Time Series Forecasting of Rainfall in Lokoja, Kogi State, Nigeria

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***Abstract*: - Understanding the rainfall process is critical for the solution of several regional environmental challenges of integrated water resources management at regional scales, with implications for agriculture, climate change and natural hazards such as floods and droughts. Statistical modeling and data analysis are the key instruments for studying these processes. The main Objective of this research is to use Time Series Forecasting technique to develop a model for forecast of rainfall in Lokoja based on secondary monthly data obtained from NIMET station in Lokoja, Kogi state. Descriptive summary statistics in the form of centrality and dispersion, time plot, and autocorrelation functions were generated using Minitab statistical software .The Box Jenkins ARIMA modeling procedure (model characterization, model estimation and model validation) was used to determine the best model for the data because ARIMA modeling procedure has been found suitable for seasonal data. Model diagnostics based on residual analysis and hypothesis testing were performed to assess the adequacy of the identified fitted model. The autocorrelation function (ACF) and partial autocorrelation function (PACF) parameters of stationary series were used to identify appropriate model. Final model developed was then used to forecast monthly rainfall for Lokoja .The model application to 2014 data to validate the model for the study area show the reliability of the model. Percentage errors are low for the months of April to October with errors of -8.28%, -7.89%, -8.96%, -8.40%, -5.72%, -8.52% and -8.60% respectively. These are the months for rain fed agriculture and possibility of flooding are focus of this research. The model was fitted using January to December rainfall values and only values for rainfall period. The results of the models are the same. The low percentage errors for rainy season which is the focus of this research makes the model very reliable. Also, the study established that there was a variation over Lokoja within the period under study which shows some evidence of seasonal change in the study area. This shows that the fitted ARMA model developed is good for short term forecast and planning purposes.**

***Keywords:* Rainfall, Time Series, Forecasting, Auto Regressive Moving Average (ARMA), Modeling**

I. INTRODUCTION

Rainfall is very pertinent for the economic growth and development of Nigeria at large and Kogi State in particular as larger percentage of the people (especially adults of age ranging from 30- 45 years and above) vigorously participate in rain fed agricultural practices (crop production, fishing, animal husbandry, poultry farming and cassava plantation).

The impact of climate change is becoming more pronounced worldwide with consequences of climatic hazard such as severe storms, hurricane, floods, heat waves and droughts. As a result of the large inter-annual rainfall variability which often results in climatic and environmental hazards, there is a need to study rainfall characteristics in the study area as a result of recent socio-economic developments such as urbanization, industrialization and over-population. The Study Area Lokoja which is the capital of kogi State, Nigeria has a central location in the middle belt.

Weather and climate are among the foremost factors which determine how a society develops in geographical region. Weather usually describes the particular event or condition for the short period of time such as hours or days whereas climate refers to the behavior of the atmosphere to a place over many years. In Nigeria, the major form of precipitation is rainfall. Because of its location in the low pressure zone of the earth and its proximity to the Atlantic ocean in the South particularly in north Central of the country. This is why rainfall in Nigeria is latitude dependent .The standard Rain gauge used by Nigeria Meteorological Service to Measure rainfall consist of a funnel –shaped collector which is attached to measuring tube. While modern day rain gauges are automated with memory system to measure various aspect of rainfall such as daily, weekly and monthly totals (Newman et.al, 2006; Agbor et.al, 2013; Ewona et.al, 2008; 2009 & 2013) significant changes in rainfall have occurred both in pattern and seasonality. Incidentally, rainfall is an important index in climate change consideration.

Oladipo (1995), reported that rainfall decline in Nigeria started in the beginning of the 1960s, when a decade of relatively wet years, according to him is the persistence of low mean rainfall in the last two decades before 1995 in Nigeria is an indication of abrupt changes in climate. To obtain reliable estimates of rainfall data, it is necessary that segments of Time Series Analysis should be homogenous. Previous researches applied in Northern part of Nigeria are often based on climatic standard.

However, Times series analysis plays a significant role in modeling meteorological data such as humidity, temperature, rainfall and other environmental variables (Collischonn et al., 2005; Hung et al., 2009; Meher & Jha, 2013; Kanna et al., 2010; Mahsin et al., 2012; Ansari, 2013; Htike & Khalifa, 2010). Rainfall forecasting is crucial for making important decisions and performing strategic planning. The ability to predict and forecast rainfall quantitatively guides the management of water related problems such as extreme rainfall conditions like floods and droughts among other issues (Htike & Khalifa, 2010; Ansari, 2013; Kanna et al., 2010; Meher & Jha, 2013).

Aim and Objectives

Aim: To forecast and study rainfall variability trends in Lokoja Metropolis using monthly rainfall data.

The objectives of the research are to:

i. determine the seasonality of monthly rainfall in Lokoja ,Kogi State;
ii. determine annual variability of rainfall for the study area;
iii. develop a model to forecast rainfall for the study area.

Study Area

Lokoja is the capital of Kogi state with an area of 3,180km^2 and population of 195,261 (2006 census). It is bounded by Niger state in the north and in the east upstream from the capital extending to the border of kwara state. The city of Lokoja lies on latitude 7.9^{0}N and Longitude 6.45^0 E with Geological features depicting sedimentary rocks and alluvium along river beds which promotes agricultural activities .The notable features includes famous hills like Ososo hill which spread from Edo State to the western part and Aporo hill on the eastern part. Another famous mountain is patti in Lokoja which stands at about 750m above sea level. This is a massive hill towering over Lokoja with about 15sqkm flat top where one could see the confluence point of River Niger and Benue. Lokoja Kogi has an average Max Temperature of 33.2^0 and Average Minimum temperature of 22.8^0 which is generally hot throughout the year. It has two distinct seasons dry season that last from November to March and rain season which last from April to October .Annual Rainfall ranges from 1016mm to 1524mm.

II. METHODOLOGY

Data source

Rainfall data used for this study were obtained from the Nigeria Meteorological Agency (NIMET) Lokoja in Kogi as presented in Table 1.0 below. Standard rain gauge was used to measure rainfall in millimeters according to World Organization Standard (WMO, 2015). Descriptive summary statistics in the form of measures of centrality and dispersion, time series plots and auto correlation functions were generated using Minitab statistical software. Box Jenkins's ARIMA modeling procedure (model characterization, model estimation, model validation) was used to analyze the best model fitted for the data. This is because ARIMA modeling procedure has been found suitable for seasonal data (Aribisala, 2007, Box and Jenkins, 1970). The model developed was used to forecast monthly rainfall for Lokoja. Rainfall that was used for this study is an indication that rainfall was a key climatic variable .The research covers climatic period of 30years which conforms to the World Meteorological Organization (WMO) Standard, which stipulated period of 30 to 35 years.

Table 1.0 Monthly rainfall data from 1986-2016

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1986	0	42	59.6	**22.7**	148.9	139.7	157.9	331.3	140.9	127.8	**0**	0
1987	8.6	75.3	17.3	82.9	121.3	261.2	423.5	121.2	164.7	55.4	TR	TR
1988	TR	0	13.1	47.9	228.8	164	301.1	289.9	248.2	227.1	0	0
1989	0	0	0	80.7	133.9	133.1	213.1	274	175.6	105.8	17.1	3.8
1990	0	0	60.4	159.8	238.4	231.6	205.7	325.6	248.1	91.1	0	0
1991	0	0	2.7	86.3	251.6	146.5	131.5	151.6	245.2	60.2	7.5	0
1992	0	33.4	16.5	81.5	190.6	136.1	110.8	82.9	218.1	121.4	4.3	0
1993	0.8	0	12.4	152.7	186.4	135	154.7	**397.8**	178.9	88.3	0	0
1994	0	0	88.7	112.4	188.9	93.9	301.4	201.4	80.4	205.4	18.6	0
1995	0	0	80	202.1	168.2	106.3	**402.2**	200.6	160.2	200	12.4	0
1996	0	0	88.7	112.4	188.9	93.9	301.4	201.4	80.4	206.4	18.6	0
1997	TR	10.3	0.3	168.8	108.2	107.5	164.8	235.6	322.3	122.9	TR	TR
1998	1.8	0	169.3	116.5	304.1	76.1	126.6	303.3	267.6	130.5	0	0

1999	0	0	TR	120.9	98.2	227.9	169.9	107.9	206.4	149.8	0	0
2000	TR	0	TR	162.6	97.2	155.2	97.2	190.1	216.6	91.8	TR	0
2001	0	0	4	112	77.3	125.1	198.3	157.9	252.1	46.2	0	0
2002	0	0	2.9	162.2	79.6	93.2	325.9	298	193.4	139	1.8	0
2003	0	15.3	9.4	38.5	92.7	180.9	271.4	53.1	163.7	147.1	14.7	0
2004	0	TR	3.4	157.5	246	168.4	225.5	78.6	252.1	203.1	0	0
2005	0	32.7	TR	93	134.3	170.5	60.9	132.9	143	167.5	3.4	0
2006	12.4	19.3	40.9	61.8	370	62.1	303.9	352.8	290.6	169.3	0	0
2007	0	0	11.6	82.3	277.3	184.5	231.8	225	246	240.7	2.2	0
2008	0	0	21.8	163.6	161.6	166.3	213.8	274.7	170.2	87.8	0	3.9
2009	10.1	0	5	243.6	108.4	220.1	212.8	**369.8**	255.8	206.4	0	0
2010	0	0	0	132.8	125	104.4	255.6	133	148.2	167.3	7.4	0
2011	0	TR	TR	65.7	147.3	163.2	128	140.5	191.1	76.5	0	0
2012	0	11.8	0	86.2	253.7	157.7	268.2	180.6	148.4	209.7	0	0
2013	2.9	47	29.5	138.1	254.2	134.5	225.1	123.9	135.2	219	7.1	0
2014	TR	47	39.6	197	206	183.4	194.5	274.4	192	190.5	46	TR
2015	1.5	0.3	43.9	178.6	75.4	174.2	113	90.7	265.4	158.2	TR	0
2016	0	0	81.8	93.5	176.6	117.6	120.8	**350.6**	146	76.8	0	0

Source: Nigeria Meteorological Agency, Lokoja ,Kogi State.

Autoregressive (AR) Model

Autoregressive Model is said to be a model in which the current value Y_t depends only on its own past values e.g $Y_{t-1}, Y_{t-2,}Y_{t-3}$ e.t.c

Thus, $Y_t = f(Y_{t-1}, Y_{t-2,}Y_{t-3} \dots, Y_{t-p})$ (1)

Therefore, Autoregressive (AR): is a p^{th} order autoregressive model denoted as AR is a process that can be represented by p^{th} order as stated below.

$Y_t = a_o + a_1Y_{t-1} + a_2Y_{t-2} + \dots\dots + a_pY_{t-p} + \mu$ (2)

The Autoregressive of order one AR (1) is the first order process in which the current value is based on the immediately preceding value as stated below

$Y_t = a_o + a_1Y_{t-1} + \mu$ (3)

Note: White Noise (WN) process is a sequence of random variables with mean equal to zero and constant variance equal to σ^2 $\mu \sim WN(0, \sigma^2)$. $a_1, a_2, a_3 \dots a_p$ are unknown parameters relating to $Y_t, Y_{t-1}, Y_{t-2}, Y_{t-3}, Y_{t-p}$ and must be estimated from sample data This process is stationary if $a_1 < 1$; if $a_1 = 1$, it becomes unit root process called (random walk) which is non-stationary.

The general representation in a compact form can be written as:

$Y_t = \mu + a_o + \sum_{i=1}^{p} a_iY_{t-p}$ (4)

Moving Average (MA) Model

Moving average model is said to be a model in which the current value Y_t depends only on the random error terms which follows a white noise process.

Thus $Y_t = f(\varepsilon_t, \varepsilon_{t-1,}\varepsilon_{t-2,}\varepsilon_{t-3,}\varepsilon_{t-k,})$ (5)

Moving average (MA): is a q^{th} order moving average, MA (q) is a process that be represented as

$Y_t = \beta_0 + \beta_1\varepsilon_{t-1} + \beta_2\varepsilon_{t-2} + \dots + \beta_t\varepsilon_{t-k} + \mu$ (6)

The Moving Average of order one MA (1) can be written as

$Y_t = \mu + \beta_0 + \beta_1\varepsilon_{t-1}$ (7)

The general representation **in** a compact form can be written as

$Y_t = \mu + \beta_o + \sum_{j=1}^{q} \beta_j\varepsilon_{t-k}$ (8)

Where $\beta_1, \dots, \beta_t$ are the parameters of the model, β_0 is the expectation of Y_t (often assumed to equal 0), μ is constant and the $\varepsilon_t, \varepsilon_{t-1}, \varepsilon_{t-2}, \dots \varepsilon_{t-k}$ are again, white noise error terms (Gershenfeld and Shumway, 1988)

Autoregressive Moving Average Model (ARMA) p,q

Autoregressive Moving Average processes (ARMA): is a mix model of both AR and MA models i.e ARMA (p,q) which is suitable for univariate time series modeling. The general form of such a time series model which depends on (p) of its own past values and (q) past values of white noise disturbance together with constant term is given as

Y_t = a_o + $a_1 Y_{t-1}$ + $a_2 Y_{t-2}$+… + $a_p Y_{t-p}$ + $\beta_1\, \varepsilon_{t-1}$ + $\beta_2\, \varepsilon_{t-2}$ +……+ $\beta_t \varepsilon_{t-k}$ + μ (9)

The general representation in compact form can be written as

$$Y_t = a_o + \sum_{i=1}^{p} a_i Y_{t-p} + \varepsilon_0 + \sum_{j=1}^{q} \beta_j\, \varepsilon_{t-k} \quad (10)$$

The model developed from equation (7) above was used for forecasting amount of rainfall expected from year 2017 above. ARMA of order one i.e ARMA (1,1) was fitted with

$$Y_t = \mu + a_1 Y_{t-1} + \beta_1 \varepsilon_{t-1} \quad (11)$$

where:

μ= constant term

Y_t = expected value of Y at Time t

Y_{t-1}= previous value of order p at lag 1

ε_{t-1} = error term of order q at lag 1

Therefore, using Minitab Time Series statistical software package with the estimated parameters in table 3.0 substituted in Equation (11) above we have

$$Y_{t=} 17.935 + 0.9919 Y_{t-1} + 0.1040 \varepsilon_{t-1} \quad (12)$$

Equation (12) was fitted based on the randomness of the series observed time plot in figure 4.1 on rainfall in lokoja from the years 1986-2016.

Annual Variability of Rainfall for the Study Area

In this study, rainfall variability over the period of 30 years was determined. The Mean annual rainfall data were used to construct a rainfall chart for Lokoja for the climatic period .Detailed analysis of trends of rainfall in the area was carried out using Coefficient of variability of seasonal and annual rainfall records. i.e Coefficient of variability (C_v) was expressed as percentage ratio of standard deviation to the mean given as:

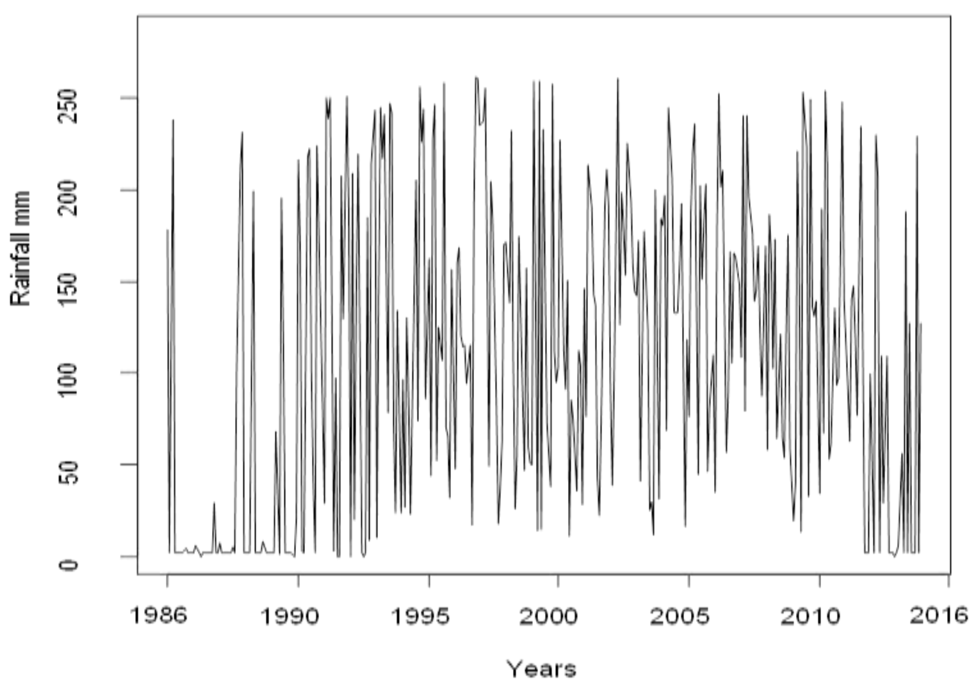
$$C_v = 100 \cdot \frac{\partial}{X} \quad (13)$$

X = Mean of the Time Series

∂ = Standard Deviation

III. RESULTS AND DISCUSSION

In the analysis, Minitab statistical software package was used to analyse the data and the results of the analysis is presented as follows:



The Time plot as shown in fig 1.0 described the behavioral pattern observed on amount of rainfall in Lokoja from the years 1986 to 2016. It was observed that there are variations associated to the series in the above graph, which shows that the series is non-stationary in the amount of rainfall on monthly and yearly bases due to geographical nature of the location. Also, there was notably high rainfall in august 1993 (397.8mm), July 1995 (402.2mm), august 2009 (369.8mm) August 2016 (350.6mm) respectively. The hydrologic years recorded with highest rainfall total are 1988, 1990 and 2014 with mean values of 138.190mm, 130.058mm and 157.04mm respectively. As shown in Table 2.0. It was observed that year 2014 has the highest rainfall total with mean of 157.04mm

Table 2.0 Rainfall total computed with Mean, standard deviation (STD) and coefficient of variation (C_v)

YEAR	TOTAL	MEAN	STD	C_v	MEAN/30YRSTOTAL(%)
1986	1170.8	97.567	97.312	99.739	2.84%
1987	1331.4	133.14	125.976	94.619	3.88%
1988	1537.2	**138.191**	126.305	91.399	4.03%
1989	1133.3	94.758	94.017	99.218	2.76%
1990	1560.7	**130.058**	118.65	91.228	3.79%
1991	1083.1	90.258	94.647	104.863	2.63%
1992	995.6	82.967	74.926	90.309	2.42%
1993	1307	108.917	119.113	109.361	3.17%
1994	1291.1	107.592	98.393	91.451	3.14%
1995	1532	127.667	120.255	94.194	3.72%
1996	1292.1	107.675	98.484	91.464	3.14%
1997	1239.9	137.856	101.534	73.653	4.02%
1998	1495.8	124.65	117.052	93.905	3.63%
1999	1081	98.273	86.899	88.427	2.86%
2000	1010.7	112.3	76.975	68.544	3.27%
2001	972.9	81.075	88.035	108.585	2.36%
2002	1296	108	117.981	109.242	3.15%
2003	986.8	82.233	88.987	108.212	2.40%
2004	1334.6	121.327	106.584	87.848	3.54%
2005	938.7	85.336	68.375	80.124	2.49%
2006	1683.1	140.258	147.907	105.453	4.09%
2007	1505.3	125.117	117.862	94.202	3.65%
2008	1259.8	105.308	98.070	93.127	3.07%
2009	1632	136	130.656	96.071	3.96%
2010	1073.7	89.475	85.874	95.976	2.61%
2011	912.3	91.23	72.965	79.979	2.66%
2012	1316.3	109.692	105.727	96.385	3.20%
2013	1316.5	109.708	91.824	83.698	3.20%
2014	1519.5	**157.04**	81.9471	52.182	4.58%
2015	1101.2	100.109	87.223	87.128	2.92%
2016	1163.7	96.975	101.053	104.205	2.83%
	TOTAL	**3430.752**			

Fitting of ARMA model on rainfall

$$Y_t = a_o + a_1 Y_{t-1} + \ldots + a_p Y_{t-p} + \beta_0 + \beta_1 \varepsilon_{t-1} + \ldots + \beta_t \varepsilon_{t-k} + \mu \quad (14)$$

Using ARMA (1,1)

$$Y_t = a_o + a_1 Y_{t-1} + \beta_0 + \beta_1 \varepsilon_{t-1} + \mu \quad (15)$$

From the estimated parameters in table 3.0

$$Y_t = 17.935 + 0.9919_{Y_{t-1}} + 0.1040\varepsilon_{t-1} \quad (16)$$

is the model used for forecast

Table 3.0 Estimates of Model Parameters

Type	Coefficients	S.E Coefficients	T	P
(p) AR 1	0.9919	0.0541	13.26	0.000
(q) MA 1	0.1040	0.0770	1.35	0.178
Constant	17.935	3.109	5.77	0.000
Mean	63.32	10.97		

Statement of Hypothesis

$H_{0:}$ The amount of rainfall in each month is not random

H_1: The amount of rainfall in each month is random

Test Statistic

Q =$N\sum_{k=1}^{t} \quad r_k^2$ where k is a lag value k=1,2,----t

N = Number of observations

r=is the number of randomness in the observation Q = is the Randomness

Decision rule.

Reject H_0 if Q>Pvalue

Table 4.0 ACF and PACF Residual For Rainfall.						
Autocorrelation	Partial Correlation	t	ACF	PACF	Q-Stat	Prob
****|. |	****|. |	1	-0.596	-0.596	135.56	0.000
.|. |	***|. |	2	0.071	-0.441	137.47	0.000
.|* |	**|. |	3	0.093	-0.209	140.82	0.000
.|. |	*|. |	4	-0.064	-0.112	142.41	0.000
.|. |	.|. |	5	0.033	-0.021	142.83	0.000
.|. |	*|. |	6	-0.052	-0.075	143.87	0.000
.|. |	*|. |	7	-0.012	-0.171	143.92	0.000
.|. |	**|. |	8	-0.000	-0.247	143.92	0.000
.|. |	*|. |	9	0.047	-0.166	144.79	0.000
*|. |	**|. |	10	-0.100	-0.259	148.69	0.000
.|. |	***|. |	11	0.023	-0.397	148.90	0.000
.|* |	*|. |	12	0.171	-0.174	160.37	0.000
*|. |	.|. |	13	-0.099	0.060	164.26	0.000
.|. |	.|* |	14	-0.029	0.104	164.59	0.000
.|* |	.|* |	15	0.083	0.179	167.34	0.000
*|. |	.|* |	16	-0.073	0.112	169.44	0.000
.|. |	.|* |	17	0.054	0.131	170.59	0.000
*|. |	.|. |	18	-0.093	0.011	174.02	0.000
.|. |	.|. |	19	0.044	0.007	174.81	0.000
.|. |	*|. |	20	-0.045	-0.094	175.62	0.000
.|. |	.|. |	21	0.050	-0.046	176.62	0.000
.|. |	.|. |	22	-0.038	0.044	177.19	0.000
.|. |	*|. |	23	-0.043	-0.095	177.93	0.000
.|* |	.|. |	24	0.174	-0.051	190.20	0.000
*|. |	.|. |	25	-0.093	-0.004	193.73	0.000
.|. |	.|. |	26	0.000	0.005	193.73	0.000

.|. |	.|. |	27	0.050	0.050	194.76	0.000
.|. |	.|. |	28	-0.055	0.018	196.02	0.000
.|. |	.|. |	29	0.042	0.067	196.76	0.000
*|. |	.|. |	30	-0.084	-0.003	199.67	0.000
.|. |	.|. |	31	0.023	-0.043	199.89	0.000
.|. |	.|. |	32	0.033	0.037	200.33	0.000
.|. |	.|. |	33	-0.062	0.012	201.94	0.000
.|. |	.|. |	34	0.003	-0.056	201.94	0.000
.|. |	.|. |	35	0.059	0.017	203.41	0.000
.|. |	.|. |	36	-0.009	-0.047	203.44	0.000

Table 4.0 shows the randomness of residual errors terms i.e comparing Q and P values. P-values is the probability that exceeded Q by chance given a random series of residual. The test result was lag to 36 which indicate that all rainfall experienced in the years under study are not the same for ACF and PACF at a given period t since Q>P values.

The model application to data of year 2014 to validate the fitted model as computed in the Table 5.0 above shows that from the month of November to March Lokoja would experience light shower or for stipulated period of five months (5months). Percentage errors computed for the months of April to October are -8.28%,-7.89%,-8.96%,-8.40%,-5.72%,-8.52% and -8.60% respectively. The mean values computed for the Months of November, December, January, February and March are 5.37mm, 0.25mm, 1.27mm, 16.84mm and 33.16mm.

Model application to rainy months of year 2014 from April to October which is stipulated period of seven months (7months) as computed in the table 5.0 clearly shows that errors are low for the months of April to October with errors of-8.28%,-7.89%,-8.96%,-8.40%,-5.72%,-8.52%and-8.60% respectively. The mean computed for only the rainy months from April to October are 123.230mm, 181.30mm, 153.46mm, 220.37mm, 222.38mm, 205.04mm and 151.99mm (see Table 2.0).from the results it shows that July, August and September has the highest rainfall totals. Therefore three months of the year from 1986-2016 indicates when Lokoja and its environment would experience peak rainfall. The validation using data 2014 gives the same accuracy with when data for January to December was used in determining the model; this is further confirmation of the reliability and validity of the model

Annual rainfall variability for the study area

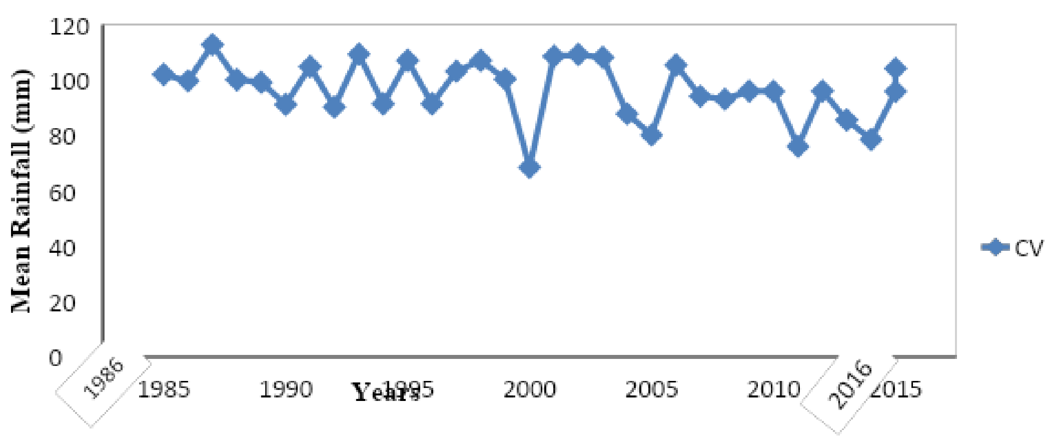


Fig 4.5 Rainfall Variability Curve in Lokoja from 1986-2016.

From Table 2.0, The Analysis of the results established that there was variability in the weather and climate system of Lokoja due to the observed shifts in rainfall within the climatic period of 30years. The average mean rainfall in Table 2.0 from 1986 to 1988 indicated that there was a gradual increase in rainfall with the mean 2.84%, 3.88% and 4.03%. After which it dropped 2.76% in 1989.And then shifted to 3.79% in 1990. It was later decreases to 2.63% and 2.42% between 1991 and 1992. The rainfall was high above 3.0% throughout between 1993 to 2013 except in 1999, 2001, 2003, 2005, 2010 and 2011 with mean 2.86%, 2.36% 2.40%, 2.49%, 2.61% and 2.66% .In 2014, it rained heavily with mean 4.58% which was the hydrologic year .There was a sharp decrease in rainfall for 2years between 2015 and 2016 with mean 2.92% and 2.83%.

IV. CONCLUSION

The Autoregressive Moving Average ARMA at order one i.e ARMA (1,1) is more appropriate stochastic model that helps to give good prediction with adequate values on the significance differences between variation on possible outcome on climatic factor such as rainfall and its effects on climatic change in Lokoja metropolis. From the results obtained heavy rainfall was experienced in the years 2005 to 2014.The model application to data of year 2014 to validate the model shows that percentage errors are high for the dry months of November, February, and March but low for the rainy season of April to October. The rainy season is the focus of this work as it accounts for rain fed agriculture and flooding. It can be deduced from the analysis that Lokoja would experience light shower or no rainfall for period of five months (5months) from November to March which is the period of dry season. The model application to rainy months(rainy season) from April to October which is the stipulated period of seven months (7months) shows the reliability of the model. The study also established that there was variation over Lokoja within the period under study which shows some evidence of climatic change in the study area. Based on the ARMA modeling of the Lokoja rainfall, despite the seasonal, rainfall variability and irregular fluctuations observed in the series the model developed could be extended to other climatic variables such as wind, temperature, humidity and evaporation for further studies.

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REFERENCES

[1]. Adefolalu , D.O. (1986), Rainfall trends in Nigeria *journal of theoretical* and *Applied Climatology,* 37 (4):205-219.
[2]. Adelekan, I.O (2009): Vulnerability of poor Urban Coastal Communities to Climate Change in Lagos, Nigeria Fifth Urban Research Symposium 2009.
[3]. Aderogba, K.A., (2012):Qualitative studies of recent Floods and Sustainable Growth and development of Cities and Towns in Nigeria .*International Journal of Academic Research in Economics and Management Sciences June* 2012, Vol 1 No.3 ISSN:2226-3624.
[4]. Ansari, H. (2013). Forecasting seasonal and annual rainfall based on non-linear modeling with Gamma test in North of Iran, International *Journal of Engineering Practical Research, 2 (1): 16-29.*
[5]. Aribisala , J.O., (2007)Water use forecast for hydro power generation. *Journal of Engineering and Applied Sciences 2(1):222-225.*
[6]. Chatfield, C.(2004).The Analysis of time series, an introduction, Sixth edition: New York, Chapman & Hall/CRC.pp.100-103
[7]. Collischonn, W., Haas, R., Andreolli, I., and Tucci, C.E.M. (2005). Forecasting river Uruguay flow using rainfall forecasting from a regional weather predicted model, *Journal of hydrology* 4 (1): 87-98.
[8]. Engle (1982), Autoregressive conditional Heterodasticity with estimates of Variance of United Kingdom inflation Econometrical (50):987-1008
[9]. Fan and Yao,.Q(2003) Forecasting spot electricity prices A comparison of parametric and semi parametric Time Series models *International Journal of forecasting* ,2008 Vol 24 issue 4, 744-763
[10]. Federal Republic of Nigeria (2013) North Central States: Kogi State
[11]. French, G. and Darand, M. (1992) Forecasting precipitation with Artificial Neural Networks Journal of Applied Sciences (9):1786-1790
[12]. Kogi State Government (2013) http://www.kogistate.org/ (Accessed Dec 20, 2013)
[13]. Ogallo,L.A, (1980): Times Series Analysis of rainfall in East Africa. PhD Thesis, Dept. of Meteorology, University of Nairobi Kenya, pp 237-238
[14]. Oguntade, A. Mafimisebi, and Okafor .C.(2011).Analysis of rainfall trend over Nigeria. Retrieved from www.research gate.net
[15]. Okorie , F.C Ezedike C.E. and Chibo, C.N Rainfall variability as evidence of climate variation in Imo State of south-eastern Nigeria. *International Journal of Sustainable Development* 4(9):50-55.
[16]. W.M.O. (1990). Statistical Analysis of Series of observations. World Meteorological Organization. W.M.O – No 415 .Geneva, Switzerland.
[17]. Weron and Misiorek 2008 A comparison of parametric and Non-parametric Time series models..2014 Vol 2 No 1 18-24
[18]. World Meteorological Organization (W.M.O) Extranet (2015) accessed 20 August 2015,| www.wmo.int