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Growth rate and direction of climate change in Nigeria: 1990-2019

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ABSTRACT

The study considered the growth rate and direction of climate in Nigeria from 1990-2019. The study used time series data spanning from 1990-2019. Secondary data on rainfall and temperature were collected from FAO. Humidity data were collected from Nigeria Meteorology, NiMeT. The various analytical tools used were KPSS to test for unit root, exponential growth rate model and graphical trend analysis was used to examine the growth of rainfall, temperature and humidity. The quadratic trend model was used to examine the direction of growth of climate change. The result of growth model further showed that the compound growth rate of rainfall was 0.40 percent, temperature 0.1 percent and humidity -0.2 percent. Further, the results showed that of temperature was decelerating, humidity was stagnant and rainfall was accelerating over the 1990-2019 period. Based on the findings of this study, it is recommended that the government should encourage eco-friendly industrial activities such as the use of solar powered machineries and hydro-power to help reduce the volume of greenhouse gases emission and balance the climate change parameters. The government should also monitor existing policies on environmental control and protection to ensure they are actually fulfilling their essence. The monitoring could be in form of appraisal; finding out if there is compliance with environmental control rule and prosecute defaulters where and when necessary.

Keywords: Growth, Direction, climate change, green-house, gases

1. INTRODUCTION

Climate change has become an issue of global concern affecting to a different degree various aspects of the world's economic activities. Its effects are being felt in different dimensions and nature by many nations engendering economic reactions to the impacts. Climate change is a complete variation of the atmosphere over time periods, ranging from decades to millions of years in a region or across the entire globe and is caused by processes internal to the earth, external forces from space or human activities (Lemke, 2006). It is though important to observe how long the changes take place, the level of change and impact on the ecosystem is significant. Ayoade (2003) opined that secular climate change that occurs over a period of ten to fifteen decades may not satisfy as an in climate change if conditions will quickly reverses,

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however, climate change usually occurs for a long time of at least 150 years with a clear and permanent impacts on the ecosystem.

The earth's climate change and cool for millions of years, as observed from historical temperature data of earth surface (Solomon, 2007). The rising temperature of the earth since the beginning of the 20th century, especially after the inception of industrial revolution made scientist to relate the man-made emission of CO_2 and other gases of greenhouse for being responsible for the contemporary changes in climate. This increase in temperature as a result of human activities and the resulting climate change is either directly or indirectly causing the rising see levels around the world, frequent and uneven precipitation distribution, flash flooding, prolonged drought, glacial melting, tropical cyclones, hurricanes, severe dust storms, dry and cold seasons have altered availability of water and its quality, impacted the plants and land use pattern and many other environmental impacts (Alam and Rabbani, 2007).

A detailed comprehension of the previous and future pattern of climate change is realised by scientific researchers using theoretical models and observations to compare previous climate data, make futuristic projections and connect the causes and effect to the climate change (Salma *et al*., 2017). Mann and Jones (2003) revealed the mean surface temperature over the past 2000 years and observed that the high temperature experienced in the late 20th century was unprecedented and attributed to human activities leading to climate change.

Jones (2001) observed that since the 19th century, average global surface temperature has been recording an increase of approximately 0.6^0C ± 0.2 (95 percent confidence interval). In the 20th century, an increase in the world temperature has been reported in two time period between 1910 to 1945 and 1976 to 2001. Solomon (2007) reported that the temperature from 1976 (0.76^oC/ decade) was slightly higher, as compared to the time period between 1910 and 1945. More so, foreseen temperature rise is expected in order of 1.4^oC to 5.8^oC over the 21st century, given that the green-house gases emission continues (Folland *et al.,* 1999; Salman *et al.,* 2017). Change in climate change being observed within last 60 years is the warmest in the past hundred decdes (Dodman, 2007).

Since incidence of the world average records from 1856, the period between 2000 to2010has been recorded the warmest (Salman, 2017). The National Oceanic and Atmospheric Administration, NOAA (2010) of Pakistan recorded that there has been an increasing trend in the trend in mean November and December temperature by 2^oC to 1.5^oC respectively from 1876. Mean humidity in December has also been increasing since 1950.

Empirical studies have been conducted on climate change effects have been conducted. For instance, For instance, Adeleke and Omoboyeje (2016) assessed the effect of climate change on aquaculture production and management, they concerned their work on farmer's perception of the effect of climate change on farming, Otene *et al*. (2020), worked on the perceived effects of climate change among rubber farmers. The work is limited to Edo state of Nigeria and concluded that climate change affect significantly affect rubber production. This study is however concerned with the growth rate and direction of Nigeria climate change: 1990-2019 a research gap to fill. The specific objectives are to:

i. Examine the growth of climate change (rainfall, temperature and humidity)
ii. Examine the direction of growth of climate change variables (rainfall, temperature and humidity)

2. MATERIALS AND METHODS

The study was carried out in Nigeria as the study area. The federal republic of Nigeria is located in West Africa between latitude 4^0N and longitude 3^0E -15^0 E. It is bordered by the Gulf of Guinea to the South, Benin to the West, Niger to the North, Cameroun and Chad to the East. Nigeria comprises of 36 states and its Federal Capital Territory, Abuja.

Secondary data were used for the study, a time series data on rainfall, temperature and humidity Growth rate model and graphical trend analysis was used to examine the growth of rainfall, temperature and humidity. The quadratic trend model was used to examine the direction of growth of rainfall, temperature and humidity (objective 1 and 2).

Model specification

The model of the KPSS test with the constant term and trend is as follows:

$$\text{KPSS}= T^{-2} \sum_{t-1}^{\gamma} S_t^2 / \hat{\sigma}_{\infty}^2 \quad (1)$$

where t= 1, 2,…,n

T is the number of observations

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$S_t = \sum_{j-1}^{t} \hat{\omega}_j$ (2)

$\hat{\omega}_j = Y_t - \bar{Y}$ is the residual of y_t and j

$\hat{\sigma}_{\infty}^{2} = \lim_{t\to\infty} T^{-1} VAR\,(\sum_{t-1}^{T} \varepsilon_t)$ is a constant estimate if the calculated test is higher than the critical value of significance of 5 percent.

Growth model

Growth or trend model was used to ascertain the direction and growth rates of variables of interest. The trend equation is given as:

$Y_t = Y_0(1+r)^t$ (3)

where:

Y_t = rainfall, temperature and humidity in year t

Y_0 = rainfall, temperature and humidity in the base year.

R = Compound rate of growth of Y,

t = time trend variable

By taking the natural logarithm of both sides, the linear form of the equation was obtained making it amenable to OLS as:

$\ln Y_t = \ln Y_0 + t\ln(1+r)$ (4)

Substituting in $\ln Y_0$ with α and In(1+r) with β, equation (4) is rewritten as

$\ln Y_t = \alpha + \beta_t$ (5)

Adding the disturbance or error term to equation (5), we obtain

$\ln Y_t = \alpha + \beta_t + U_t$ (6)

Equation (6) is the growth rate model developed for this study.

For the variables of interest, equation (6) which is an exponential growth model can be specifically stated as follows:

$\ln Temp_t = \alpha + \beta_{Temp}t + \mu_t$ (7)

$\ln Rhum_t = \alpha + \beta_{Rhum}t + \mu_t$ (8)

$\ln Rain_t = \alpha + \beta_{Rain}t + \mu_t$ (9)

where:

Temp, Rhum and Rain represents temperature, humidity and rainfall respectively.

A = intercept

β = vector of the trend variable and μ is the econometric error term.

β_{Temp}, β_{Rhum}, β_{Rain}= coefficients of the trend variable for aquaculture demand-supply gap, temperature, humidity and rainfall respectively

The parameter of utmost interest in equations (6-9) is coefficient of β, the slope coefficient which measures the constant proportional/relative change in the dependent variables for a given absolute change in the value of the regressor t.

Firstly, multiplying β by 100, gives the instantaneous growth rate (IGR) at a point in time.

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$$IGR = \beta \times 100 \tag{10}$$

where:
IGR = Instantaneous growth rate and
β = is the least-square estimate of the slope coefficient

Secondly, the compound growth rate (CGR) in percentage in each of the four cases can be recovered from the equations 12- 15 in the following manner:

$$CGR = (e^{\beta i} -1)*100 \tag{11}$$

where:
β_i = the coefficient of the trend variable in the respective cases
e= Euler's exponential constant (=2.71828)

In order to estimate the direction or pattern of growth so as to determine whether there is acceleration, deceleration or stagnation, quadratic trend equation was fitted as follows:

$$\ln Y_t = \beta_o + \beta_1 t_i + \beta_2 t_i^2 + ut \tag{12}$$

All variables are as previously defined, β_o, β_1 and β_2 are parameters to be estimated. In the specification of equation 13, the linear and quadratic time terms indicate the circular path in the dependent variable (Y_t). The quadratic time variable (t^2) 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 (i.e. coefficient of t_i^2) which reveals a measure of the growth pattern following Isah *et al.* (2015) and Maikasuwa and Ala (2013).

Finally, in equation 12, if β_2 is positive and statistically significant growth acceleration occurs, 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.

3. RESULTS AND DISCUSSION

Unit root test

The KPSS test for unit root was employed to test whether or not a variable is stationary and also to determine the order at which the variable are integrated (table 3). The null hypothesis of the KPSS test is that the series of interest is stationary; hence if we reject the null hypothesis, it implies that the variable is not stationary. The result indicated all the variables were integrated at order one and stationary at first difference this implies that the variables exhibit random walk (unit root) or the future values of these variables do not converge from the past values.

Table 1. KPSS Unit Root Test

	Level		**First difference**		**Inference**
Variable	**LM-stat**	**Prob.**	**LM-stat**	**Prob**	
Humidity	0.579	0.000	0.2974	0.713	1(1)
Temperature	0.404	0.000	0.2184	0.664	1(1)
Rainfall	0.643	0.000	0.217	0.782	1(1)

Source: Data Analysis, 2021

Growth rate and direction of humidity

The results of growth rate and direction of humidity are presented in table 2. The linear, exponential and quadratic trend equations were estimated. The coefficient of multiple determination (R^2) value of 0.476 in the quadratic model for example implies 47.6 percent of the variations in the trend of humidity were explained over time by the trend variable. The result revealed that the coefficient of the trend variable in the humidity growth process in the exponential model was negative (-0.002) and significant at 1 percent. This gives rise to an instantaneous growth rate was -0.20 percent suggesting that there has been a 0.20 percent per annum

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decrease in humidity for the period 1990-2019. The compound growth rate of humidity particularly during the period 1990-2019 was also -0.20 percent.

The direction or pattern of growth process from the quadratic term (t^2) as shown in table 5 revealed that the value of the coefficient of t^2 for humidity was negative (-0.002) and not significant at any conventional levels implying stagnancy in the growth process of humidity.

This is contrary to the findings of National Oceanic and Atmospheric Administration, (2010) of Pakistan which posited that the mean humidity has been increasing since 1950.

Table 2: Growth Rate and Direction of Humidity

Model	Exponential		Quadratic		
Determinants	Trend	Constant	Trend	Trend^2	constant
Coefficient	-0.002	4.421	-0.072	-0.002	82.914
t-stat	-4.979	798.873	-0.105	-0.602	125.988
Prob	0.000	0.000	0.502	0.552	0.000
R^2	0.470		0.476		
AIC	-5.426		3.430		
F-stat	24.800		12.195		
Prob	0.000		0.000		
IGR(%)	-0.200				
CGR(%)	-0.200				

Source: Data Analysis, 2021.

Growth rate and direction of temperature

The results of the growth rate and direction of temperature are shown in table 3. The exponential and quadratic trend equations were estimated. The result revealed that the trend coefficient in the temperature exponential model was positive (0.001) and significant at 1 percent. Therefore, the instantaneous growth rate was 0.1 percent suggesting that there has been a 0.1 percent per annum increases in temperature for the period of study. The compound growth rate of temperature was 0.1 percent. This implies a relatively slow process of growth in temperature particularly during the period 1990-2019. The coefficient of multiple determination (R^2) value of 0.671in the quadratic model for example implying that 67.08 percent of the variations in the trend of temperature was explained over time by the trend model.

The direction or pattern of growth process from the quadratic term (t^2) as shown in table 6 revealed that the value of the coefficient t^2 for temperature (-0.001) was negative and significant at 5% implying a decelerating growth in temperature. This is in contrast to the findings of Alam and Rabbani (2007), Salman *et al*. (2017) who posited that global surface temperature have been increasing. However, Caitlyn (2018) found out that the increase in world surface temperature from 1998-2012 has not been statistically significant; this finding lends a support to the findings from this study. The reasons for the lack of significant or decelerating temperature of the earth surface in the past decades is that natural climate cycles – a series of La Nina events and a negative phase of the lesser-known pacific decadal oscillation caused shifts in ocean circulation patterns that moved some excess heat into the deep ocean (Caitlyn, 2018).

Table 3: Growth Rate and Direction of Temperature

Model	Exponential		Quadratic		
Determinants	Trend	Constant	Trend	Trend^2	Constant
Coefficient	0.001	3.289	0.072	-0.001	26.635
t-stat	6.707	1033.456	3.830	-2.065	226.999
Prob	0.000	0.000	0.001	0.049	0.000

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R^2	0.616	0.671
AIC	0.653	-0.018
F-stat	44.995	27.518
Prob	0.000	0.000
IGR(%)	0.100	
CGR(%)	0.100	

Source: Data Analysis, 2021.

Growth rate and direction of rainfall

The results of the growth rate and direction of rainfall are presented in table 4. The exponential and quadratic trend equation estimated. The result revealed that the coefficient for estimating the growth rate was (-0.004) and significant at 1 percent. Thus, both the instantaneous and compound growth rates were-0.4 percent suggesting that there has been a 0.4percent per annum decrease in rainfall for the study period. The coefficient of multiple determination (R^2) value of 0.292 implies that 29.28 percent of the variations in the trend of rainfall is explained over time by the trend model.

The direction of growth processes from the quadratic term (t^2) as shown in table 6 revealed that the value of the coefficient of t^2 for rainfall (0.001) was positive and significant at 5 percent implying that there is an accelerating growth in rainfall. This is contrary to the findings of Alam and Rabbani (2007) who found that rainfall pattern is fluctuating and decreasing over the years but in line with the finding of Iliya and Emmanuel (2017) who found out that rainfall has been increasing at a rate of 0.56 percent annually in Nigeria.

Table 4: Growth Rate and Direction of Rainfall

Model	Exponential		Quadratic			Linear	
Determinants	Trend	constant	Trend	Trend^2	constant	Trend	Constant
Coefficient	-0.004	7.197	-0.018	0.001	7.265	-4.667	1341.614
t-stat	249.885	-2.033	-2.991	2.505	190.890	-2.134	36.330
Prob	0.000	0.0517	0.006	0.0186	0.000	0.0417	0.000
R^2	0.619		0.293		0.293	0.139	
AIC	-2.128		-2.270			12.181	
F-stat	4.132		5.591			4.556	
Prob	0.000		0.009			0.042	
IGR(%)	-0.400						
CGR(%)	-0.401						

Source: Data Analysis, 2021.

4. CONCLUSION AND RECOMMENDATION

The study concludes that temperature has positive growth rates while humidity and rainfall have negative growth rates. Further, the direction of growth processes showed a decelerating growth process for temperature, a stagnating growth process for humidity and an accelerating growth process for rainfall. Bases on the research findings, it is recommended that the government should encourage eco-friendly industrial activities such as the use of solar powered machineries and hydro-power to help reduce the volume of greenhouse gases emission and balance the climate change parameters. The government should also monitor existing policies on environmental control and protection to ensure they are actually fulfilling their essence. The monitoring could be in form of appraisal; finding out if there is compliance with environmental control rule and prosecute defaulters where and when necessary.

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Conflict of Interest

The author declares that they have no conflict of interest.

Data and materials availability

All data associated with this study are present in the paper.

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