ISSN No:-2456-2165

An Assessment of the Effects of Climate Change on Rainfall Variability and Drought over Abuja, Nigeria

O. O. Itiowe, M.Sc*
Central Forecast Office, Nigerian Meteorological Agency,
Abuja Nigeria

S. M. Hassan
Department of Geography and Environmental Management,
Faculty of Social Science, Abuja
Nigeria

O. D. Oghenejabor, M.Sc
Research and Training Unit, Nigerian Meteorological Agency,
Abuja Nigeria

Abstract:- The unsteady characteristics of rainfall in recent times can be attributed to alterations in the global climate. This has exposed the environment to hazards of extreme weather events such as droughts and floods thereby posing threat to livelihood especially in developing countries with a low climate adaptation capacity. Among other factors, rainfall variability in recent times has become a complex phenomenon hampering the implementation of suitable adaptation initiatives required in mitigating consequent extreme events. This paper presents an analysis of the fluctuations in the rainfall over Abuja between 1986 and 2016 with special emphases on the magnitude of wetness and dryness of the area within the period of study. The Standardized Precipitation Index (SPI) and Precipitation Variability Index (PVI) were used to assess the level of wetness and dryness as well as the extent of meteorological drought in a season based on thirty one year rainfall data from the Abuja station of the Nigerian Meteorological Agency. The results obtained indicated that rainfall is highly variable in Abuja ranging from least to moderate as well as high variability. The study shows high rainfall variability throughout the period under review with more dryness over the last decade which was more pronounced in 2013 and 2014 respectively. Findings from this paper will be helpful in developing tools for regular warnings against meteorological drought with the possibility of massive water intervention especially for crop management amongst other mitigation and adaptation practices.

Keywords:- *Climate Change, Rainfall Variability, Mitigation and Adaptation Strategies.*

I. INTRODUCTION

The temperature of the earth's climate has increased with about 0.7 degrees within the last century (IPCC, 2018). This global shift in climate is significant in space and through time among different regions (IPCC, 2018) primarily due to the gradual heating up of the earth surface (Purkey and Johnson, 2010; Santamouris, 2013) which has resulted to variability in global rainfall. Precipitation projections in general circulation models (GCMs) have large uncertainties compared to other model variables, such as temperature (Knutti and Sedlacek, 2013). The most confident estimates indicate that precipitation will increase in mesic areas particularly the wet tropics, the mid to high latitudes of the Northern Hemisphere, and decrease in semi-arid regions particularly the subtropics.

Climate variability study over temporal and spatial scale is important to understand the behaviour of different climate systems and their effects on environment and community (Oguntunde et al. 2012). Ziervogel et al. (2006); UNDP (2010) states how climate variability directly impacts on cropping in several ways, which has constantly hindered the prospects of attaining specific Millennium Development Goals (MDG); such as alleviation of poverty and hunger. In recent times, Nigeria has been regarded as a country having more people living in extreme poverty which could increase from 44.2% to 45.5% in 2030 (World Poverty 2018). Adger et al. (2007) argued that difficulties in coping with droughts and rainfall variability have contributed to the deepening poverty. Scholarly studies by Tambo and Abdoulaye (2013); Abaje et al. (2014); Amwata et al. (2016), have revealed that elongated period of drought can result to starvation in most rural communities in Africa since most household depend on agriculture for their livelihood.

Although, several studies have reported substantial upsurge in the frequency and intensity of drought in Africa, such has not been experienced over the last 3 decades in Nigeria (Ekpoh and Nsa 2011). Contrarily, there have been reports of Nigeria being situated within the high drought risk zones of the world; increase in temperature over the last 45 years and about 20% decrease in precipitation between 1901 and 2001 has amplified the occurrence of droughts in various African nations (World Bank 2005; . Oguntunde et al., 2011; Masih et al., 2014; Abatan et al 2016). However, the nonexistence of drought reports in Nigeria over the years highlights the need to investigate the effect of climate change on droughts in Abuja located at the centre of the country.

Kim et al. (2010) examined the Impact of Climate Change on the East Asia Droughts. Result shows "increase in the mean precipitation over East Asia and decreased precipitation in Southeast Asia. Hence, due to the increased rainfall pattern, East Asia tends to be wetter with decreased frequency and duration of drought, while intense droughts are predicted to be more frequent in Southeast Asia". (Ambrosino, Chandler and Todd, 2010) worked on Southern African Monthly Rainfall Variability using Generalized Linear Models for the study. Findings of the study showed variability in precipitation in the region.

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Among the retained indices, relative humidity and El Niño accounted for the highest degree of explained variability. The location and intensity of the jet stream were also found to have a statistically significant and physically meaningful effect upon rainfall variability. Isikwue et al. (2013) conducted a study on Analysis of Rainfall Variability over some cities in Nigeria using Harmonic Analysis Technique to estimate the annual rainfall amounts over Port Harcourt and Kano from 1977 to 2008. The estimated rainfall values of 2011 – 2014 were validated using a T-test analysis on the estimated and measured rainfall values of 2009 and 2010 data. Results showed that rainfall variability in the two stations representing two different vegetative zones in Nigeria is strongly periodic and that the cyclic fluctuations in the rainfall are dominated by first harmonics, having large amplitudes of 90.40% and 75.41% in Port Harcourt and Kano respectively, indicating strong annual variations of rainfall in the stations. The mean monthly rainfall for both stations show different modal patterns. The 2009-2010 prediction of monthly average rainfall for the stations were validated at 95% confidence level. Nouaceur and Muraresc u, (2016) examined rainfall variability and trend of annual rainfall in Northern Africa. Their investigation showed extreme variability which was represented by the beginning of a gradual return to wetter conditions since the early 2000s in Algeria and Tunisia and from 2008 for Morocco (this trend is confirmed by recent agricultural production data in 2011/2012 and 2012/2013).

An assessment of monthly rainfall distribution in Nigeria between 1985-1994 and 1995-2004 was conducted by Eludoyin et al. (2009). Findings of the study showed some fluctuations in almost all the months in each year within the two decades. According to Ayansina and Ogunbo (2009) rainfall variability in Nigeria will continue to be on the increase as a result of climate change. This paper seeks to analyse fluctuations in the rainfall over Abuja between 1986 and 2016 with special emphases on the magnitude of wetness and dryness of the area as well as consider some adaptation strategies to mitigate the induced stress of extreme weather and climate especially on agriculture.

II. STUDY AREA

The study area, Abuja lies at the centre of Nigeria between coordinates of latitude 8º 25' and 9º25' north of the equator and longitude 6º 45'and 7º 45' east of Greenwich. The territory covers an area of 8,000 square km. It is bordered to the north by Kaduna State, to the east by Nasarawa State, to the south west by Kogi State and to the west by Niger State. The Nigerian climate is characterized mainly by the interplay between the dry north-easterly and the moist south-westerly winds. The climate of the study area is the hot and humid tropical type. Its relative humidity is not as high as in the southern part and temperatures are not as high as in the far north either (Oyekale, 2009). The maximum temperatures occur in March with amounts varying from 37ºC in the south-west to about 30ºC in the north-east (Adakayi, 2000). Abuja represents a transitional character between the zone of double rainfall maximum to the south and of a single maximum to the north. This coupled with its locational advantage to the windward of the Jos Plateau are some of the factors responsible for the variation in rainfall amounts received in a year (Adakayi, 2000). Rainfall starts at about 20th of March on the southern boundary of territory to about 10th of April at the northern limits. Rainfall cessation dates range from 20th October in the north to about 18th November in the south, giving a duration of between 190-240 days.

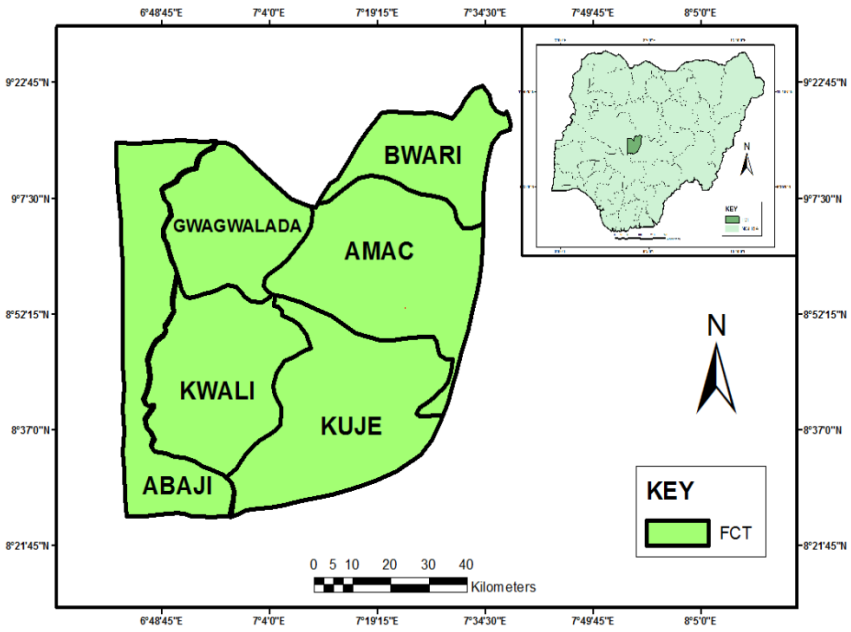

Fig 1:- Map showing the study area
Source: University of Abuja Geographic Information Systems Laboratory

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III. MATERIALS AND METHODS

Rainfall is particularly important with respect to agriculture in Abuja since agriculture in the region is mostly rain-fed. Thirty one years (1986 – 2016) quality-controlled daily rainfall data from the Abuja station of the Nigerian Meteorological Agency (NIMET) was used for the study.

➢ *Data Analysis*

The Standardized Precipitation Index (SPI) and Precipitation Variability Index (PVI) were used to analyse the daily, monthly and annual mean rainfall as well as the degree of Abuja's variability with reference to dryness and wetness. Rainfall trends for three (3) decades were also determined. Positive SPI values indicated greater than mean precipitation while negative values indicated less than mean precipitation.

Formula for SPI is given as $\frac{x - \bar{x}}{SD}$

Where, x = Actual Rainfall;
$\bar{x}$ = Mean Rainfall and;
SD = Standard Deviation from normal rainfall.

Formula for PVI is given as PVI = (A/Y-B/Y) 100% = Hd/m-Ld/MY
Where, Hd = highest daily rainfall in a month
Ld = lowest daily rainfall in a month
m = monthly rainfall total
MY = monthly total * annual total

This model explains the tendency of doughtiness in a given season. It has three threshold levels that explain the regions variability in the dryness and vulnerability to drought, i.e.

i. Least Variable = ≤ 20%
ii. Moderately Variable = ≥ 20% but ≤ 30% and
iii. Highly Variable = ≥ 30%

IV. RESULTS AND DISCUSSION

➢ *Precipitation Variability*

The study shows high rainfall variability throughout the years under review. Table 1 shows 72% precipitation in 1986 as against -99% in 1988. It further deepened to -106% in 1989 but experienced a sharp rise to 123% in 1994 and 131% in 1999 respectively. Widely against the WMO climate normal of 1440mm for the base years of 1981 to 2010, the year 2000 experienced dryness of -122% but an extreme wet year with PVI value of 279% in 2002. The present study is in accordance with the studies of Marengo et al. (2018) whose focus was on "Climatic Characteristics of The 2010-2016 Droughts in The Semiarid Northeast Brazil Region". Analysis using drought indicators and meteorological fields shows that "since the middle 1990s to 2016, 16 out of 25 years experienced rainfall below normal, which implies that the present drought may have started since late 90s, with the intense drought of 1993 and 1998, and then the sequence of dry years (interrupted by relatively wet years in 2007, 2008, 2009 and 2011) after that may have affected the levels of reservoirs in the region, resulting to intense water crisis that was magnified by the negative rainfall anomalies since 2010". In addition to the present study, high variability in the nature of precipitation of Abuja persisted even in the last decade with -135% in 2008 to 139% in 2010, downshift to -175% in 2013 and a rise of 87% in 2016. NiMet Quarterly Weather Review (2016) also captures precipitation as highly variable in Abuja.

Year	Rain (x)	$\bar{x}$	SD	$\bar{x}$-x	SPI = $\bar{x}$-x/SD	$\bar{x}$-x/SD*100
1986	1558.6	1424.3	185.4	134.3	0.7	72.4
1987	1391.7	1424.3	185.4	-32.6	-0.2	-17.6
1988	1240.7	1424.3	185.4	-183.6	-1.0	-99.0
1989	1227.2	1424.3	185.4	-197.1	-1.1	-106.3
1990	1438.3	1424.3	185.4	14.0	0.1	7.5
1991	1499.6	1424.3	185.4	75.3	0.4	40.6
1992	1377	1424.3	185.4	-47.3	-0.3	-25.5
1993	1522.7	1424.3	185.4	98.4	0.5	53.0
1994	1651.5	1424.3	185.4	227.2	1.2	122.5
1995	1310.9	1424.3	185.4	-113.4	-0.6	-61.2
1996	1401.6	1424.3	185.4	-22.7	-0.1	-12.3
1997	1336.3	1424.3	185.4	-88.0	-0.5	-47.5
1998	1455.1	1424.3	185.4	30.8	0.2	16.6
1999	1667.9	1424.3	185.4	243.6	1.3	131.4
2000	1198.3	1424.3	185.4	-226.0	-1.2	-121.9
2001	1383	1424.3	185.4	-41.3	-0.2	-22.3
2002	1941.6	1424.3	185.4	517.3	2.8	279.0

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2003	1428.3	1424.3	185.4	4.0	0.02	2.1
2004	1541.2	1424.3	185.4	116.9	0.6	63.0
2005	1471.8	1424.3	185.4	47.5	0.3	25.6
2006	1311.6	1424.3	185.4	-112.7	-0.6	-60.8
2007	1388.9	1424.3	185.4	-35.4	-0.2	-19.1
2008	1174.7	1424.3	185.4	-249.6	-1.4	-134.6
2009	1444.6	1424.3	185.4	20.3	0.1	10.9
2010	1682.2	1424.3	185.4	257.9	1.4	139.1
2011	1212.4	1424.3	185.4	-211.9	-1.1	-114.3
2012	1638.1	1424.3	185.4	213.8	1.2	115.3
2013	1099.9	1424.3	185.4	-324.4	-1.8	-175.0
2014	1128.9	1424.3	185.4	-295.4	-1.6	-159.3
2015	1443.3	1424.3	185.4	19.0	0.1	10.2
2016	1586	1424.3	185.4	161.7	0.9	87.2

Table 1:- Percentage Variability of Rainfall

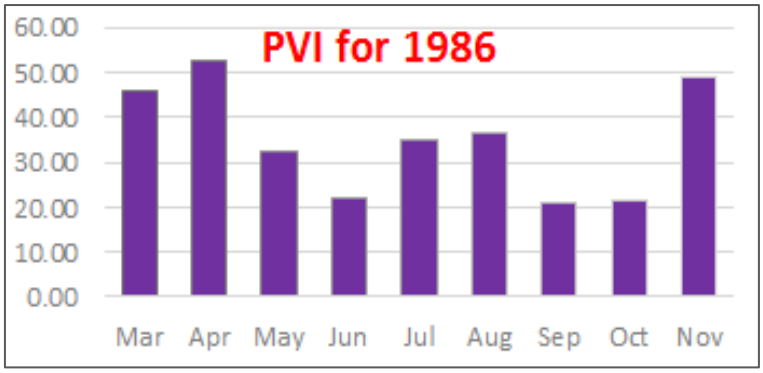

Fig 2:- Precipitation Variability Index for 1986

Figure 2 shows PVI values for March, April, May, July, August and November, 1986 as highly variable because they are greater than 30% while June, September and October as moderately variable because they are greater than 20% but less than 30%.

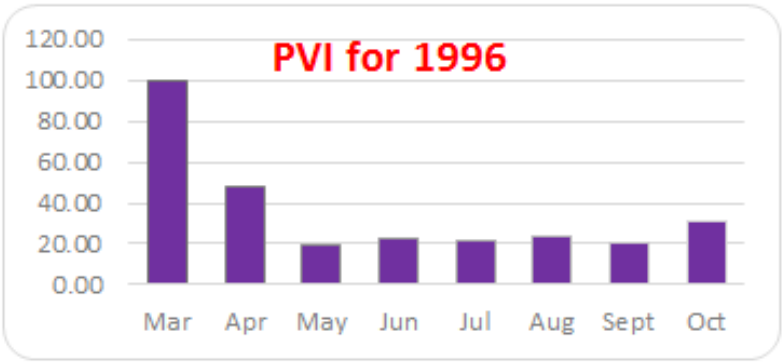

Fig 3:- Precipitation Variability Index for 1996

The PVI for 1996 shows some level of deviation from the past decade with only three months of high variability, four months of moderate variability and one month having least variability as against 1986 with high variability of six months and three months of moderate variability. This is in agreement with Adakayi (2012) who explained that variability, in terms of fluctuation or trend is an inherent attribute of climate or weather. He noted that considering the reality of climate change/variability, what is of more significance is the degree of variability that climate is subject to as well as the duration of such variability.

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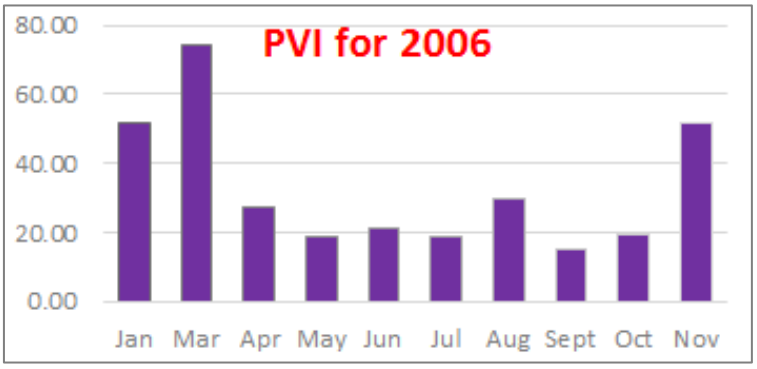

Fig 4:- Precipitation Variability Index for 2006

Figure 4 shows early rains in January with high variability value. High PVI was also observed in March and November. The months of April, June and August experienced moderate variability while least variability was observed in May, July, September and October, 2016. The early rain recorded in the year is an indication of fluctuation in the onset date in Abuja. Apparently, Nigeria being among the most populous countries in the world with an estimate of 200.8 million people (UN, 2019), stress the need to pay more attention to the current trends of climate variations especially as it affects agriculture and other forms of human livelihood in the country. Nkwunonwo et al. (2015) observed that climate change/variability have increased the frequency and intensity of rainfall which may have contributed to the recent flood incidences in some parts of the country. In the same vein, the study suggested modelling and vulnerability assessment as useful tools for future weather and climate risk and disaster reduction.

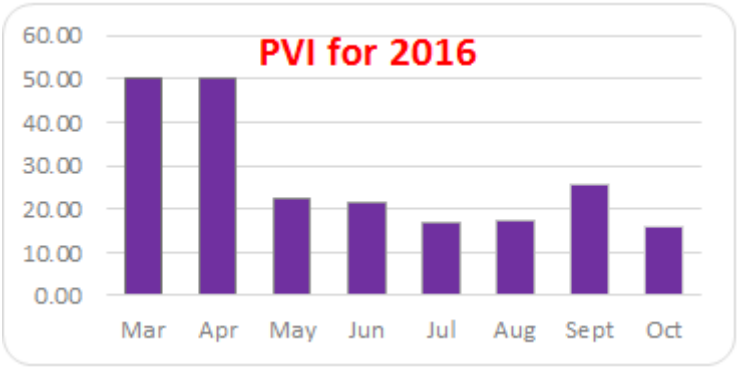

Fig 5:- Precipitation Variability Index for 2016

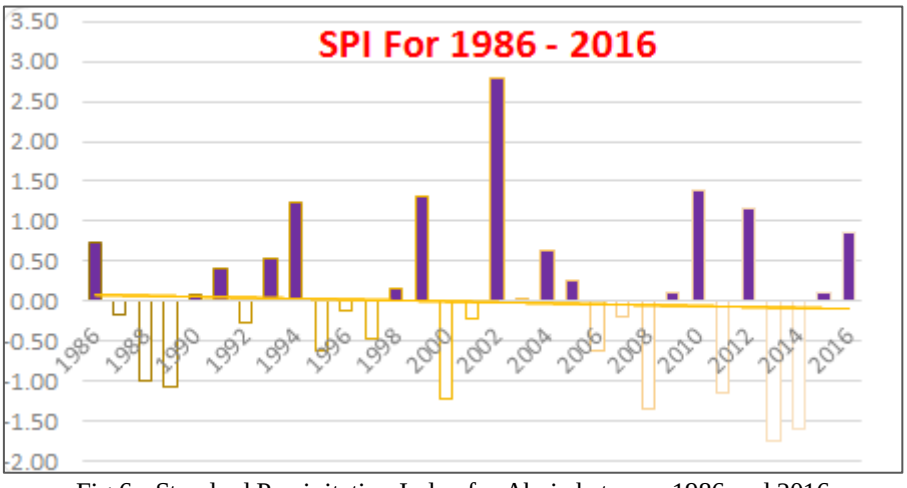

Fig 6:- Standard Precipitation Index for Abuja between 1986 and 2016

Generally, Abuja exhibits a pattern of rainfall ranging from least, moderate to high variability. However, some years tend to be more variable than others. The PVI values for 2016 shows two months with high variability, moderate and least variability appeared in three months and one month respectively. There is a gradual downward trend of rainfall in Abuja from 1986 to 2016. Figure 6 shows consistent fluctuations in the rainfall amount received in the last thirty one years except 2013 and 2014 which was observed as severely dry years thus indicating meteorological drought in Abuja. The trend and pattern of rainfall observed in this work gives an indication that Abuja is gradually getting drier and highly variable in daily, monthly and annual precipitation received.

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➢ *Decadal Rainfall Patterns and Inter-annual Meteorological Drought*

The PVI gives a critical insight of the extent of meteorological drought in a season. Table 2 shows that Abuja received less than normal rainfall for six years as well as above normal rainfall for four years indicating drier than wet years between 1987 and 1996. In the same vein, the table shows 1988 and 1989 as the driest years during the period. Although there was a rise in rainfall from 1990 through to 1994, the following year 1995 experienced a decline in rainfall. Moderate dryness was observed twice in 1988 and 1989 while other years had mild and normal dryness. The study shows varying drought levels over Abuja in the last four decades. Ajileye et al. (2015) observed slight increase in drought incidences over Abuja as well as a gradual shift from wet to dry climate confirming occurrence of drought over Nigeria in the last two decades

Year	Rain (X)	Mean	SD	X-MEAN	SPI= X-MEAN/SD
1987	1391.7	1406.1	130.4	-14.4	-0.1
1988	1240.7	1406.1	130.4	-165.4	-1.3
1989	1227.2	1406.1	130.4	-178.9	-1.4
1990	1438.3	1406.1	130.4	32.2	0.3
1991	1499.6	1406.1	130.4	93.5	0.7
1992	1377	1406.1	130.4	-29.1	-0.2
1993	1522.7	1406.1	130.4	116.6	0.9
1994	1651.5	1406.1	130.4	245.4	1.9
1995	1310.9	1406.1	130.4	-95.2	-0.7
1996	1401.6	1406.1	130.4	-4.5	-0.03

Table 2:- Yearly Rainfall of Abuja from 1987 to 1996

Mar	46%
Apr	53%
May	33%
Jun	22%
Jul	35%
Aug	37%
Sep	21%
Oct	21%
Nov	49%

Table 3:- PV1 for 1986

Year	Rain (x)	— x	SD	—X-x	SPI— X-x/SD
1986	1558.6	1424.3	185.4	134.3	0.7
1987	1391.7	1424.3	185.4	-32.6	-0.2
1988	1240.7	1424.3	185.4	-183.6	-1.0
1989	1227.2	1424.3	185.4	-197.1	-1.1
1990	1438.3	1424.3	185.4	14.0	0.1
1991	1499.6	1424.3	185.4	75.3	0.4
1992	1377	1424.3	185.4	-47.3	-0.3
1993	1522.7	1424.3	185.4	98.4	0.5
1994	1651.5	1424.3	185.4	227.2	1.2
1995	1310.9	1424.3	185.4	-113.4	-0.6
1996	1401.6	1424.3	185.4	-22.7	-0.1
1997	1336.3	1424.3	185.4	-88.0	-0.5
1998	1455.1	1424.3	185.4	30.8	0.2
1999	1667.9	1424.3	185.4	243.6	1.3
2000	1198.3	1424.3	185.4	-226.0	-1.2
2001	1383	1424.3	185.4	-41.3	-0.2

2002	1941.6	1424.3	185.4	517.3	2.8
2003	1428.3	1424.3	185.4	4.0	0.02
2004	1541.2	1424.3	185.4	116.9	0.6
2005	1471.8	1424.3	185.4	47.5	0.3
2006	1311.6	1424.3	185.4	-112.7	-0.6
2007	1388.9	1424.3	185.4	-35.4	-0.2
2008	1174.7	1424.3	185.4	-249.6	-1.4
2009	1444.6	1424.3	185.4	20.3	0.1
2010	1682.2	1424.3	185.4	257.9	1.4
2011	1212.4	1424.3	185.4	-211.9	-1.1
2012	1638.1	1424.3	185.4	213.8	1.2
2013	1099.9	1424.3	185.4	-324.4	-1.8
2014	1128.9	1424.3	185.4	-295.4	-1.6
2015	1443.3	1424.3	185.4	19.0	0.1
2016	1586	1424.3	185.4	161.7	0.9

Table 4:- Rainfall Pattern of Abuja for 31 years

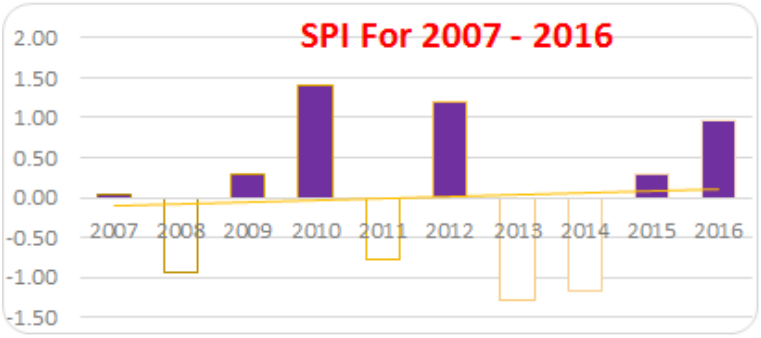

Fig 7:- Standard Precipitation Index for Abuja from 2007 to 2016

Figure 7 shows a pattern of mild to moderate dryness in Abuja. The study shows more of mild wetness in 2007, 2009 and 2015 compared with the previous decades especially in 2002 with extreme wetness. Although the SPI values for the three decades in Table 4 shows some similarities in the level of wetness and dryness, however, the study reveals that there is a slow and steady decline of rainfall in Abuja particularly with reference to the severe dryness observed in 2013 and 2014.

Value	**Rating**
≥ 2	Extreme wetness
< 2 ≥ 1.5	Severe wetness
≥ 1 < 1.5	Moderate wetness
≥ 0.5 < 1	Mild wetness
< 0.5	Normal
> -0.5	Normal
≥ -0.5 < -1	Mild dryness
≥ -1 < -1.5	Moderate
> -2 ≤ -1.5	Severe
≤ -2	Extreme

Table 5:- SPI Table (Komuscus) measuring Wetness and Dryness

V. CONCLUSION

Climate variability and climate change seem to have taken the centre stage in Abuja with gradual but consistent decrease in rainfall recorded in the last three decades and sharply represented in the immediate past decade. The study observed high variability in terms of daily and monthly and annual precipitation. This is in accordance with Ayansina and Ogunbo (2009) who adduced that rainfall variability in Nigeria will continue to be on the increase as a result of climate change. The variations in inter-annual dryness as well as varying onset, cessation and length of raining season reveals Abuja's vulnerability to meteorological drought. This invariably implies that,

climate variability and climate change seem to be the major contributing factors to drought incidences in Abuja especially meteorological drought.

This paper suggests a few climate adaptation measures amongst which are; early warning alert and forecast system to mitigate occurrences of meteorological drought with the possibility of massive water intervention especially for crop management. Another critical adaptation measure is the urgent need for more weather observatories for sufficient climatic data of Abuja and all over Nigeria. Modelling and vulnerability assessment can also serve as useful tools for future weather and climate risk and disaster reduction. Other aspects of mitigation and adaptation practices for drought especially through strategic national policies and intervention programs by government should be employed to reduce the effects of climate change on Abuja.

REFERENCES

[1]. Abaje, I. B., Sawa, B. A., & Ati, O. F. (2014). Climate variability and change, impacts and adaptation strategies in Dutsin-Ma Local Government Area of Katsina State, Nigeria. Journal of geography and Geology, 6(2), 103.

[2]. Abatan, A. A., Abiodun, B. J., Lawal, K. A., & Gutowski, W. J. (2016). Trends in extreme temperature over Nigeria from percentile-based threshold indices. International Journal of Climatology, 36(6), 2527-2540.

[3]. Adakayi, P. E. (2000).Vegetation of FCT in Geography of Federal Capital Territory: edited by Dawam, P.D. pp.23-27. The Abuja journal of Geography and Development.

[4]. Adakayi P. E. (2012). An Assessment of Rainfall and Temperature Variations in parts of Northern Nigeria. PhD Thesis in the Department of Geography and Planning, University of Jos, Nigeria

[5]. Adger, W. N., Agrawala, S., Mirza, M. M. Q., Conde, C., o'Brien, K., Pulhin, J., and Takahashi, K. (2007). Assessment of adaptation practices, options, constraints and capacity. Climate change, 200.

[6]. Ajileye O. O., Aigbiremolen I. M., Mohammed S. O., Halilu A. S., Alaga A. T. (2015). Effect of Climate Variability on Drought Occurrence Probability over Nigeria. British Journal of Applied Science and Technology 12(1): 1-13, 2016, Article no.BJAST.19951 ISSN: 2231-0843, NLM ID: 101664541

[7]. Ambrosino, C., Chandler, R. E., & Todd, M. C. (2011). Southern African monthly rainfall variability: An analysis based on generalized linear models. Journal of climate, 24(17), 4600-4617.

[8]. Amwata, D. A., Nyariki, D. M., & Musimba, N. R. K. (2016). Climate factors as determinants of food security in semi-arid Kenya: a longitudinal analysis (No. 310-2016-5371).

[9]. Ayansina, A., & Ogunbo, S. (2009). GIS approach in assessing seasonal rainfall variability in Guinea Savanna part of Nigeria. In 7th FIG regional conference, Vietnam (Vol. 16).

[10]. Eludoyin, A. O., Eludoyin, O. M., & Oyinloye, M. A. (2009). Monthly variations in the 1985–1994 and 1995–2004 rainfall distributions over five synoptic stations in western Nigeria. J Meteorol Clim Sci, 7, 11-22.

[11]. Ekpoh, I. J., & Nsa, E. (2011). Extreme climatic variability in North-Western Nigeria: An analysis of rainfall trends and patterns. Journal of Geography and Geology, 3(1), 51.

[12]. Isikwue, B. C., Ameh, M. E., & Utah, E. Y. (2013). Analysis of rainfall variability over some cities in Nigeria using harmonic analysis technique. Nigerian Journal of Physics, 24, 16-24.

[13]. IPPC (2018) Historical Overview of Climate Change Science. [Online] available from https://www.ipcc.ch/site/assets/uploads/2018/03/ar4-wg1-chapter1.pdf [21 April 2019]

[14]. Kim, D. W., Choi, K. S., Lee, J. S., & Byun, H. R. (2010). Impact of climate change on the East Asia droughts. In Advances in Geosciences: Volume 16: Atmospheric Science (AS) (pp. 165-177).

[15]. Marengo, J. A., Alves, L. M., Alvala, R., Cunha, A. P., Brito, S., & Moraes, O. L. (2018). Climatic characteristics of the 2010-2016 drought in the semiarid Northeast Brazil region. Anais da Academia Brasileira de Ciências, 90(2), 1973-1985

[16]. Masih, I., Maskey, S., Mussá, F. E. F., & Trambauer, P. (2014). A review of droughts on the African continent: a geospatial and long-term perspective. Hydrology and Earth System Sciences, 18(9), 3635-3649.

[17]. Nkwunonwo U. C., Malcolm W., Brian B. (2015). Flooding and Flood Risk Reduction in Nigeria: Cardinal Gaps. Journal of Geography and Natural Disaster 5:136. doi: 10.4172/2167-0587.1000136

[18]. Nouaceur, Z., & Murărescu, O. (2016). Rainfall variability and trend analysis of annual rainfall in North Africa. International Journal of Atmospheric Sciences, 2016.

[19]. Oguntunde, P. G., Abiodun, B. J., & Lischeid, G. (2011). Rainfall trends in Nigeria, 1901–2000. Journal of Hydrology, 411(3-4), 207-218.

[20]. Oguntunde, P. G., Abiodun, B. J., Olukunle, O. J., & Olufayo, A. A. (2012). Trends and variability in pan evaporation and other climatic variables at Ibadan, Nigeria, 1973–2008. Meteorological Applications, 19(4), 464-472.

[21]. Oyekale, A. S. (2009). Climatic variability and its impacts on agricultural income and households' welfare in southern and northern Nigeria. Electronic Journal of Environmental, Agricultural and Food Chemistry, 8(1), 13-34.

[22]. Purkey, S. G., & Johnson, G. C. (2010). Warming of global abyssal and deep Southern Ocean waters between the 1990s and 2000s: Contributions to global heat and sea level rise budgets. Journal of Climate, 23(23), 6336-6351

[23]. Santamouris, M. (2013). Energy and climate in the urban built environment. Routledge.
[24]. Tambo, J. A., & Abdoulaye, T. (2013). Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. Regional Environmental Change, 13(2), 375-388.
[25]. UNDP (2010) United Nations Development Program. The Millennium Development Goals 2000. Available online at: <http://web.undp.org/mdg/basics.shtml>Accessed April 2011
[26]. World Bank (2005) Natural Disaster Hotspots A Global Risk Analysis.[Online) Available from <http://documents.worldbank.org/curated/en/621711468175150317/pdf/344230PAPER0Na101official0use0only1.pdf>[20th May 2019]
[27]. World Poverty (2018). The Percentage of Nigerians Living in Extreme Poverty Could Increase by 2030.[Online) Available from <https://worldpoverty.io/blog/index.php?r=12> [20th May 2019]
[28]. Ziervogel, G., Nyong, A., Osman, B., Conde, C., Cortés, S., & Downing, T. (2006). Climate variability and change: Implications for household food security. Assessment of Impacts and Adaptations to Climate Change (AIACC): Washington, DC, USA.