheat had accelerated growth process in Nigeria during the period of the study (Table 4).

This is consistent with the findings of FAO (2016) who posited that, climate change, environmental degradation and stagnating yields could have catastrophic effects and reduce yields of wheat yields in Nigeria by 20%. This finding is however in contrast with Togun *et al.* (2019) who reported that, the marketing of food grains in Nigeria has experienced not only price variations from year to year but also price variability.

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Table 3: Estimated growth models of prices of rice, maize and wheat in Nigeria (1981 – 2020)

Variable	Crops	Model	Determinant	Co-efficient	t-stat	F-stat	R^2	AIC
Prices	Rice	Linear	Trend	2,042.18	15.68	246.14	0.866	21.205
			Constant	523.06	1.77			
		Quadratic	Trend	323.51	6.78	144.54	0.88	21.09
			$Trend^2$	30.386	2.57			
			Constant	12,717.02	3.17			
		Exponent	Trend	0.132	11.540	133.17	0.778	2.529
			Constant	7.09	27.30			
	Maize	Linear	Trend	2,076.90	20.20	408.15	0.91	20.73
			Constant	945.36	4.05			
		Quadratic	Trend	2,174.92	5.34	199.07	0.915	20.78
			$Trend^2$	2.51	5.24			
			Constant	10,071.21	2.93			
		Exponent	Trend	0.155	13.517	182.72	0.827	2.53
			Constant	6.327	24.33			
	Wheat	Linear	Trend	1,897.14	11.16	124.68	0.766	21.73
			Constant	3,369.35	0.87			
		Quadratic	Trend	3,399.08	5.45	74.05	0.80	21.63
			$Trend^2$	38.51	2.49			
			Constant	12,881.61	2.45			
		Exponent	Trend	0.131	10.66	113.77	0.749	2.68
			Constant	7.04	25.14			

Source: Data analysis (2021).

Table 4: Growth rates and direction of growth of outputs rice, maize and wheat

Variable	Crops	IGR (%)	CGR (%)	Direction of Growth
Output	Rice	4.3	4.39	Acceleration
	Maize	4.8	4.92	Acceleration
	Wheat	1.5	1.51	Stagnation

Note: IGR = Instantaneous growth rate; CGR = Compound growth rates; % = Percentage.
Source: Data analysis (2021).

CONCLUSION AND RECOMMENDATIONS

The study shows that, climate change, environmental degradation and stagnating yields could have catastrophic effects and reduce yields of wheat in Nigeria by 20%. Whereas, the marketing of food grains such as rice, maize and wheat in Nigeria has experienced not only price variations from year to year but also price variability. There was stagnation in the growth rates of rice and maize production and accelerated growth process in wheat production as well as acceleration growth of food grains' (rice, maize and wheat) prices in Nigeria. This shows that, agriculture in Nigeria is highly dependent on climate change. From the result of the analysis, it can be seen that, maize and rice yielded more with increase in rainfall while the growth rate of wheat was affected by increase in rainfall intensity- showing that, increase in rainfall might not be favourable to wheat growth and yield.

The study recommended that, if rice and maize yields will be increased and sustained, irrigation, as a constant water supply, should be applied in maize and rice production. Hence, effort should be gear towards providing irrigation facilities in order to adjust any unfavourable influence of increase or decrease in rainfall on food grains such as rice, maize and wheat growth and yield in Nigeria.

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