Trend Analysis of Rainfall in Nigeria by some States from 2002 to 2012

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Abstract: The issues concerning global warming/climate change cannot be over emphasized since it affects virtually every part of live. The pattern of rainfall in Nigeria using data on the average rainfall for a period of eleven years was examined. The result showed a continuous increase in the pattern of rainfall for a period of five years within the period under study. However the pattern was inconsistence for the remaining year with some kind of fluctuations. Sequence plot showed a clear presence of trend with the peak period being the seventh year corresponding to 2008 within the period under study. Analysis result shows that the test is significance with p-value of 0.006 and coefficient of determination - R2 value of 0.581. The model built was used to make predictions for a period of six years ahead; which shows continuous increase in the pattern of rainfall based on the available data. The irregularity in the pattern of rainfall calls for serious commitment in joining the force for climate change abatement process.

Keyword: Agriculture, Climate change, Economy, Fluctuations, Farming, Rainfall, Trend,

INTRODUCTION

More than ever before, the issue of climate change has become more threatening, not only to the sustainable development for social economics, (including agricultural) activities of any nation but to the totality of human existence. This consequently informed the response of the United Nations General Assembly in 1990, the inter-governmental negotiating committee that drafted, negotiated and subsequently adopted the United Nations Framework Convention on Climate Change (UNFCCC) on 9th May, 1992. When opened for signature in June 1992, Nigeria was among the first set of 165 countries that signed the convention which entered into force on 21st March 1994. Nigeria ratified the convention on 29th August 1994.

Article 1 of the convention clearly defined climate system as the totality of the atmosphere, hydrosphere, biosphere, geo-sphere and their interaction with human beings. The average state of the climate system is controlled by forces extended to this system. The external forces include solar variability, astronomical effects, tectonic processes and volcanic eruptions while the internal radioactive forces include atmosphere composition and cloud cover.

Climate change impacts depend on average of climate parameters changes and on the country's social, cultural, geographical and economic backgrounds. The location and size of Nigeria give rise to a variety of climates ranging from tropical rainforests climate along the coast to the Sahel climate to the Northern parts of the country. The climate of the country strides from a very wet coastal area with annual rainfall greater than 3500mm to the Sahel region in the North-Western and North-eastern parts with annual rainfall less than 600mm. the inter-annual variability of rainfall, particularly in the Northern parts is large, often resulting in climate hazards especially floods and droughts with their devastating effects on food production and associated sufferings. More often, some parts of Nigeria receive less than 75% of their annual rainfall and this is peculiar to the North.

Since 1970s, there has been the existence of atmospheric imbalance; the world has been passing through a regime of climate change patterns. There are beliefs of global variability in pattern of precipitation. Weather conditions have continued to change, more especially rainfall in the sub-Sahara African including South-eastern Nigeria. Many studies have shown that there exists clear inter-annual mean rainfall variability over sub-Sahara West Africa in recent years [1]. Studies have shown that rainfall changes over Nigeria have concentrated on countrywide averages; these have tended to disguise the regional discrepancy in the country's rainfall [2].[3].

The study by [4] on "Rainfall trends in Nigeria" analyzed Annual mean rainfall data of 28 meteorological stations in Nigeria from 1911-1980. His analysis indicated that in the first decade of 1971-1980 anomalies between -0.2 and -1.6 were predominant, in the second decade of 1981-1990, only five stations shows positive anomaly while greater portion of the country were normal with evidence of warming in the third decade of 1991-2000. His results further indicated that there have been statistically significant increases in precipitation and air temperature in vast majority of the country. The trend analyses suggest a sequence of alternately decreasing and increasing trends in mean annual precipitation and air temperature in Nigeria during the study period.

[5] examined the variations of rainy season rainfall over the Southern, Middle Belt, and Northern regions of Nigeria as well as the country as a whole over a 72-year secular period (1916–1987). He investigated the extent and nature of nonrandom changes, such as fluctuations, trend and persistence. The trend analysis showed a tendency towards decreasing seasonal rainfall totals in all the regions According to his evaluation, the Northern region and the country as a whole were significant; no significant persistence was evident in any of the regions during this secular period. Based on the aforementioned, this study intends to forecast the mean annual rainfall in Nigeria and to identify the year with maximum rainfall and the area mostly affected.

METHODOLOGY

The data for this study were collected from the Nigerian metrological agency (NIMET), on rainfall according to geopolitical zones for a period of eleven year starting from 2002 to 2012. The data are tabulated as follows

TABLE 1 DATA ON ANNUAL RAINFALL (MM) IN NIGERIA BY STATES FROM 2002-2012.

Year / States	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total	Mean
Abia	114.5	140.6	125.1	125.3	171.7	135.5	144.2	1980.1	2201.5	221.4	980.1	6340	1056.7
Adamawa	935.1	1043.9	960.4	865.7	1057.3	827.4	468.5	718.1	1204.1	304.2	245.3	8630	1438.3
Akwa Ibom	1391.3	1152.1	1265.2	2711.8	2558.7	2532.2	2106.2	1911.7	1781.2	1540.1	1421.5	20372	3395.3
Anambra	105.1	134.5	122.3	159.7	1910.3	2026.8	2056.7	2273.4	2292.1	1834.2	995.1	1391.2	2318.4
Bauchi	131.6	1122.6	900.2	1104.5	1017.9	1136.9	1133.1	1621.3	1852.6	1973.4	1194.6	13188.7	2198.2
Bayelsa													
Benue	1158.9	871.9	1308.7	871.3	1343.0	1339.9	1050.7	1401.5	1102.1	189.7	894.3	11532	1922
Borno	630.5	534.8	406.9	971.3	553.7	1076.3	600.9	587.5	1842.0	945.3	615.3	8764.5	1460.8
Cross River	3218.8	2722.6	3424.8	3862.1	8896.8	3427.9	3060.8	2521.8	2941.2	1849.6	3245.2	39171.6	6528.6
Delta	1664.1	1486.3	1275.2	1756.4	1906.4	1802.4	1765.1	1765.8	2645.1	1469.3	1185.6	18721.7	3120.3
Ebonyi													
Edo	2200.6	2018.7	2201.5	2014.0	2358.5	2647.8	2670.0	2122.6	2956.5	2645.3	1567.6	25403.1	4233.9
Ekiti	732.6	216.5	564.3	114.6	109.7	123.8	846.5	108.9	897.5	846.5	124.8	4685.7	780.95
Enugu	1990.9	1463.2	1907.5	1697.4	2096.3	1911.2	1738.4	1757.2	1956.5	1546.3	1278.1	19343	3223.8
Gombe	346.2	726.4	565.8	975.5	955.4	833.6	985.9	346.2	967.8	764.3	568.9	8036	1339.3
Imo	2691.5	2527.3	2476.6	2247.2	2350.2	2362.1	2818.0	2738.0	2945.3	2521.3	456.7	25677.5	4668.7

Jigawa													
Kaduna	744	889.3	1240.8	994.2	88.7	865.0	827.9	1267.9	1842.3	1674.2	1805.1	12239.4	2039.9
Kanu	570.5	1397.8	1289.3	14.7	109.1	13.1	109.0	246.3	124.8	253.1	182.6	4310.3	718.8
Katsina	413.2	156.3	473.2	750.6	726.5	704.1	557.1	473.8	384.2	456.3	256.8	5352.1	892.2
Kebi	164.3	186.3	135.2	1025.0	959.2	886.9	1223.0	1196.0	1943.2	1675.2	1328.1	10722.4	1787.1
Kogi	386.2	746.8	538.4	939.4	1681.9	1531.4	1259.7	1631.5	1489.2	1813.2	7563.2	19580.9	3263.4
Kwara	745.5	1349.5	1334.4	1234.9	1303.8	1308.8	1468.5	1322.3	1567.4	1265.3	1803.2	14703.6	2450.6
Lagos	1649.1	1039.9	2019.9	1484.9	1675.2	1649.1	1816.0	1391.7	1984.7	1764.3	1458.1	17932.9	2988.9
Nasarawa	568.2	1165.5	845.3	1290.7	1320.1	1569.6	1072.8	1566.0	456.3	184.3	1245.5	20930.3	3488.4
Niger	1690.4	1237.3	940.2	110.7	1423.2	1423.3	1269.2	1421.6	1542.3	1364.2	1145.6	13568	2261.3
Ogun	1471.6	1118.4	1254.9	924.2	1142.1	876.2	1371.7	1465.5	1843.2	1863.4	1584.3	14915.5	2486.0
Ondo	180.1	1406.8	1509.5	1317.1	1318.1	1405.7	1466.1	1309.6	1578.1	1643.2	1346.4	14480.7	2413.5
Osun	1293.5	1021.1	1164.2	1130.2	1469.7	1421.7	1597.6	1277.7	1956.4	1765.8	1946.5	16044.4	2674.1
Oyo	1105.1	1022.7	1294.9	1192.0	1260.2	1218.8	889.4	1702.1	1945.6	1874.2	1346.2	14851.2	2475.2
Plateau	436.2	1261.3	1329.3	1203.5	1248.4	1357.2	1259.8	1236.9	1456.7	1863.4	1734.1	14386.8	2397.8
Rivers	1065.9	232.2	2334.8	2055.2	2868.6	2865.2	1606.6	2601.6	2845.3	2654.2	2456.3	23585.9	3931.0
Sokoto	714.8	845.9	645.5	635.1	745.5	636.4	514.6	603.0	724.5	456.3	856.5	7378.1	1229.7
Taraba	234.2	708.3	567.4	872.0	923.6	1070.6	1038.4	1569.1	1784.2	1672.5	1573.9	12014.2	2002.4
Yobe	124.2	264.3	189.5	448.6	409.5	483.1	320.3	366.5	394.2	435.1	482.0	3917.3	652.9
Zamfara	285.6	783.2	562.1	920.3	961.8	615.8	954.0	1006.0	934.5	801.2	346.1	8170.6	1361.8
Fct Abuja	1021.8	1367.4	1257.9	1471.8	1311.6	1388.9	1174.7	1444.6	1948.8	1462.5	1168.3	15018.3	2503.1
Total	3218.1	3436.7	3843.2	3949.9	5023.7	4547.7	5288.4	4695.8	5633.4	4559.8	4595.2		
Mean	1838.6	1963.5	2196.1	2256.7	2870.4	2598.6	3022.1	2683.1	3218.9	2605.3	2702.7		

From table 1 above it can be observed that the annual mean rainfall ranges between 18389mm to 3219mm. There was a steady increase for a period of five years within the years under study (2002 -2006); it then fluctuated for the rest of the years with maximum level in 2010.

To determining the trend over the years, using the least square model stated as

$$y_t = a + b_t \qquad (1)$$

Where, Y_t= the trend value for a given time period a = the intercept on Y_t= (i.e the trend line value at t = 0) b = the gradient or slope of the trend line t = independent variable (unit of time). To determine the presence of trend on the data over the years, a sequence plot is as shown on figure 1 below

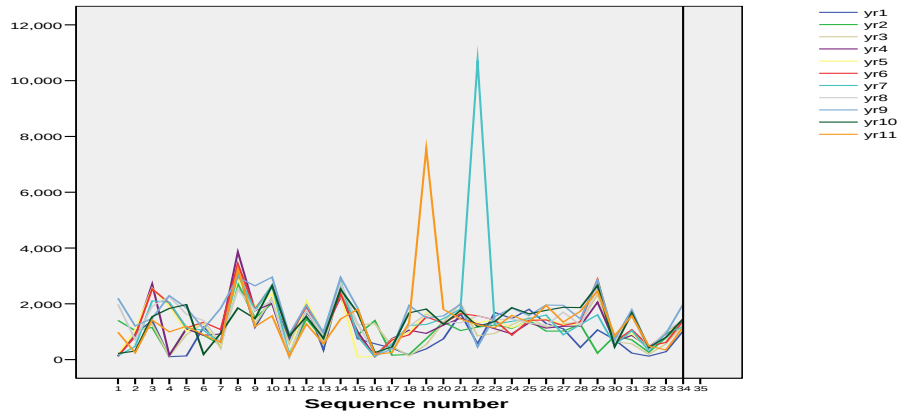

Fig.1. Sequence plot of the annual rainfall (mm); for the states over the years, within the period under study.

Figure 1 above clearly indicates existence of trend in the annual rainfall over the years. The peak period was year 7 which corresponds to 2008, followed by year 11 corresponding to 2012. The sequence number corresponding to states where data is available shows that Lagos state had the greater level of rainfall in 2008.

To predict for future rainfall level in the subsequent years based on the knowledge of current trend; considering the mean rainfall over the year irrespective of the state, linear regression analysis was considered and the data are as presented on table 2 below. Using the data on table 2 SPSS the analysis gave the following results as presented on table 3 below:

TABLE 2: Annual Mean Rainfall over the years

Years	t	y
2002	1	1838.6
2003	2	1963.5
2004	3	2196.1
2005	4	2256.7
2006	5	2870.4
2007	6	2598.6
2008	7	3022.1
2009	8	2683.1
2010	9	3218.9
2011	10	2605.3
2012	11	2702.7
Total	66	2541.456

Table 3 Linear Regression Analysis Result

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square	F Change	df1	df2	Sig. F

					Change				Change
1	.762(a)	.581	.534	295.86402	.581	12.476	1	9	.006

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1092134.112	1	1092134.112	12.476	.006(a)
	Residual	787819.655	9	87535.517		
	Total	1879953.767	10			

a Predictors: (Constant), Years
b Dependent Variable: Rainfall

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta	B	Std. Error
1	(Constant)	1943.604	191.326		10.159	.000
	Years	99.642	28.210	.762	3.532	.006

From the analysis result on table 3 above, R^2 of 0.581 gave a good fit also the test is significant with p-value of 0.006. This shows that the model built with the variables can be used for prediction. The estimated trend equation is given as

$$\widehat{y_t} = a + b_t \qquad (2)$$

Substituting yields

$$\widehat{y_t} = 1943.604 + 99.642t \qquad (3)$$

Using the model in eqn.(3) above to forecast for a period of six years starting from 2015 to 2020 ,

$\widehat{y_{2015}} = 1943.604 + 99.642 * 14 = 3338.592$
$\widehat{y_{2016}} = 1943.604 + 99.642 * 15 = 3438.234$
$\widehat{y_{2017}} = 1943.604 + 99.642 * 16 = 3537.876$
$\widehat{y_{2018}} = 1943.604 + 99.642 * 17 = 3637.518$
$\widehat{y_{2019}} = 1943.604 + 99.642 * 18 = 3737.160$
$\widehat{y_{2020}} = 1943.604 + 99.642 * 19 = 3836.802$

The forecasted values above show a continuous increase in future rainfall.

ANALYSIS

From the results above, this study agrees with the previous studies cited on the literature that rainfall in Nigeria does not follow a regular pattern rather it fluctuates over the years. This anomaly could be attributed to the effect of global warming which causes atmospheric imbalance. This irregularity will have some negative effect on farmers in the country, since they depend so

much on rainy season for their agricultural yield. This in one way or the other affects the populace as there could be scarcity of food some times. Farmers are not certain on the outcome of each year's rainfall, at time it may result to massive flooding which could destroy their farms or there may be a period of scanty rain which equally affects their farm yield. This in turn affects the economy of the nation negatively.

CONCLUSION

Based on the data available for this study, it has been clearly observed that the average rainfall pattern in Nigeria is not certain; hence farmers and other people who depend on the rainfall outcome for their economic activities cannot make good predictions. This has serious effect on the wellbeing of every Nigerian and generally affects the economy of the country. There cannot be a better alternative than to join in the global warming abatement process. If irrigation process is considered as an alternative to the period of scanty, one wonders what will be the alternative in the period of massive flooding.
Therefore, this study suggests commitment on everybody towards taking climate change issues serious.

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