SPATIAL VARIATION OF RAINFALL IN GALMA, KADUNA CENTRAL AND MADA CATCHMENT AREAS OF KADUNA STATE, NIGERIA

Danbaba Goma
[1]Department of Environmental Management,
Faculty of Environmental sciences,
Bingham University, Kodape-Karu, Nigeria.
Email: danbaba.goma@binghamuni.edu.ng ; danbaba.goma@gmail.com
GSM No: 08067045111

Abstract
The rainfall data for Galma, Kaduna central and Mada catchment areas for the period 1984-2014 which is further projected to 2030 were used in this study to analyse the spatial variation of rainfall in the three catchment areas with a forecast to 2030 in Kaduna State. The rainfall data was obtained from Global Weather Data for SWAT (Soil Water Assessment Tools) since other studies have utilized rainfall data from the Nigerian Meteorological management agency (NIMET). Rainfall data were only available in SWAT platform till the end of 2014. The Data were collected from twelve (12) remotely sensed stations around Kaduna State. 10 years non-overlapping mean, Cramer's test and Auto-Regressive Integrated Moving Average (ARIMA) time series modeller fit the data used to achieve this aim. The results revealed that the mean annual rainfall of the study area decreased from 1733.4mm in Mada catchment area to 1203.5 mm in Galma and 1032.3 mm in Kaduna central catchment areas respectively. The annual rainfall shows that Mada catchment area (460.56mm) has the highest rate of increase in rainfall for the period under study. This is followed by the Galma catchment area (236.09 mm)with the least- Kaduna central catchment area (78.22mm). The annual increase in rainfall for Mada catchment area occur substantially in the months of July to September respectively while the increase in Galma catchment area happens in August. Findings from the 10 years non-overlapping sub-period analysis of both the monthly and annual rainfall revealed an upward increase in the last three decades for Mada and Galma catchment areas. The result further revealed that Mada and Galma catchment areas were significantly wet in the last 30 years while Kaduna central catchment area had a normal condition. The forecast rainfall indicated that Mada has returned values (336.84mm), followed by Kaduna central (309.74mm) and Galma catchment area (320.05mm) as the minimum and best model performance index. It is recommended that agricultural planning, water resources management and government policies in Kaduna State should be based on recent rainfall trends.

Keywords: Rainfall, Spatial variation, Catchment, Kaduna State, Nigeria.

Introduction

The variability in global climate indicates an alteration in either the mean state of climate or of its variability occurring for many decades or more. Rainfall is one of the most important fundamental parameters of climate as it determines the environmental condition of a particular region (Khavse *et al.*, 2015).The amount of rainfall received in an area is an important factor in determining the amount of water available to meet various demands, such as agricultural, industrial, domestic water supply and hydroelectric power generation. Therefore, global climate changes may influence long-term rainfall patterns impacting the availability of water, along with the danger of changes in the pattern of rainfall will possibly lead to drought or flooding (Jain and Kumar, 2012).

Rainfall variability receives higher attention among other climatic elements especially in relation to agriculture. The variability in rainfall can be explained spatially depending on the purpose needed (Song *et al.,* 2014). A better understanding of the spatial variations of rainfall on different time scales and the adjustment of specific theoretical models like models that generate design storms and models that allows for the simulation of continuous time series at a point or spatially distributed are important for many applications (Vernieuwe *et al.,* 2015). The resulting models will lead to a better management of a great variety of problems associated with variations in rainfall and will make it possible to improve statistical weather forecasts and climate monitoring (Penalbaa and Vargasa, 2008).

The West African region has experienced a marked decline in rainfall from 15 to 30% depending on the area (Niasse, 2005). The trend was abruptly interrupted by a return of adequate rainfall conditions in 1994. This was considered to be the wettest year of the past 30 years and was thought to perhaps indicate the end of drought. Unfortunately, dry conditions returned after 1994 (McCarthy *et al.*, 2001 cited in (Suleiman *et al.* 2021). Rainfall in Southern Africa is likely to decrease in much of the winter rainfall region and western margins. There is likely to be an increase in annual mean rainfall in East Africa (Christensen *et al.*, 2007). West Africa has experienced marked multi-decadal variability in rainfall. Wet conditions in the 1950s and 1960s gave way to drier conditions in the 1970s, 1980s and 1990s. The rainfall deficit in this region during 1970 to 1990 was spatially uniform. The decreasing rainfall and devastating droughts in the Sahel region during the last three decades of the 20th century are among the largest climate changes anywhere (Trenberth *et al,* 2007).

Rainfall in Nigeria has changed it is currently changing due to a wide range of different natural and anthropogenic factors which operate over a variety of time scales (Abaje *et al,* 2015). The pattern of rainfall in Northern Nigeria is highly variable in spatial and temporal dimensions with inter-annual variability of between 15% and 20% (Oladipo, 1993). An increase or decrease in rainfall has consequences on water resources and often results in extreme weather events such as floods or droughts, coupled with their devastating effects on food security and associated calamities and sufferings (Suleiman *et al.,* 2021).

Several studies have identified the characteristics of extreme rainfall that are associated with flood frequency to include duration, intensity, frequency, seasonality, variability, trend and fluctuations. Most of the recent researches are reviewed below:

Eludoyin(2009) studied monthly rainfall distribution in Nigeria between 1985-1994 and 1994-2004. The study noticed some fluctuations in most months within the decades. The trends, both annual and seasonal, showed increased tendency in rainfall during the period. Akinsanola & Ogunjobi (2014) studied rainfall and temperature variability in Nigeria using observations of air temperature and rainfall from 25 synoptic stations for a period of 30 years. Their finding indicated that there has been significant increase in precipitation and air temperature in vast majority of the country. (Ayansina & Ogunbo, 2009) also investigated the seasonal rainfall variability in guinea savanna part of Nigeria using three Meteorological stations data and concluded that rainfall variability continues to be on the increase as an element of climate change. Egbinola and Amobichukwu (2013) also focused on the assessment of climatic variation in Ibadan region based on the variation of rainfall within the period 1970-2012 using one Meteorological station's data. The result revealed that there is an upward trend in total rainfall within the period of study. Abaje *etal.* (2010) investigated the rainfall trend in Kafanchan from 1974-2008 using the relative seasonality index and one Meteorological station's data. Their investigation revealed rainfall regime for the area is markedly seasonal with long drier season. Abaje *et al*, (2018) analysed the spatial-temporal distribution of rainfall in Kaduna State from 1961- 2016 using three Meteorological stations data and the result revealed that rainfall in Kaduna State is unevenly distributed. Suleiman *et al,* (2021) assessed the spatio-temporal variation of rainfall in Zaria, Kaduna State using one Meteorological station's data. The result revealed that there is significant increase in rainfall in the area.

Based on these studies carried out, a number of gaps have been identified. There is no studies that utilized Global Weather Data for SWAT to assess rainfall variation in the study area. Most of the studies used only two and three Meteorological stations data to carry out their studies except Akinsanola and Ogunjobi (2014) that used twenty-five stations on a large scale covering the entire Nigeria, thereby necessitating the need to expand the frontiers of knowledge by studying in detail, using Twelve (12) SWAT stations data which covers the whole State with the test SWAT data.This study therefore examines the spatial variation of rainfall in these three catchment areas- Galma, Kaduna central and Mada in Kaduna State.

Method of Study

Kaduna State is located between latitudes 9° 02″N and 11°32″ North of the equator and between longitude 6°15″E and 8°50″E East of the Greenwich meridian in the North western region of Nigeria in Sub-Saharan Africa. Kaduna State is bounded to the North by Katsina, Zamfara and Kano States; to the West by Niger State; to the East by Bauchi and to the South by Plateau, Nasarawa and Federal Capital Territory, Abuja (KDSG, 2018- Nigeria Vision 20:2020, 2009) characterized by tropical wet and dry or savannah climate (Aw).

The combined Temperature and Rainfall of the State shows that, the mean maximum and minimum temperature experienced in the State increases during the first part of every year to its peak during the hot season in late March and April. At the beginning of the rain, mean maximum temperature usually fall below 33.0°C and subsequently minimum temperatures are experienced during rainy season, which remains fairly constant (Yusuf, 2015). Towards the end of the rainy season, daily maximum temperature rises throughout the little hot season which allow crops to get ripe (KDSG, 2018).

Secondary source data records of rainfall was taken for thirty-one years (1984-2014). The rainfall data were obtained from Global Weather Data for SWAT (Soil Water Assessment Tools) through the internet http://www.globalweatherdataforswat/ . This is because the rainfall data was only available till the end of 2014 and needed to be validated compared with Nimet data. The Data were collected from twelve (12) remotely sensed stations around Kaduna State and projected to 2030. See figure (1)

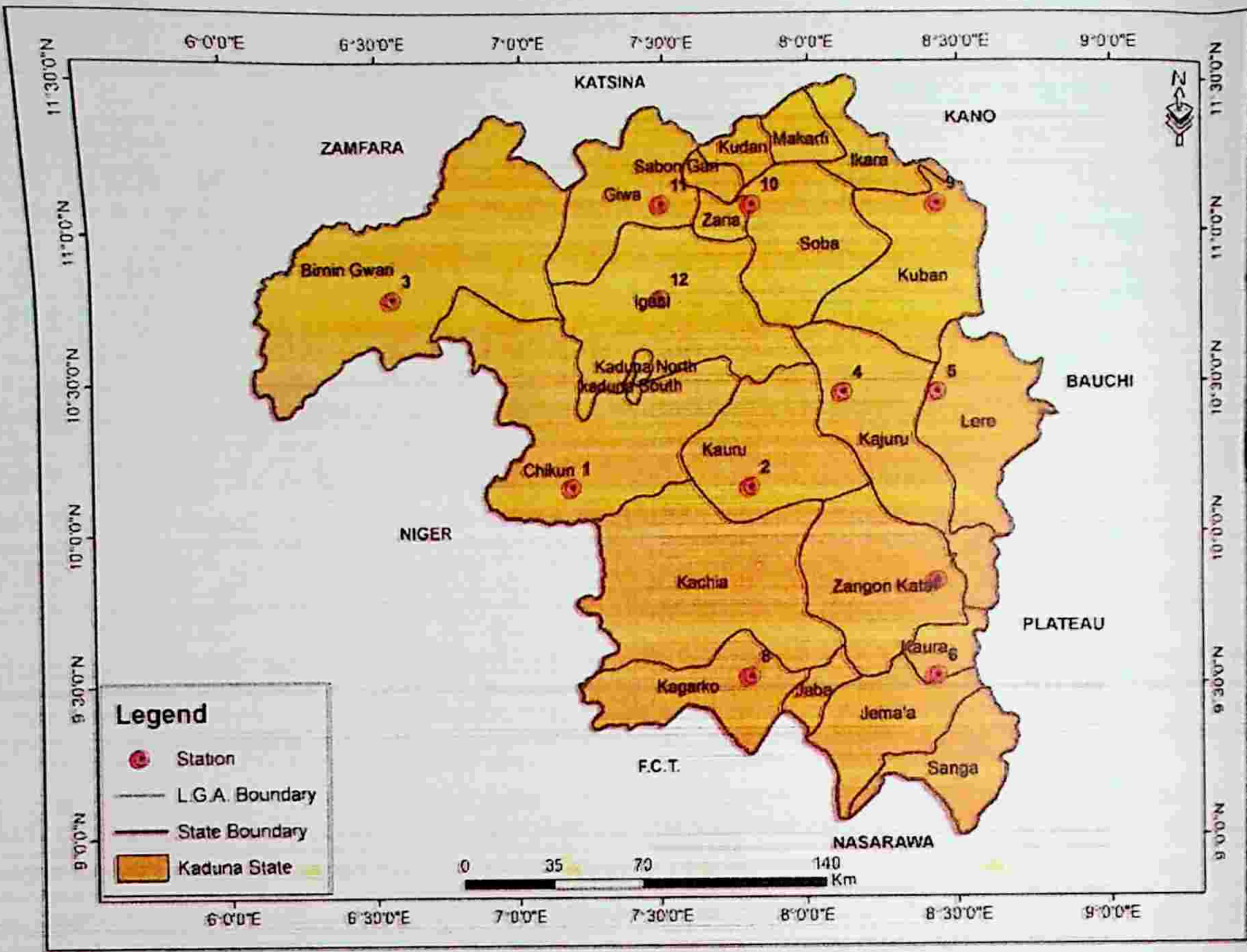

Figure 1: Kaduna State showing Remotely Sensed Stations
Source: Adapted from Administrative Map of Kaduna State

Trends of rainfall along geographic transect for the period 1984 – 2014 was analysed. In this study, only time series of rainfall total for the months of April to October and the annual were used. These are the months during which the study area receives over 85% of its annual rainfall total (Oladipo, 1993). The main reason is that 85% of the total annual rainfall received in the study area are within these months. The normality in the rainfall series was tested using the Fisher standardized coefficient of Skewness (Z_1) and Kurtosis (Z_2) (equations 1 and 2) statistics as defined by Brazel and Balling (1986) and were used to determine, if the data collected are normally distributed as precondition of the application of the Auto-Regressive Integrated Moving Average (ARIMA) time series modeller to fit the data set. The standardized coefficient of Skewness (Z_1) was calculated as:

$$Z_1 = \left[\left(\sum_{i=1}^{N} \left(x_i - \bar{x} \right)^{3/N} \right) \Big/ \left(\sum_{i=1}^{N} \left(x_i - \bar{x} \right)^{2/N} \right)^{3/2} \right] \Big/ \left(6/N \right)^{1/2} \quad \ldots\ldots\ldots\ldots\ldots 1$$

and the standardized coefficient of Kurtosis (Z_2) was determined as:

$$Z_2 = \left[\left(\sum_{i=1}^{N} \left(x_i - \bar{x} \right)^{4/N} \right) \Big/ \left(\sum_{i=1}^{N} \left(x_i - \bar{x} \right)^{2/N} \right)^{2} - 3 \right] \Big/ \left(24/N \right)^{1/2} \quad \ldots\ldots\ldots\ldots\ldots 2$$

Where $\bar{x}$ is the long term mean of x_i values and N is the number of years in the sample. These statistics were used to test the null hypothesis that the samples came from a population with a normal (Gaussian) distribution. If the absolute value of Z_1 or Z_2 is greater than 1.96, a significant deviation from the normal curve is indicated at the 95% confidence level.

In ascertaining the nature of trends and measurement of variability, the standard deviation (equation 3), which provides the deviation from normal (average) for rainfall amount. The standard deviation is giving by the formula:

$$\delta = \sqrt{\frac{\sum(x-\bar{x})^2}{n}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where:
x = value of rainfall observations.
$\bar{x}$ =mean value of rainfall observations
n =number of rainfall observations of sample.
δ = standard deviation

To further identify trends, the rainfall series were divided into 10 years non-overlapping sub-periods (1984-1993, 1994-2004 through 2005-2014). The Cramer's test (Lawson, Balling, Peter and Rundquist, 1981) was used to compare the means of the sub-periods (n-year) with the mean of the whole record period (N-year).

Analysis of variance (ANOVA) is one such technique that may be assessed, if there are statistically significant variations between the means of several groups based on a sample of data. ANOVA may also determine the likelihood of getting a result as severe or more extreme than the observed one by chance alone or the p-value for each comparison. Assuming there is no difference between the groups, a p-value near to zero suggests strong evidence against the null hypothesis, whereas a p-value close to one implies weak evidence.

Result and Discussion

Analysis of rainfall in Galma catchment area

Trend analysis of rainfall data in the Galma stations (3, 9, 10, 11) is presented in Table1. The results of the monthly trend for the period of study (1984-2014) revealed an upward trend in rainfall amount in almost all the months with the exception of October that revealed a downward trend of -11.62mm at the rate of -0.29mm per year. The result also shows an increase in the annual rainfall yield in June, August and September rainfall.

Table 1: Amount of Rainfall in Galma from 1984 to 2014

Rainfall (mm)	April	May	June	July	August	September	October	Annual
Mean	37.5	116.7	145.0	232.2	280.1	166.5	40.4	1032.3
Standard Deviation	33.31	65.63	50.13	70.27	84.06	73.19	44.05	165.48
Range	107.3	315.9	215.1	348.2	359.7	332.1	166.1	746.2
Minimum value	00	7.2	69.3	59.0	113.4	23.9	00	660.1
Maximum value	107.3	323.1	284.4	407.2	473.1	356.0	166.1	1406.3
Trend (mm/year)	0.27	0.67	1.47	0.79	1.84	1.12	-0.29	5.90
Total change (mm/31 years)	10.88	26.89	58.86	31.48	73.76	44.88	-11.62	236.09

Source: Researcher's Analysis (2021)

The result of the 10-year analysis for the monthly and annual rainfall is presented in Table 2. The annual total for the last two decades (1994-2003 and 2004-2014) is having positive values which is an indication of increasing rainfall yield in the last two decades while the first decade of 1984-1993 indicated decrease in rainfall.

Table 2: 10-year Non-Overlapping Sub-Period of Monthly and Annual Rainfall in Galma

Sub-period	April	May	June	July	August	September	October	Annual
1984-1993	-1.35	0.53	-2.17	00	0.85	-0.39	-0.42	-0.70
1994-2003	1.09	00	2.35	0.96	-0.42	0.11	-0.28	1.41
2004-2014	-0.21	0.46	0.56	-0.07	1.29	1.09	-0.28	1.21

Significant at 95% confidence level

Source: Researcher's Analysis (2021)

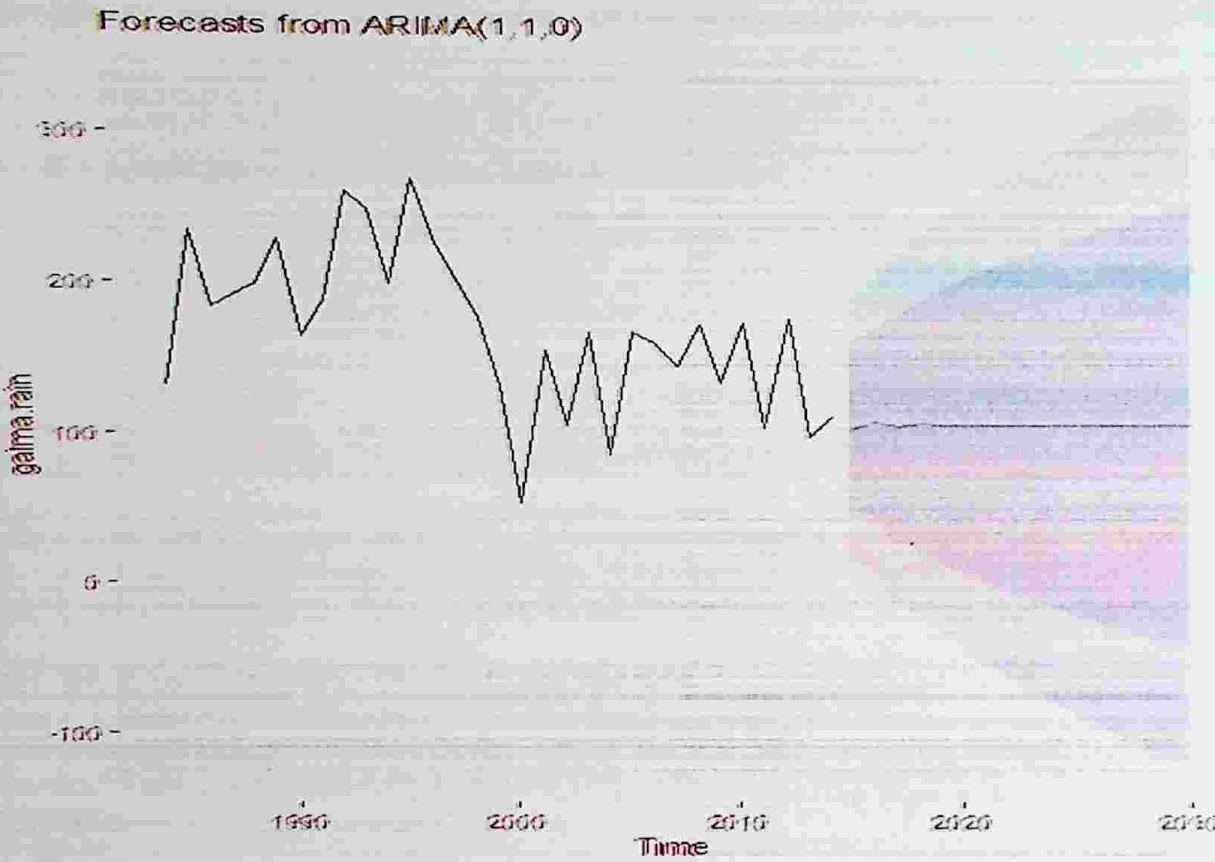

Figure 2: Trend Forecast from ARIMA (1, 1, 0) for Rainfall in Galma

The auto-arima model was used to forecast the trend in rainfall of Galma catchment area. The model thus produced and selected ARIMA (1, 1, 0) as the best model with least error measure. The AIC, AICc and BIC returned values of 317.24, 317.69 and 320.05 respectively as the minimum and best model performance index for the selected model. The model ARIMA (1, 1, 0) was then used to produce 16 years forecast with their respective 80% and 95% confidence interval of forecast. Also, the trend and forecast plot was also produced in figure 2 to further describe the result. The result shows variations in rainfall throughout the forecast period under study.

Analysis of rainfall in the Kaduna central catchment area

Analysis of rainfall data for the Kaduna central catchment area, represented by remotely sensed data from stations 1, 2, 4, 5 and 12, presented table 3.

Table 3: Analysis of Rainfall Data of Kaduna central catchment from 1984 to 2014

Rainfall (mm)	April	May	June	July	August	September	October	Annual
Mean	54.9	117.0	178.4	229.0	291.9	246.9	75.7	1203.5
Standard Deviation	46.66	52.66	57.32	81.80	93.23	91.58	51.12	193.71
Range	246.0	232.8	277.8	352.3	382.0	411.4	204.5	787.4
Minimum value	2.2	15.4	80.9	54.3	166.8	24.6	2.8	848.9
Maximum value	248.2	248.2	358.7	406.6	548.8	436.0	207.3	1636.3
Trend (mm/year)	-0.91	-0.32	0.07	0.18	1.20	0.77	1.05	1.96
Total change (mm/31 years)	-36.40	-12.93	2.94	7.16	48.11	30.88	42.18	78.22

Source: Researcher's Analysis(2021)

The result of the trend in Table 3 for the period of study (1984-2014) for both monthly and annual rainfall revealed little increase in rainfall yield in the Kaduna central catchment area. The result of the decadal analysis for the monthly and annual rainfall is presented in Table 4. A careful examination of the last two decades (1994-2003) and (2004-2014) shows that all the months and the annuals were normal at 95% confidence level but the positive t_k values were more than the negative values which is an indication of increasing rainfall yield in the last decades.

Table 4: 10-years Non-Overlapping Sub-Period of Monthly and Annual Rainfall of Kaduna Central

Sub-period	April	May	June	July	August	September	October	Annual
1984-1993	-1.69	-0.86	-1.12	-0.53	1.62	-0.80	-0.46	-0.85
1994-2003	0.42	-1.02	1.43	1.35	-0.99	0.73	-0.86	0.86
2004-2014	-0.93	0.32	-0.73	-0.93	0.53	0.25	0.89	-0.25

Significant at 95% confidence level

Source: Researcher's Analysis (2021)

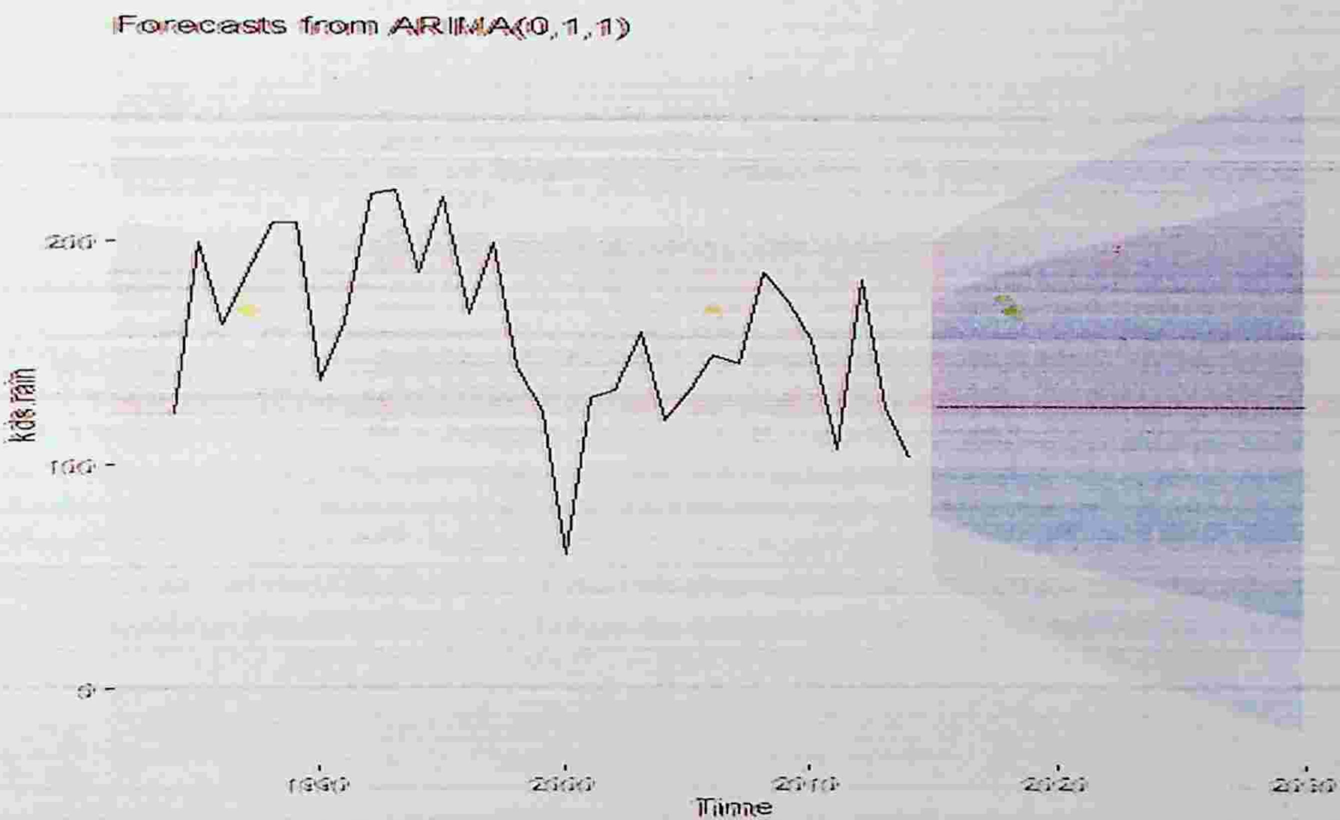

Figure 3: Trend Forecast from ARIMA (0,1,1) for Rainfall in Kaduna Central

The auto-arima model was used to forecast the trend in rainfall in Kaduna central catchment area. The model thus produced and selected ARIMA (0, 1, 1) as the best model with least error measure. The AIC, AICc and BIC returned value of 306.93, 307.38 and 309.74 respectively as the minimum and best model performance index for the selected model. The model ARIMA (0, 1, 1) was then used to produce 16 years forecast with their respective 80% and 95% confidence interval of forecast. Also, the trend and forecast plot was also produced in figure 3 to further describe the result. The result indicated consistency in rainfall throughout the forecast period under study.

Analysis of rainfall in Mada Catchment area

The result of the analysis of rainfall data from stations 6, 7, 8 represents Mada catchment area which is presented in Table 5. The trend for both the monthly and annual rainfall generally showed an upward trend in rainfall.

Table 5: Analysis of Rainfall Data of Mada from 1984 to 2014

Rainfall (mm)	April	May	June	July	August	September	October	Annual
Mean	109.8	202.4	228.7	334.6	362.6	319.0	145.1	1733.4
Standard Deviation	86.33	70.94	65.61	124.67	101.76	83.34	86.16	312.86
Range	438.5	290.6	250.8	474.8	481.8	317.2	375.7	1182.1
Minimum value	4.0	69.0	141.2	174.4	170.6	144.6	11.3	1151.3
Maximum value	442.5	359.6	392.0	649.2	652.4	461.8	387.0	2333.4
Trend (mm/year)	1.16	1.80	1.80	2.53	1.77	2.46	0.90	11.51
Total change (mm/31 years)	47.98	72.16	71.81	101.32	70.67	98.56	35.82	460.56

Source: Researcher's Analysis(2021)

The change in annual rainfall for the period of study (1984-2014) indicated an increase of approximately 460.56mm at the rate of 11.51mm per year. The result therefore indicated that an increase in the annual rainfall yield is predominant as a substantial increase in July, August and September rainfall.

A general examination of the monthly standard deviation for the rainfall shows that years of rainfall above the mean standard deviation are more than those below it in the last 21 years of (1994-2014). This indicates an increasing rainfall yield in the last years.

Table 6: 10-year Non-Overlapping Sub-Period of Monthly and Annual Rainfall of Mada

Sub-period	April	May	June	July	August	September	October	Annual
1984-1993	-0.99	-0.49	0.18	-0.28	-0.25	0.07	-0.11	-0.39
1994-2003	-0.28	0.66	1.43	-0.39	-0.35	0.60	-0.73	0.14
2004-2014	1.29	1.29	0.25	1.43	0.83	1.38	1.12	1.97

Significant at 95% confidence level

Source: Researcher's Analysis (2021)

The results of the 10-year non-overlapping sub-period presented in Table 6, revealed that all the months for the sub-period 2004-2014 have positive t_k values which is an indication of wetness while all the months including the annual total for the sub-period 1984-1993 have negative t_k values which is an indication of dryness. This further confirms the increasing nature of the rainfall yield in the last decade which is in tandem with the findings of Salihu *et al*. (2020), that indicates higher variability of annual water yield in respect to wet season in the entire Guinea and Sudano-Sahelian ecological zones significantly.

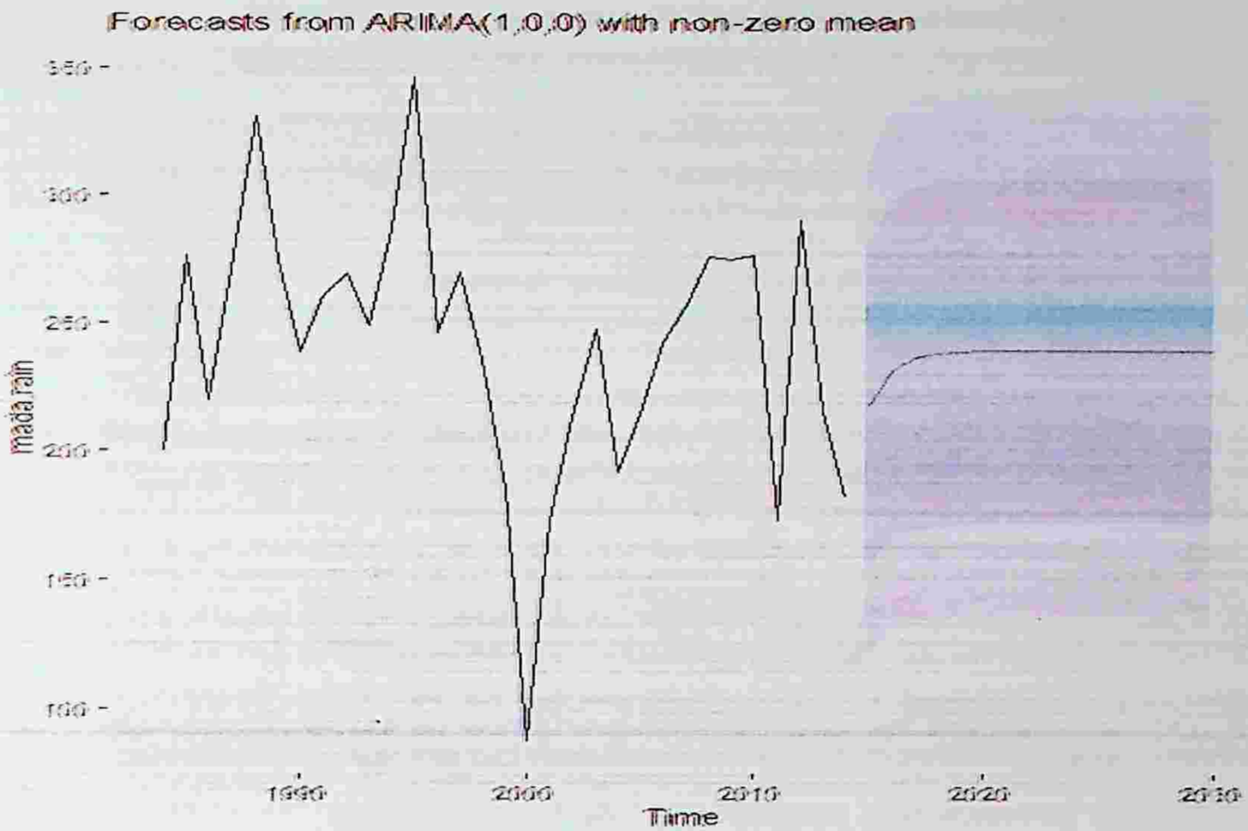

Figure 4: Trend Forecast from ARIMA (1,0,0) with non-zero Mean for Rainfall in Mada

The auto-arima model was used to forecast the trend in rainfall in Mada catchment area. The model thus produced and selected ARIMA (1, 0, 0) as the best model with least error measure. The AIC, AICc and BIC returned values of 332.54, 333.43 and 336.84 respectively as the minimum and best model performance index for the selected model. The model ARIMA (1, 0, 0) was then used to produce 16 years forecast with their respective 80% and 95% confidence interval of forecast. Also, the trend and forecast plot was also produced in figure 4 to further describe the data. The result shows variations in rainfall throughout the forecast period under study.

Comparison of the rate of total change in rainfall in the three catchment areas.

Table 7: Rate of Monthly and Annual Change in Rainfall of the three Catchment Areas

Station	April	May	June	July	August	September	October	Annual
Galma catchment	10.88	26.89	58.86	31.48	73.76	44.88	-11.62	236.09
Kaduna central catchment	-36.40	-12.93	2.94	7.16	48.11	30.88	42.18	78.22
Mada catchment	47.98	72.16	71.81	101.32	70.67	98.56	35.82	460.56

Source: Researcher's Analysis (2021)

Table 7 compares the rate of change in rainfall during the period under investigation for the three-catchment areas in the State. The annual rainfall shows that Mada catchment area is having the highest rate of increase in rainfall for the period under study in the State. This is followed by the Galma catchment area and the least is Kaduna central catchment area. The annual increase in rainfall for the Mada catchment area occur in substantial increase of rainfall in the months of July to September respectively, while the increase in the Galma catchment area occurs in August. The forecast's result equally collaborates remotely sensed data with significant changes in rainfall in the three-catchment areas in Kaduna State (see figure 5).

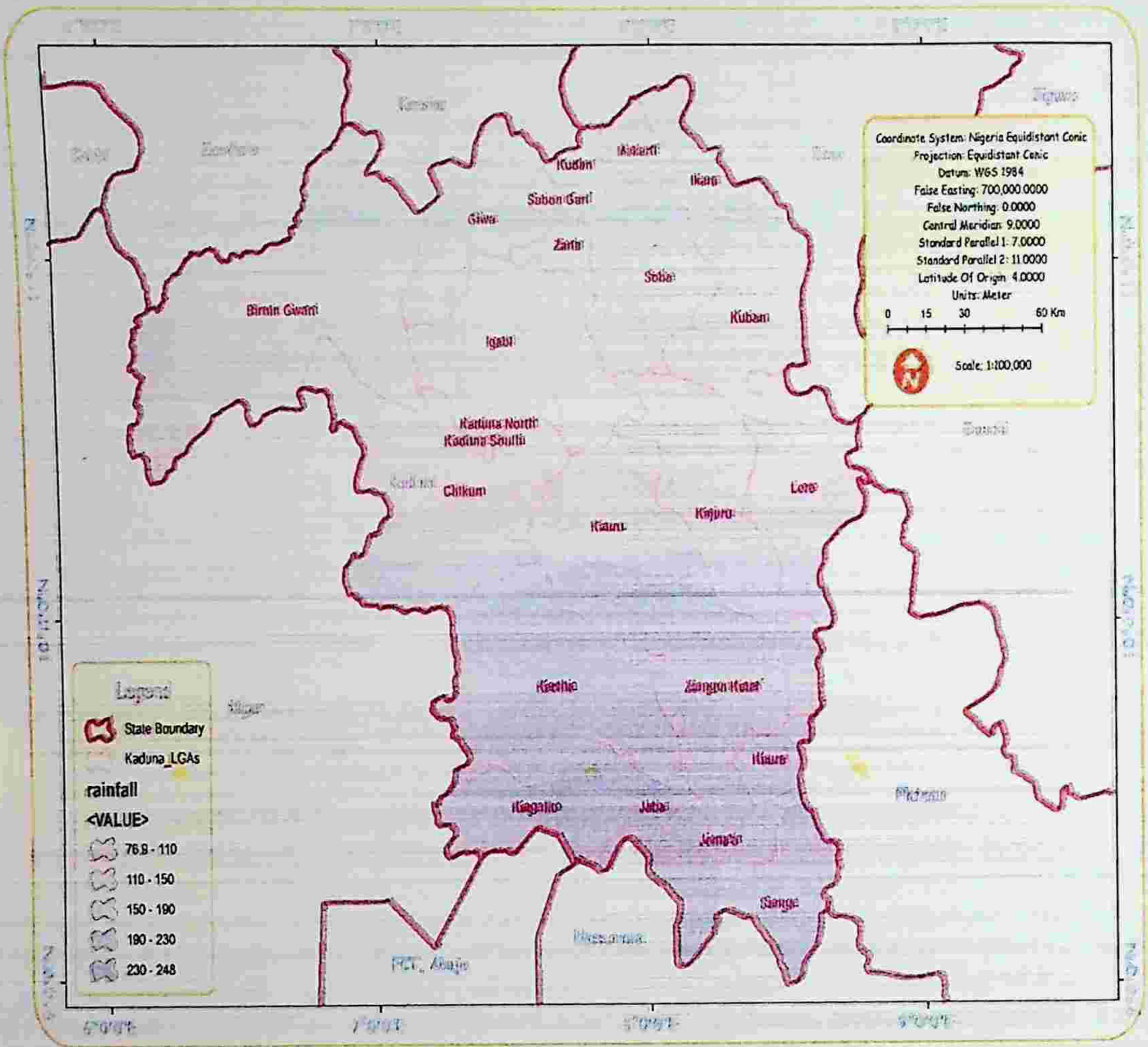

Figure 5: Map of Interpolated Rainfall

Hypothesis Testing Analysis

Table 8 shows the result of variance that was conducted to ascertain variations among the three catchment areas.

Table 8 Significant variation of rainfall in Kaduna State.

Catchment Areas		Sum of Squares	Df	Mean Square	F	Sig.
Mada Catchment Area	Between Groups	232597173.9	30	6286410	51.545	.009
	Within Groups	50734972.89	416	121959.1		
	Total	283332146.8	446			
Kaduna Central Catchment Area	Between Groups	222331168.6	30	5175320	43.435	.004
	Within Groups	4062861.78	416	111876.1		
	Total	272221135.7	446			
Galma Catchment Area	Between Groups	212243221.5	30	4456531	35.334	.000
	Within Groups	3052752.67	416	1221345.1		
	Total	261112224.6	446			

Source: Researcher's Analysis, 2022

The findings of these studies showed that rainfall is statistically different at a p-value of less than 001, contradicting the null hypothesis, which holds that there are no significant differences between the three catchment areas. The null hypothesis is therefore rejected because there is significant variation between the three catchment areas in the study area.

In the current study, the period is too short to determine the factors responsible for change but that rainfall is on the increase. From the analysis, the situation in Kaduna State can best be described as quasi-periodic because of the noticeable distribution between the Mada, Kaduna central and Galma catchment areas. Similarly, the results aligned with Salihu *et al*, (2019) findings, which attributed the climate variability in the sudano-sahelian ecological zones to vegetation depletion. However, the Salihu *et al* (2019), assertion seems to be more believable, but the changes observed are only variations. However, once the vegetation is depleted like in the case of Kaduna State, the local atmosphere is further influenced by increased dust loads. Most modelling efforts led to a conclusion that increased mineral aerosol loads will cool the surface, warm the lower atmosphere, stabilize the atmosphere and reduce local rainfall (Littmann, 1991; Moulin *et al.,* 1997). Overgrazing, drought, de-vegetation and increased dust clouds and aerosol actually could have been responsible for the lower rainfall in June (2004-2014) and June (1994-2003). In this study, the variability is rather small so also is the duration. Ayoade (2003) also concluded that what we observed now is just "noise and not signal". This work also supports this assertion. The rapidity of variability heightens man's risk to water scarcity. It is generally confirmed in this study that we are still within a warm period which started in the 1990s. Whether human activities will prevent a return to cold period is yet to be seen. We must however, appreciate the relationship between deforestation, drought and even desertification because all these three are very prominent in the study area.

Finally, as at now, we have concluded that it is only variation which is normal that is taking place in the study area. A new climate normal has yet been achieved, neither is there any trend towards that, but regular research should continue to detect any early signal.

Conclusion and Recommendations

This study provides valuable insight on the spatial variation of rainfall in three catchment areas in Kaduna State. The results revealed that there is significant increase in rainfall in the catchment areas. The rainfall over all the remotely sense stations revealed that there was a composite nature in which some dry years were mixed with wet years and vice versa. Lastly, the spatial analysis of the annual and monthly data for the catchment areas show that there is a significant difference among the catchment areas and rainfall in Kaduna State is unevenly distributed. Changes in rainfall amount of Kaduna State from the various statistical methods used, that is, the decadal non-overlapping sub-period analysis, the ANOVA for the temporal changes in the rainfall amount between the three non-overlapping sub-periods (1984-1993, 1994-2003 and 2004-2014) and the forecast ARIMA modelling technique generally showed that rainfall amount is increasing in recent years. The increase in the annual rainfall is as a result of a substantial increase in rainfall amount in, July, August and September. Findings also revealed that the Mada catchment area has the highest rate of increase in annual rainfall at those periods. This is followed by Galma catchment area and the least is the Kaduna central catchment area.

Based on the findings, this study recommends the analysis of existing series of observed rainfall data in order to provide useful information on the onset, cessation and length of the rainy season and the amount of available water during the season. Crop varieties that can withstand much water should be planted in areas of high rainfall and government policies related to agriculture and water resources development should be based on increasing rainfall trends.

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