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STATISTICAL ANALYSIS OF RAINFALL TREND IN AKURE, ONDO STATE, NIGERIA

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Abstract: The pattern of rainfall in Akure has been haphazard, because it has not followed its natural trend for a long time as a result of climate change effect. This research aimed to examine the trend of rainfall in Akure using 50 years rainfall data. Data was collected from the Nigerian Meteorological Agency, Oshodi, Lagos state, Nigeria. Descriptive statistics (mean and standard deviation) and inferential statistics (time series and correlation analysis) were used to analyse the data. The results from time series analysis showed that rainfall fluctuated in an upward trend through the period of study. The predicted rainfall for 2016 - 2045 indicated a positive trend of (+0.274), meaning that rainfall will increase in intensity, number of raining-days and duration. The study equally revealed a significant increase in rainfall trend for Akure between 1966 and 2015. The study therefore, recommended that flood forecasting and early warning should be adhered to by all stakeholders. Flood prevention through effective urban planning and provision of relief materials to the victims of environmental disasters should be encouraged.

Key words: Climate, Rainfall, Statistics, Environment, Planning, Prediction, Trends,

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INTRODUCTION

Rainfall is described as the most significant climatic feature in Africa and hence can be used as an index of climate change. Rainfall is an element of climate required by man in moderate form, its surplus causes flood while its deficit results in drought of varying magnitudes, these two climatic extremes have their numerous adverse effects man and his daily activities.

Rainfall is the most important natural factor that determines the agricultural production in Nigeria, particularly in the South western part of Nigeria. The variability of rainfall and the pattern of extreme high or low precipitation are very important for agriculture as well as the economy of the state. It is well established that the rainfall is changing on both the global and the regional scales due to global warming (Hulme et al., 1998; Kayano, 2008). As the moves to encourage agriculture to ensure food security continues to gain ground and acceptability, information on

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rainfall probabilities is vital for the design of water supply and supplemental irrigation schemes and the evaluation of alternative cropping and of soil water management plans. Such information can also be beneficial in determining the best plant species and the optimum time of seeding to reestablish vegetation on deteriorated rangelands. Much as long rainfall records are mostly available in many countries, little use is made of this information because of the unwieldy nature of the records (Mina and Sayedul, 2012).

Babatolu (2002) however noticed that rainfall distribution of Ondo during the period of study (1961-2000) showed wide variability. The highest rainfall figure in the decade was recorded in 1963 (2,440.94 mm) and the lowest was recorded in 1997 (1,217.10 mm). The rains decreased generally in the last decade (1991-2000), meaning that rainfall distribution along the axis of Ondo and Benin is quite varied (Ikhilek and Aifesehi, 2011). Although, Olaniran (2002) agreed that the likelihood of flooding in the southwestern Nigeria is as a result of abundant of rainfall received by the region especially Ondo and Ado flooding in 1999. He further explained that flooding is common in these areas in the month of July as evidence that the area is experiencing normal rainfall but not in rainfall frequency.

Olaniran (2001) concluded that there has been a progressive early retreat of rainfall over Nigeria up to half a century now and consistent with this pattern with decline in frequency of rainfall. This pattern is as a result of noticeable changes in the beginning and end of rainy season in recent times in Nigeria. Odjugo (2010), Oguntude et al., (2012) separately reported that spatial and temporal variations in temperatures were noticed in Nigeria where air temperature has been on the increase gradually since 1901 and with a noticeable increase from 1970. Igwenagwu (2015) find that the average annual rainfall in coastal area of Enugu is around 2000 mm as a result of heavy rainfall amount received during raining season. Humid tropical rainfall is characterised by torrential downpours of short duration and little spatial extent which occur mostly in the afternoon and late evening (Ayoade, 2002).

The Earth's climate is dynamic and naturally varies on seasonal, decadal, centennial, and longer timescales. Each *"up and down"* fluctuation can lead to conditions which are warmer or colder, wetter or drier, more stormy or quiescent (NOAA, 2007). These changes in climate may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (Bates et al., 2008). Climate change seems to be the foremost global challenge facing humans at the moment, even though it seems that not all places on the globe are affected.

Babatolu (2002) studied spatial distribution of rainfall in Ondo State, (Olaniran, 1990) investigated climate change in Nigeria, variation in rainfall receipt per rain - day and observed that there has been a progressive early retreat of rainfall over the whole country, and consistent with this pattern, reported a significant decline of rainfall frequency in September and October which, respectively coincide with the end of the rainy season in the northern and central parts of the country. Climate variability has been noted to arise as a result of changing rainfall pattern, some regions have experienced marked decline in rainfall patterns depending on the location. For state whose economy largely depends on efficient and productive rain-fed agriculture, rainfall patterns and trends are often quoted as one of the major causes of several socio - economic problems like food insecurity in the state (Ekwe et al., 2014).

STUDY AREA

Akure lies on Latitude $7^{o}15'0''$N and longitude $5^{0}11'42''$ E, it is the capital of Ondo state. It falls in the tropical climate and belongs to the equatorial rain forest belt, it has an average rainfall of 1524 mm annually, the rainy season last for 7 months (April - October) and the temperature range between 24^{o} C and 31^{o} C with an average temperature of 27.5^{o} C. Akure is located in the rainforest vegetation belt of Nigeria (figure 1, 2).

Akure Metropolis is underlain by four of the six petrological units of the Basement Complex of southwestern Nigeria as identified by Rahaman (1988). The drainage pattern of Akure is dendritic; it is drained by River Ala, River Owena and River Ogburugburu.

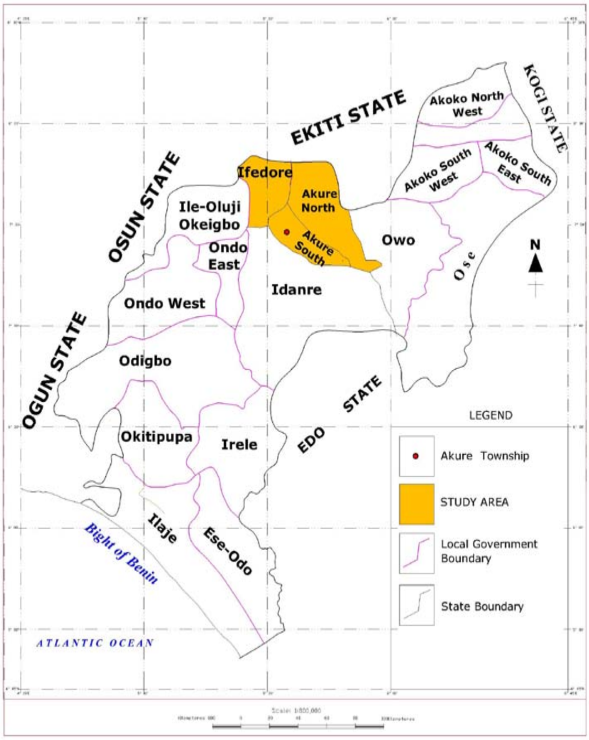

Figure 1. Map of Ondo showing Akure
Source: Ondo State Ministry of Lands and Survey, Akure (2014)

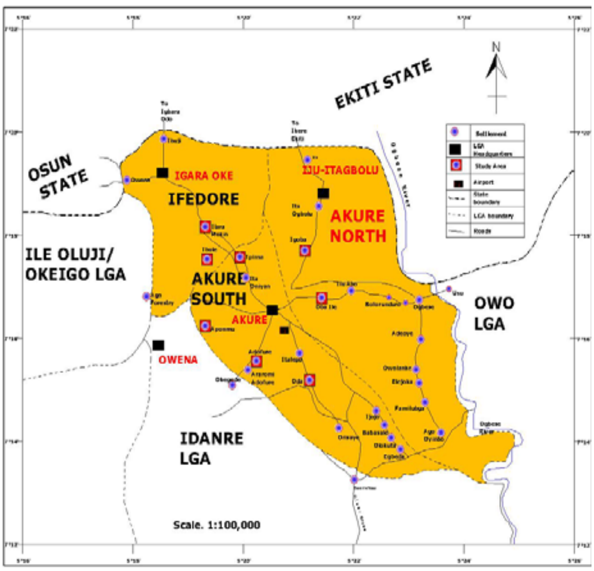

Figure 2. Map of Akure
Source: Ondo State Ministry of Lands and Survey, Akure (2014)

MATERIALS AND METHODS

The type of data required for this research is rainfall data measured in millimeters (mm) collated for twelve (12) months of the year. Rainfall data that spanned 50 years from (1966 to 2015) was collected for the study area and these were sourced from the archival records of the Nigerian Meteorological Agency (NIMET) Headquarters, Oshodi, Lagos State, Nigeria. The statistical methods employed were both descriptive and inferential statistics. Descriptive statistics employed includes mean and standard deviation. Inferential statistics involved time series and correlation analysis. Results of the study were presented using tables and charts.

RESULTS AND DISCUSSION

Mean Annual Rainfal in Akure between 1966 - 2015

As showed in table 1, rainfall received in the study area from 1966 - 1975 varies, the lowest rainfall was experienced in 1972 with 105.9 mm while the highest rainfall was experienced in 1968 with 186.4 mm. In 1966, 1967, 1969 and 1970 the study area experienced 132 mm, 107.1 mm, 139.8 mm and 111.5 mm respectively while 1971, 1973, 1974 and 1975 experienced rainfall of 120.4 mm, 136.2 mm, 150.7 mm and 150.7 mm respectively. The mean rainfall experienced for the first decade (1966 - 1975) is 134.07 mm with a standard deviation of 24.83.

Table 1. Mean Annual Rainfall in Akure between 1966 – 2015
(Data source: Author's computation, 2016)

Year	Rainfall (mm)	Year	Rainfall (mm)	Year	Rainfall (mm)	Year	Rainfall (mm)	Year	Rainfall (mm)
1966	132	1976	106.3	1986	130.5	1996	146.7	2006	121.1
1967	107.1	1977	111.3	1987	122.1	1997	125.5	2007	133.1
1968	186.4	1978	171.3	1988	141.2	1998	135	2008	193.1
1969	139.8	1979	148.2	1989	160.8	1999	139.3	2009	135.1
1970	111.5	1980	172.5	1990	113.1	2000	141.4	2010	170.3
1971	120.4	1981	115.2	1991	231	2001	133.4	2011	142.2
1972	105.9	1982	107.6	1992	138.2	2002	160.5	2012	132.6
1973	136.2	1983	104.8	1993	121.1	2003	151.6	2013	135.4
1974	150.7	1984	123.3	1994	150	2004	147	2014	134.6
1975	150.7	1985	231.1	1995	167.9	2005	129.2	2015	144.8
Mean	**134.07**		**139.16**		**147.59**		**140.96**		**144.23**
STD	**24.83**		**41.55**		**34.18**		**10.74**		**21.39**

The lowest rainfall for the second decade (1976 - 1985) was experienced in 1983 with 104.4 mm while the highest rainfall was experienced in 1985 with 231.1 mm. Rainfall experienced in 1976, 1977, 1978 and 1979 was 106.3 mm, 111.3 mm, 171.3 mm and 148.2 mm respectively while rainfall experienced in 1980, 1981, 1982 and 1984 was 172.5 mm, 115.2 mm, 107.6 mm and 123.3 mm respectively. The mean rainfall recorded was 139.16 mm with a standard deviation of 41.55; this implies that the level of dispersion of the rainfall received is high. The lowest rainfall experienced in the third decade (1986 - 1995) was in 1990 with 113.1 mm while the highest rainfall was experienced in 1991 with 231 mm. In 1986, 1987, 1988 and 1989 rainfall experienced was 130.5 mm, 122.1 mm, 141.2 mm and 160.8 mm respectively while 1992, 1993, 1994 and 1995 experienced rainfall of 138.2 mm, 121.1 mm, 150 mm and 167.9 mm respectively. The mean rainfall experienced in the third decade (1986 - 1995) is 147.59 mm with a standard deviation of 34.18; this implies a deviation from the mean.

The lowest rainfall experienced in the fourth decade (1996 - 2005) was in 1997 with 125.5 mm while the highest rainfall was experienced in 2002 with 160.55 mm. Rainfall experienced in 1996, 1998, 1999 and 2000 was 146.7 mm, 135 mm, 139.3 mm and 141.4 mm while the rainfall experienced in 2001, 2003, 2004 and 2005 was 133.4 mm, 151.6 mm, 147 mm and 129.2 mm respectively. The mean rainfall experienced was140.96 mm with a standard deviation of 10.74;

this implies that the dispersion from the data is not much. From table the lowest rainfall for the fifth decade (2006 - 2015) was experienced in 2006 with 121.1mm while the highest rainfall was experienced in 2008 with 193.1mm.Rainfall experienced in 2007, 2009, 2010 and 2011 was 133.1 mm, 135.1 mm, 170.3 mm and 142.2 mm while rainfall experienced in 2012, 2013, 2014 and 2015 was 132.6 mm, 135.4 mm, 134.6 mm and 144.8 mm respectively. The mean rainfall experienced was 144.23 mm with a standard deviation of 21.29; this indicates the dispersion from the mean.

Possible explanations for these variations in the amount of mean annual rainfall for Akure could be as a result of a combination of the many factors such as relief of the area, the intensity of sunlight, surface of the area, vegetation of the area, wind etc. the intensity of the sun determines the rate of evapotranspiration and if it is high, rainfall will be high, the nature of the surface also determines rainfall, if the surface has vegetal cover, sunlight will be absorbed leaving little to be reflected but if the surface is bare, reflection will be high leading to an increase in the temperature of the area which in turns affects evapotranspiration. Wind also affects rainfall, the tropical maritime wind bring rainy season in the study area, if the wind is low, rainfall will be low and if the wind is high, rainfall will be high.

Trend in Mean Annual Rainfall for 1966 - 2015

The finding shown in table 2 indicates an increasing trend of rainfall for the observed period 50 years. Analysis carried out indicates a positive relationship (+0.2767) between rainfall and time (years). The result (r=0.145) also shows a positive correlation between rainfall and time, the trend of rainfall is being accounted for by a variation of 2.1% (R2) with a total variation of 0.1%.

Table 2. Trend of Rainfall between 1966 - 2015
(Data source: Author's computation, 2016)

Variable	1966-2015
Included observation	50
Linear Trend equation	Y_t=0.2767x+134.15
R	0.145
R^2	0.0211
R^2 adjusted	0.001

As shown in figure 3 the trend line of rainfall is upward sloping; this implies that there is an increase in the amount of rainfall received during the study period.

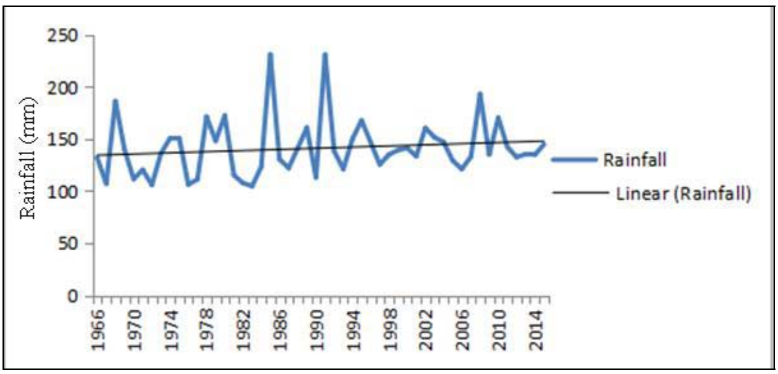

Figure 3. Trend of Annual Rainfall between 1966 – 2015
Source: Author's computation, 2016

Prediction for future Rainfall in the study area 2016 - 2045

Table 3 shows the projected mean of annual rainfall for the study area with a linear trend equation of Yt = 0.274+134.01. This shows that Akure will experience a predicted increase of 0.274 mm of rain annually, but about 6.9% decrease in rainfall in 2015. Using 2016 as a base line, it can be seen that an increase of rainfall of 0.21% is expected on an annual basis except some years with the exception of 0.31%.

Table 3. Predicted Rainfall
(Data source: Author's computation, 2016)

Year	Rainfall	Percentage increase or decrease from base year (%)
2016	134.29	- 6.97
2017	134.56	0.20
2018	134.87	0.23
2019	135.11	0.18
2020	135.38	0.19
2021	135.65	0.21
2022	135.93	0.19
2023	136.2	0.20
2024	136.47	0.19
2025	136.74	0.31
2026	137.17	0.08
2027	137.29	0.19
2028	137.56	0.20
2029	137.84	0.20
2030	138.11	0.19
2031	138.38	0.20
2032	138.65	0.20
2033	138.93	0.18
2034	139.19	0.20
2035	139.47	0.20
2036	139.74	0.19
2037	140.02	0.20
2038	140.29	0.20
2039	140.56	0.20
2040	140.83	0.19
2041	141.11	0.20
2042	141.55	0.31
2043	141.65	0.07
2044	141.92	0.20
2045	142.37	0.31

As shown in figure 4 the rainfall trend is upward sloping; this implies that there will be an increase in the annual rainfall received in the study area over the years for a period of 50 years.

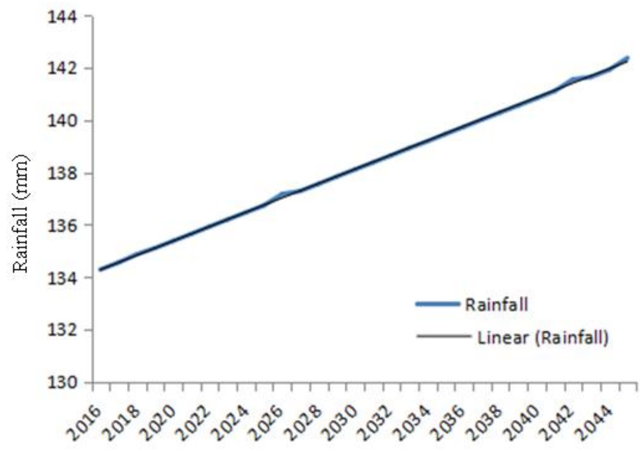

Figure 4. Predicted rainfall Trend from 2016 - 2045
Source: Author's computation, 2016

Due to the frequent flooding and drought episodes linked to rainfall in Nigeria over the past 60 years, an analysis of rainfall trend was carried out in Akure over a period of 50 years of 1966 - 2015. The aim of this research work is to examine the trends of rainfall in Akure. Descriptive analysis such as mean, standard deviation and time series analysis was employed to explain the findings in the rainfall trend of the study area, Regression and correlation analysis was also used to test the relationship between rainfall and time and rainfall amongst the decades. A plunge into the future through the aid of times series equation for a period of 50 years (2016 - 2045) has shown a forecast of increase rainfall in the study area

The results from the findings show that the third decade (1986 - 1995) recorded the highest mean annual rainfall of 147.59 mm which implies that there was an increase in agricultural produce and flooding incidence ought to occur as a result of high amount of rainfall, but none was recorded. While the first decade (1966 - 1975) recorded the lowest mean annual rainfall with 134.07 mm second, fourth and fifth decade recorded mean annual rainfall of 139.16 mm, 140.96 mm and 144.23 mm respectively. Analysis of trend line for the first decade (1966 - 1975) showed a linear equation of Yt=0.7961x+129.75, second decade (1976 - 1985) showed a linear equation of Yt=4.2158x+115.97, third decade (1986 - 1995) showed a linear equation of Yt=2.9182x+131.54, fourth decade (1996 - 2005) showed a linear equation of Yt=0.7976+136.57 while the fifth decade (2006 - 2015) showed a linear equation of Yt=0.6079x+147.57. Results also showed a linear trend equation for a period of 50years of Yt=0.2767+134.15.

The result of correlation also shows the relationship among rainfall in the decades, the result shows that second decade (r=0.453), third decade (r=0.090) and fifth decade (r = 0.512) shows a direct relationship with rainfall in the first decade, this implies that as rainfall increase in the first decade, it also increase in the second, third and fifth decade respectively.The study also shows the result third decade (r=0.084) and fifth decade (r=0.544) which is directly related to rainfall in the second decade and fourth decade (r = -0.480) which is inversely related to the second decade. The result shows fourth decade (r= -0.310) and fifth decade (r= -0.075) which is inversely related to third decade, as rainfall increase in third decade, it decrease in the fourth and fifth and finally, the result (r= -0.288) shows that there is a inverse relationship between the fourth and fifth decade.

The finding also showed a prediction of rainfall for 50 years (2016 - 2045), the result produced a trend line equation of Yt =0.274+134.01, it also showed an annual increase of rainfall of between 0.21% - 0.31% annually. This result showed that rainfall is going to increase in the study area.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the study revealed a significant increase in rainfall trends for Akure from year 1966 - 2015 a period of 30 years with a forecasted 50 years period from 2016 - 2045. Therefore, ceteris-paribus the significant increase witnessed in the area will strengthen in the future years to come. Meaning the study area would have more wet year in the future (more flood occurrence). The implication of these is that of a devastating impact on man and his ecosystem. The study recommends that disaster management, especially in relation to flooding, should be tilted beyond relief, rescue, rehabilitation and recovery to a new paradigm that stress on prevention, mitigation, preparedness and emergency response.

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