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Growing Season Rainfall Trends, Alterations and Drought Intensities in the Guinea Savanna Belt of Nigeria: Implications on Agriculture

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Abstract
This paper examined the growing season rainfall trends, alterations and drought intensities in the Guinea Savanna belt of Nigeria using monthly rainfall data of 1941-2010 from eight synoptic weather stations (Ilorin, Minna, Bida, Lokoja, Enugu, Makurdi, Jos and Kaduna). Simple linear regression and second order polynomial were used to investigate the rainfall trend of the synoptic weather stations. The rainfall data were partitioned into two periods (1941-1975 and 1976-2010). Simple percentage and t-test statistics were used to examine to monthly and growing season changes in rainfall while the drought intensities for the growing season were computed as percentage deviation below the mean (PDBM). The results revealed upward trends in Bida, Lokoja and Enugu during the 1941-2010 period with that of Lokoja being sharpest while Ilorin, Minna, Makurdi, Jos and Kaduna experienced downward trend with that of Jos being the sharpest. Rainfall in Minna, Lokoja, Enugu, Makurdi and Kaduna exhibited curvilinear attribute while Ilorin, Bida and Jos exhibit linear pattern. Only Makurdi and Jos revealed significant difference between the 1941-1975 and 1976-2010 periods. While Makurdi witnessed the highest percentage change in growing season rainfall, Bida experienced the lowest. Alterations of rainfall among the selected synoptic stations reveal mixed variations while the droughts were of slight and moderate intensities with the exception of Enugu which witnessed severe drought in 1966. The paper concludes that the change in growing season rainfall, especially in Makurdi and Jos, as well as the drought incidences could pose negative implications on Nigeria's food security if measures such as irrigation, cultivation of drought resistant varieties as well as alignment of cropping schedules with unfolding climatic patterns are not adopted.
Keywords: Growing season, rainfall, drought, Guinea Savanna, Nigeria

1. Introduction

Climate change causes an intensification of extremes of the global hydrological cycle has major impacts on water resources, affecting both ground and surface water supply for domestic and industrial uses, irrigation and in-stream ecosystems (FAO, 2007; Mimi and Jamous, 2010; Manyatsi *et al*., 2010). Associated with this extreme of the global hydrological cycle is the variation of the length of the growing season. Besides, growing season varies spatially, temporarily and with crops (Umar, 2010). Thus, although climate change poses a threat to both agricultural and non-agricultural activities, agricultural activities appear to be generally more vulnerable to climate change than other sectors (Ajetomobi and Abiodun, 2010, Mongi, *et al*., 2010; Atedhor, 2015).

Despite the agricultural significance of the savanna belts of Nigeria both as the prime source of grains and animal protein, it has been identified as the zone that is most characterized with rainfall variability (Owonubi, 1994) and coupled with this variability is drought which implies a period of unusually dry weather, extensive enough to cause severe interruption of crop production or ecological unit function (IPCC, 2012).

The savanna ecological zones are besieged with unprecedented droughts (Olaniran 2002; Odjugo, 2007; Ati *et al*., 2010; Atedhor and Odjugo, 2012; Umar, 2012; Atedhor, 2014). The Guinea savanna occupies a more extensive landmass among the savanna ecological zones (Binswanger-Mkhize *et al*., 2011), and it is significant both as a major source of grains and tuber crops due to its relatively high rainfall compared to the more northerly Sudan and Sahel savannas. For instance, more than 85% of the Nigeria's yams are currently grown in Guinea Savanna part of the country annually (IITA, 2004 in Ayanlade *et al*., 2009). As in other parts of Nigeria, the Guinea Savanna region receives rainfall from the tropical maritime air mass (*mT*) which originates from the Atlantic Ocean. The moist *mT* is overlain by the tropical continental air mass (*cT*) which blows from the Sahara Desert with the zone of convergence of the two air masses at the surface being a zone of moisture discontinuity known as the Inter Tropical Discontinuity (ITD). The seasonality of rain producing systems in Nigeria is associated with latitudinal shifts of the ITD (Adefolalu, 2002).

Because agricultural production is predominantly rain-fed in Nigeria, rainfall variability becomes decisive when moisture availability plunges beneath what is optimal for biomass development in diverse phases of the farming cycle, leading to poor yield (Ayanlade *et al*., 2009). Although rainfall variability can be adverse to all crops, the high moisture demands by root crops particularly make them more vulnerable. It is on this premise that this paper examined growing season rainfall trends, alterations and drought intensities in the Guinea Savanna belt of Nigeria.

2. Study Area

The study area covers the Guinea savanna which is the largest ecological landmass, occupying almost half of the country's landmass and extending from the northern limit of the Rainforest to the southern limit of the Sudan savanna ecological belts (Figure 1).

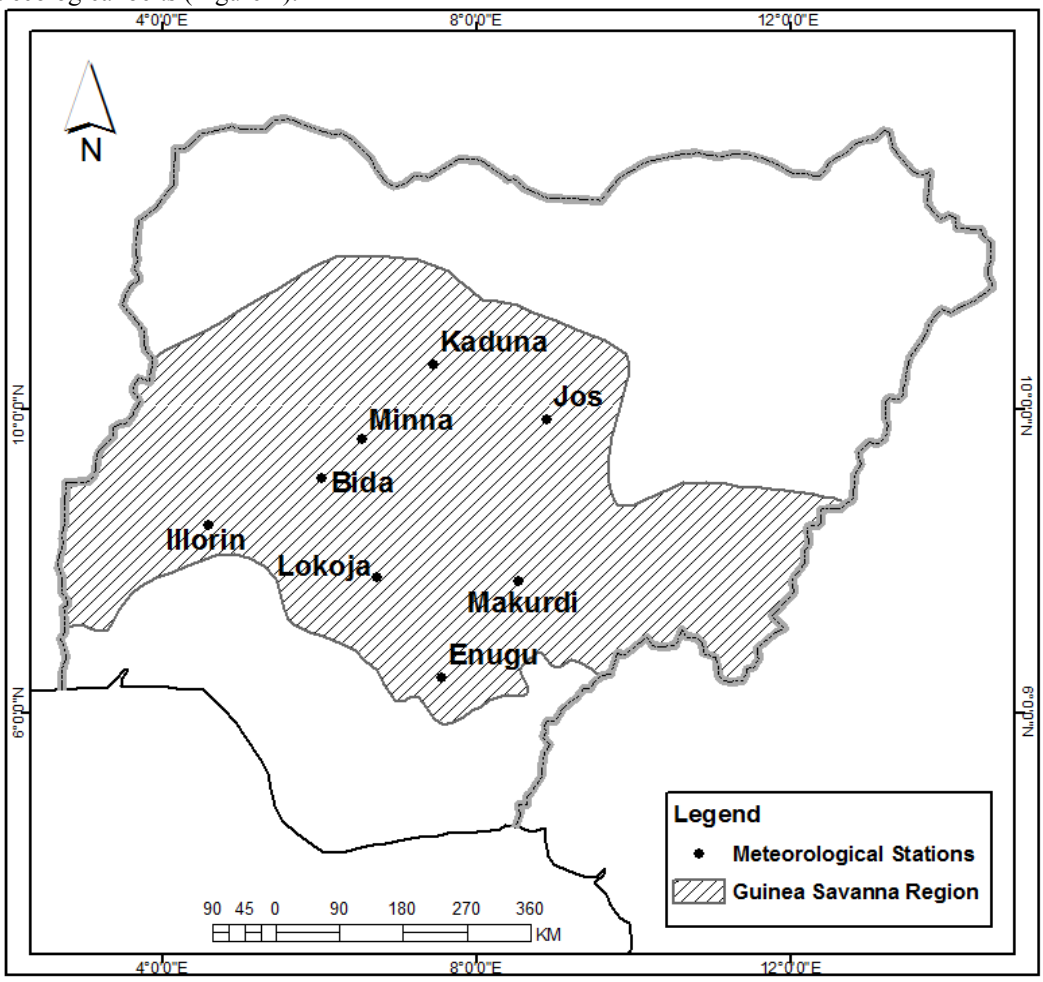

Figure 1: Guinea Savanna Region and Synoptic Weather Stations for the Study

The area witnesses annual rainfall of approximately 1500 mm in its southern parts at its boundary with the Rainforest region and about 1000 mm around its northern boundary with the Sudan savanna (Aregheore, 2009). The length of the rainy season in the area, as in other parts of the country, is largely dictated by the northward excursion and retreat of the ITD (Ilesanmi, 1971; Ayandike, 1986; Olaniran 2001). The length of the growing season which coincides with the rainy season lasts from April to October (Odekunle, 2004; Odeyemi and Ogunkoya, 2006). The Niger-Benue trough, which records the highest mean temperature in Nigeria (Adefolalu, 2002) lies in this area. The Jos Plateau which constitutes the north central highland is a major feature of the Guinea savanna with relatively low mean temperature and high annual rainfall due to elevation. The Jos plateau forms an extensive part of the Northern Central plateau with an elevation of 1500 to 1800 m with a south-west steep scarp that overlooks the high plains from a height of about 1600 m in the north-east (Aregheore, 2009). Savanna vegetation mixed with trees characterizes the area.

3. Materials and Methods

Monthly rainfall data for the growing season (April - October) from 1941-2010 were collected from the archives of the Nigeria Meteorological Agency, Oshodi. The data covered 8 synoptic weather stations (Enugu, Ilorin, Lokoja, Makurdi, Minna, Bida, Kaduna, and Jos). The growing season rainfall data were partitioned into two periods of 35 years each (1941-1975 and 1976-2010). Decadal variations of mean rainfall for each of the synoptic weather stations were computed while changes in mean rainfall between the two-35 years period were investigated using *t*-test. Simple linear regression and second order polynomial were used to investigate the trend of growing season rainfall trend in each of the synoptic station. The annual drought intensities were computed as percentage deviation from the mean and classified in line with (Ayoade, 1988; 2008) as follow:

Percentage	Intensities
11-25	Slight
26-45	Moderate
46-60	Severe
>60	Disastrous

4. Results and Discussion

The trends of growing season rainfall in the selected synoptic stations are presented in Figures 2-9. Ilorin, Minna, Makurdi, Jos and Kaduna witnessed declining trends of growing season rainfall while Bida, Lokoja and Enugu experienced increasing trends. While Jos and Minna recorded the worst and least decreasing trends of growing season rainfall with regression coefficients of -3,792 and -0.3374 respectively, Lokoja and Enugu experienced the highest and lowest increasing trends of growing season rainfall with regression coefficients of 3.9139 and 1.8031 respectively.

The high positive trend of growing season rainfall could be attributed to its proximity to the Rivers Niger and Benue since water bodies exert influence on the hydrological cycle (McCartney *et al,* 2001 cited in Akindele *et al* 2013; Aribo *et al*, 2015). The trends of the growing season rainfalls based on the second order polynomial, show recovery tendencies in Enugu, Minna and Makurdi while Kaduna shows persisting decrease. Ilorin and Jos exhibited negative linear rainfall patterns while Lokoja and Bida show positive linear patterns. This implies that regardless of whether the rainfall trend is upward or downward, growing season rainfalls in Ilorin, Jos, Lokoja and Bida during the period under investigation displayed linear pattern and not curvilinear. Ilorin, Minna, Bida and Makurdi experienced marked low growing season rainfall during 1972-1996, 1981-1993, 1979-1987 and 1958-1988 respectively. While the 1972/73 drought falls within the years of marked low rainfall in Ilorin and Makurdi, the 1983/84 drought occurred within the years of discernible low rainfall in Ilorin, Minna, Bida and Makurdi.

In Ilorin, while the highest growing season rainfall (1646.2mm) was recorded in 1968 during the 1941-2010 period, the lowest (683.3mm) was recorded in 2001 with the period 1972-1996 depicting a low rainfall. In Minna, the highest (1798.6mm) and lowest (809.9mm) rainfalls during the period were recorded in 1947 and 1987 respectively with a marked low rainfall during the 1981-1993 period. Bida witnessed the highest rainfall (1681.4 mm) in 2009 while the lowest (810.5mm) was recorded in 1972. Lokoja recorded the highest rainfall (1760.7mm) in 2008 while the lowest (678.9mm) was witnessed in 1942 with the period 1979-1987 revealing marked low growing season rainfall. However, it is important to note that despite the declining trend of growing season rainfall in Lokoja, the synoptic station has witnessed upward trend of annual rain-days as reported in Atedhor (2013). In Enugu, the lowest (862.6 mm) growing season rainfall was witnessed in 1966 while the highest (2054.3mm) was recorded in 1990. The highest (1946.5mm) and lowest (737mm) rainfalls in Makurdi were recorded in 1955 and 2003 respectively with a near persistent declining pattern from 1958 to 1988. The highest (1709mm) and lowest (814.7mm) growing season rainfall in Jos were recorded in 1969 and 1995 respectively. Kaduna witnessed the highest (1684.8mm) and lowest (848.9 mm) growing season rainfall in 1957 and 2008 respectively. Thus, despite being located in the same ecological zone, the synoptic stations have diverse years of maximum and minimum growing rainfall. This implies that apart from the causative mechanisms of rainfall such as ITD, Tropical Easterly Jet (TEJ), El Nino Southern Oscillation (ENSO) and Sea Surface Temperature Anomalies (SSTA), local changes in land cover, whether due to the activities of man or animals influence rainfall could create Biogeophysical Feedback Mechanisms (BFM) (Olaniran, 2002; Fasona *et al*, 2013; Shehu *et al*, 2015).

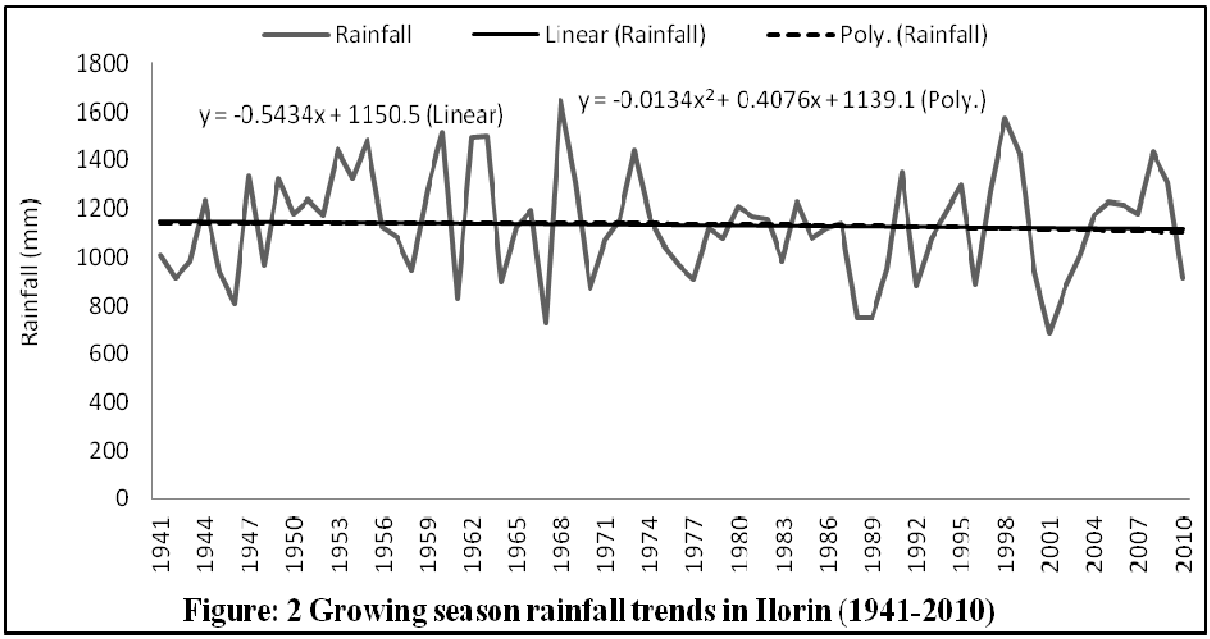

Figure: 2 Growing season rainfall trends in Ilorin (1941-2010)

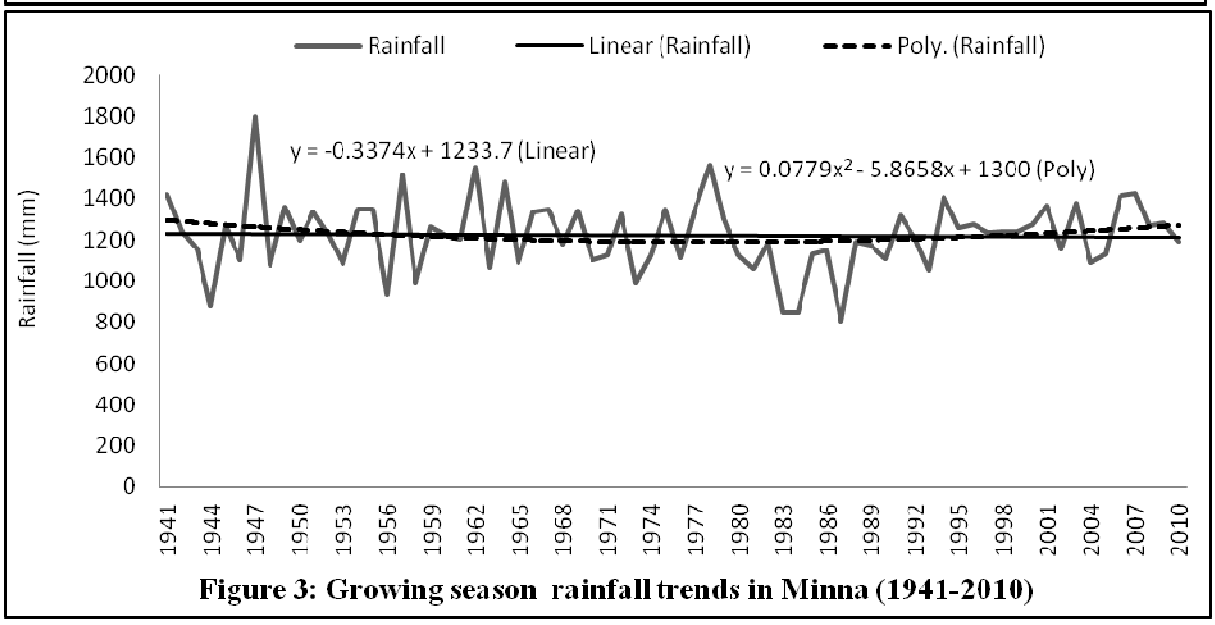

Figure 3: Growing season rainfall trends in Minna (1941-2010)

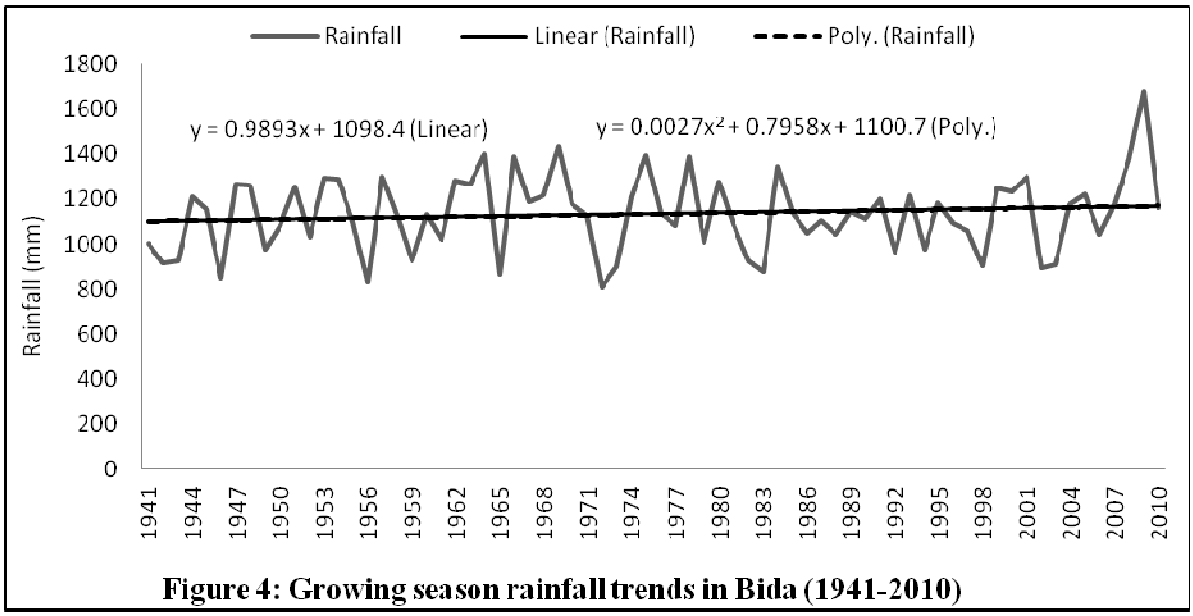

Figure 4: Growing season rainfall trends in Bida (1941-2010)

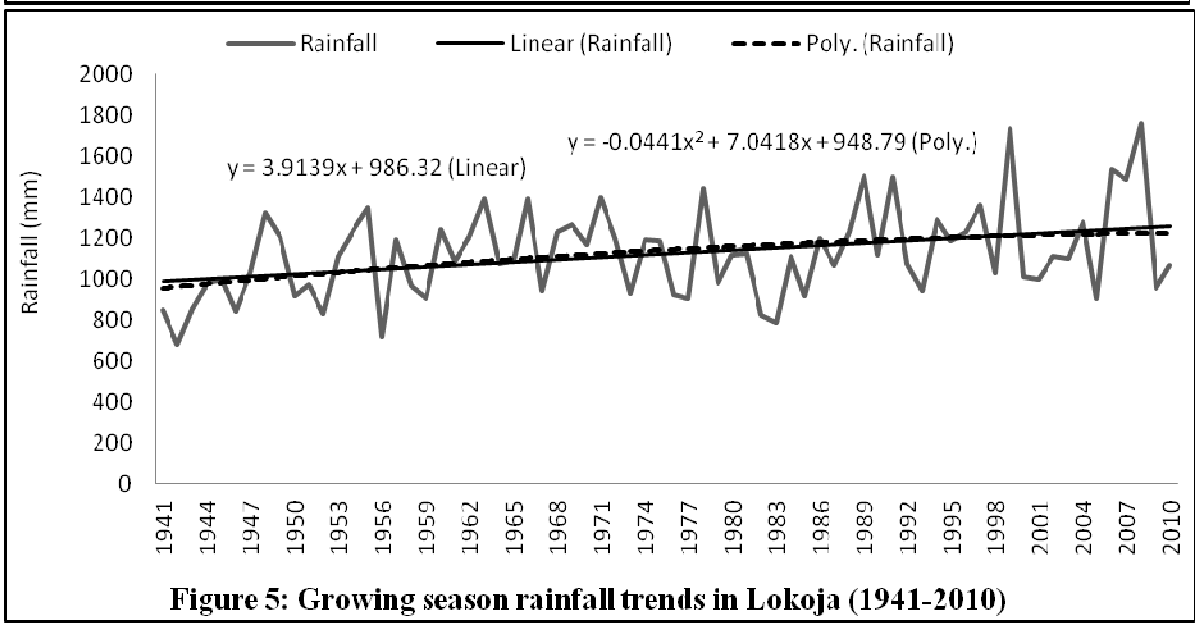

Figure 5: Growing season rainfall trends in Lokoja (1941-2010)

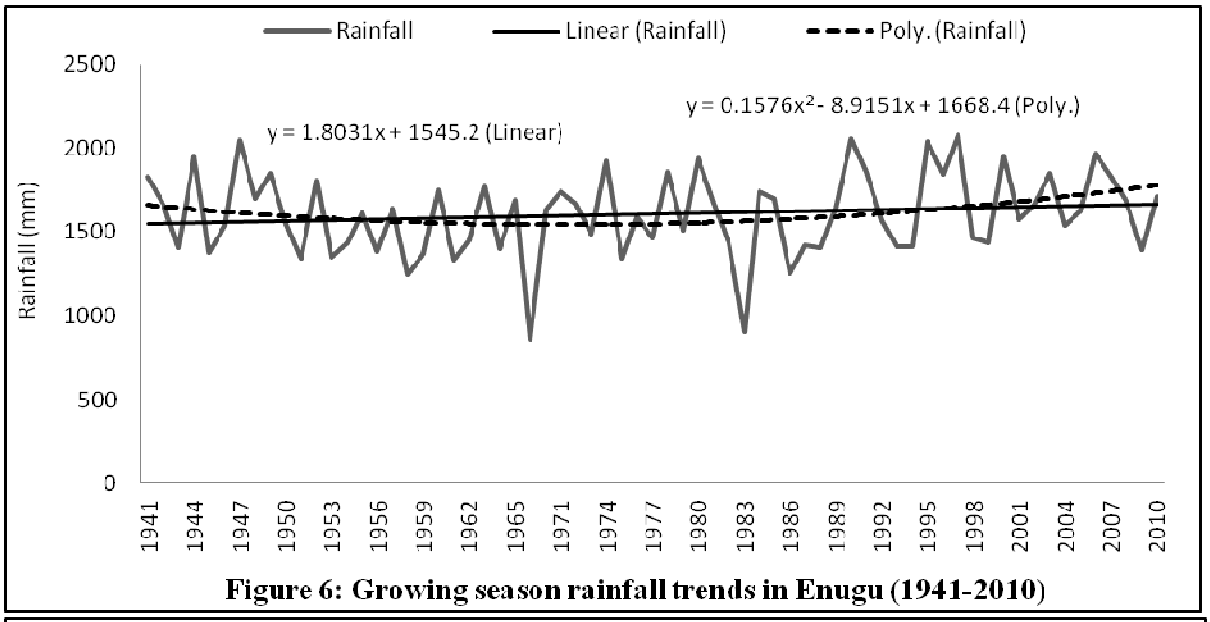

Figure 6: Growing season rainfall trends in Enugu (1941-2010)

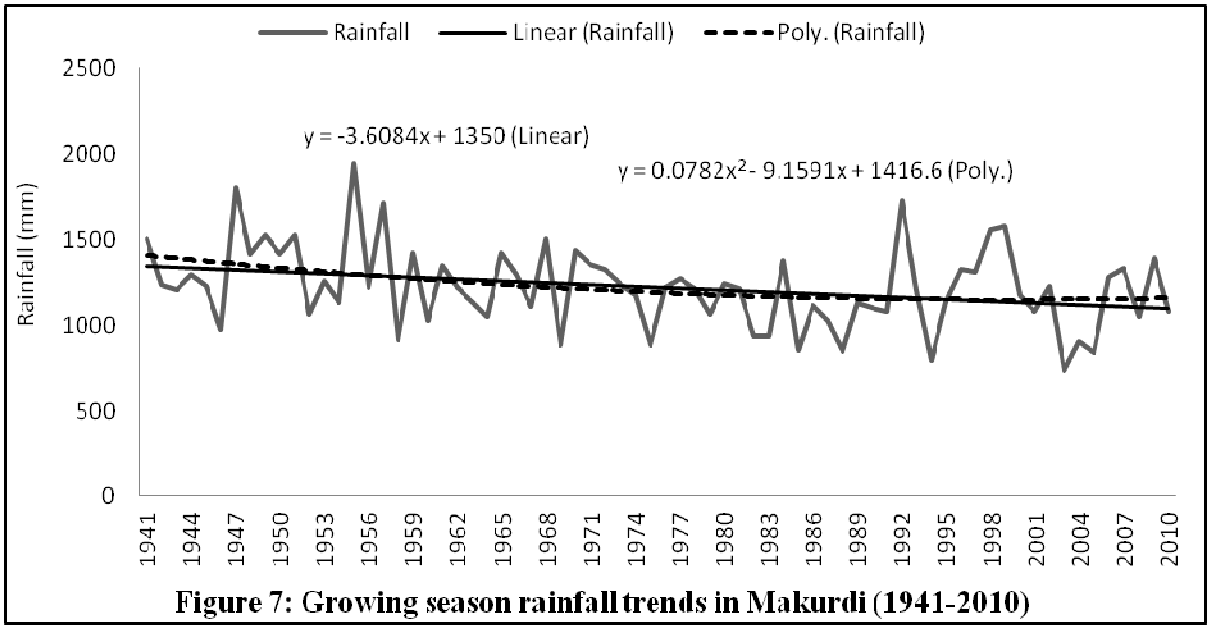

Figure 7: Growing season rainfall trends in Makurdi (1941-2010)

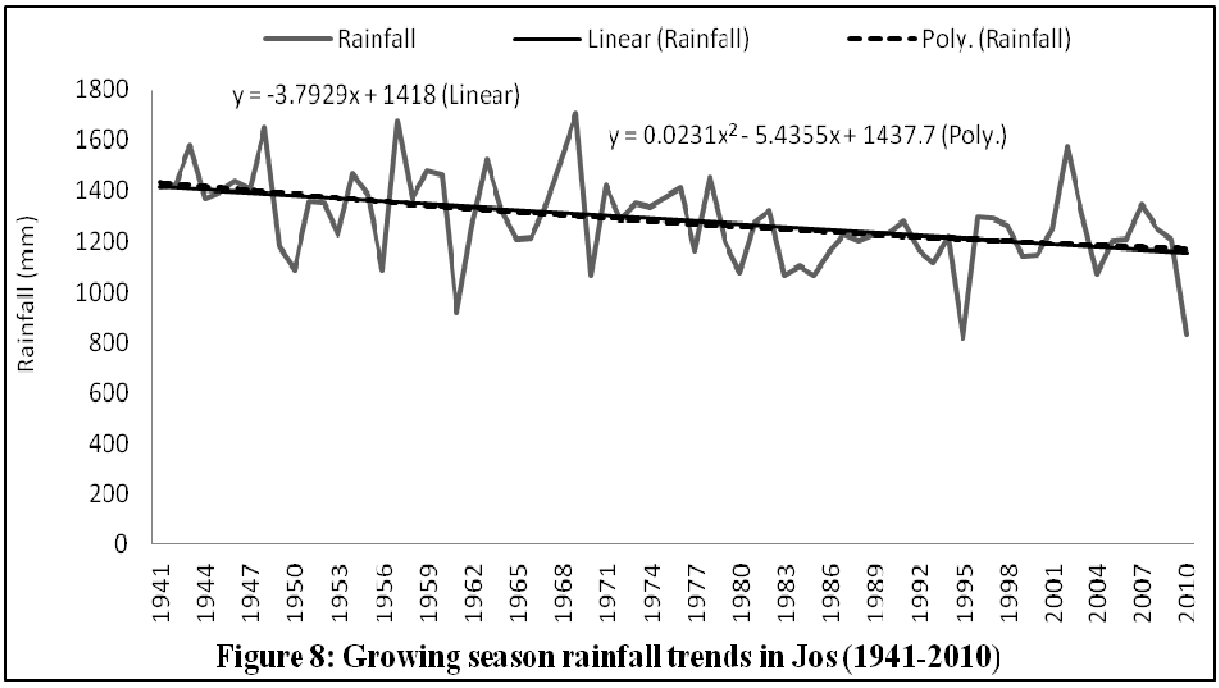

Figure 8: Growing season rainfall trends in Jos (1941-2010)

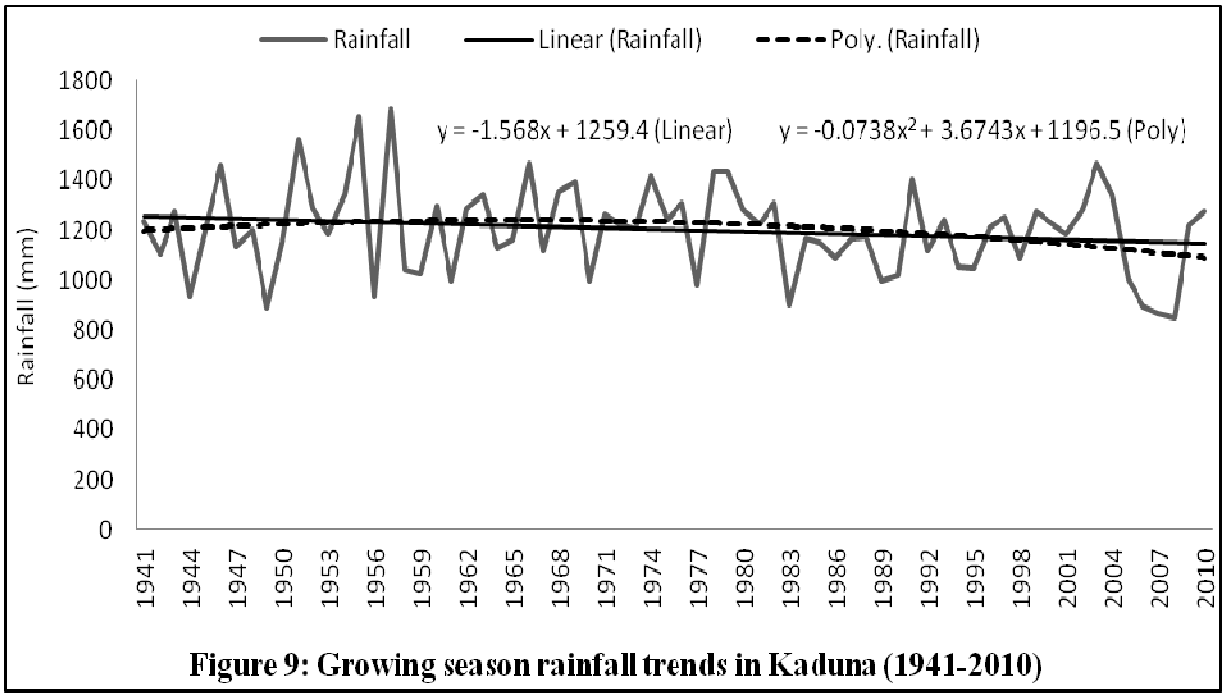

Figure 9: Growing season rainfall trends in Kaduna (1941-2010)

The alterations of the growing season rainfall in the selected synoptic weather stations during the 1941-1975 and 1976-2010 period are presented in Figure 10. A comparison of the alterations of rainfall among the selected synoptic stations reveals mixed variations. In Ilorin, mean rainfall were lower in April, June, September, and October during the 1976-2010 period while in Minna, lower mean rainfall occurred in July, September and October during the 1976-2010 period. Lower mean rainfall in Bida were witnessed in May, September, and October during the 1976-2010 period while in Lokoja, lower mean rainfall occurred only in October throughout the growing season during the 1976-2010. Mean rainfall were higher in Enugu in April, September and October during the 1976-2010 period while in Makurdi, April, May, June, August, September and October witnessed lower mean rainfall during the 1976-2010 period. Jos experienced lower mean rainfall in April, May, June, July, August and September during the 1976-2010 period while Kaduna witnessed lower mean rainfall in April, May and September.

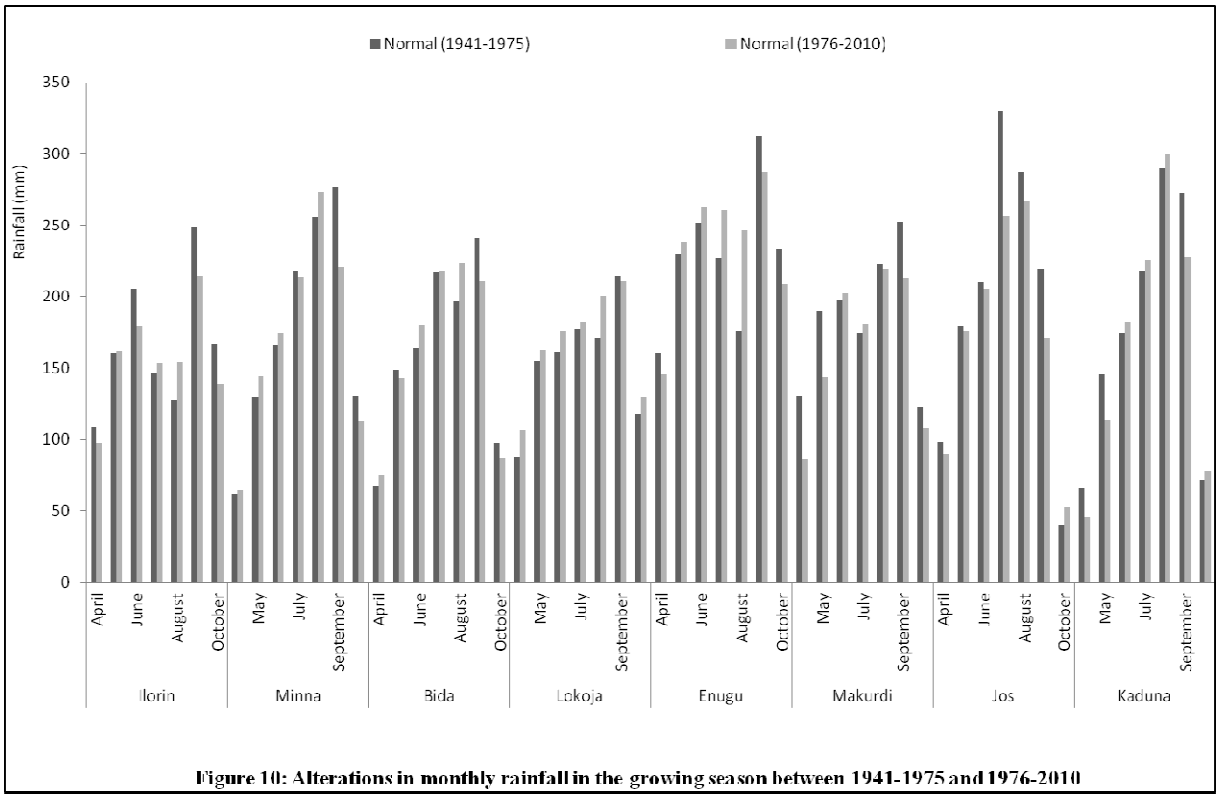

Figure 10: Alterations in monthly rainfall in the growing season between 1941-1975 and 1976-2010

The percentage differences of mean growing season rainfall for the selected synoptic stations between the 1941-1975 and 1976-2010 periods are presented in Table 1. In Ilorin, the highest difference of mean rainfall between the 1941-1975 and 1976-2010 periods occurred in the month of August at 26.8 mm (21.1%) while the lowest occurred the month of September at -34.7 mm (13.9%). The mean rainfall difference between the 1941-1975 and 1976-2010 periods for the entire growing season stood at -65.7 mm (5.6%). In Minna, the highest difference in mean rainfall between the two periods occurred in the month of August at 17.6 (6.9%) while the lowest occurred in the month of September at -55.3 mm (20%). The difference for the entire growing season in Minna stood at -36.8 mm (3%). In Bida, the highest rainfall difference between the 1941-1975 and 1976-2010 occurred in the month of August at 26.4 mm (13.4%) while the lowest was witnessed in the month of September at -30.5 mm (12.7%). The difference between the two time slices was 3.6 mm (0.3%). The highest difference of mean rainfall between the two time slices in Lokoja occurred in the month of August with a difference of 29.5 mm (17.3%) while the lowest occurred in the month of September -4.3 mm (2%). The difference for the entire growing season was 82.0 mm (7.6%). Enugu witnessed the highest mean rainfall in the month of August at 70.0 mm (39.8%) while the lowest occurred in the month of October at -25.3 mm (10.8%). The difference for the entire growing season between the two time slices was 75.2% (4.8%). The highest mean monthly rainfall occurred in the month of July at 6.6 mm (3.8%) while the lowest occurred in May at 46.9 mm (35.9%). The difference for the entire growing season was -139.1 mm (10.8%). The highest difference of monthly rainfall during the growing season occurred in October at 13.1 mm (33.1%) while the lowest occurred in July at -72.9 mm (22.1%). The difference for the growing season was -175.1 mm (11.5%). Benue State where Makurdi is located is popularly known as the food basket of the nation. Rainfall in Makurdi shows negative deviation between the 1941-1975 and 1976-2010 periods in the months of April, May, August, September October and growing season at -44.9 mm (34.4%), -46.9mm (35.9%), -3.0 (1.3%), -40.5 mm (16%), -14.9 mm (12.2%) and 139.1 (10.8%) mm respectively while the months of June and July show slight positive differences of 4.7 mm (2.4%) and 6.6 mm (3.8%). In Kaduna, the highest difference of mean monthly rainfall occurred in August at 10.3 mm (3.6%) while the lowest difference was recorded in September at -45.4 mm (16.6%). The difference for the entire growing season between the two periods was -65.1 mm (5.6%). With the exception of Lokoja and Kaduna, there appears to be reduction in the mean monthly rainfall in the months of September and October during the 1976-2010 period.

Table 1: Percentage changes in mean monthly and growing season rainfall between 1941-1975 and 1976-2010

Synoptic Weather Station	Monthly/Growing Season	Normal (1941-1975)	Normal (1976-2010)	Difference	Percenage Change
Ilorin	April	108.6	97.9	-10.7	9.2
	May	160.2	161.5	1.3	0.8
	June	205.6	179	-26.6	12.9
	July	146.7	153.2	6.5	4.4
	August	127.1	153.9	26.8	21.1
	September	249.1	214.4	-34.7	13.9
	October	166.8	138.7	-28.1	166.8
	Growing season	1164.1	1098.4	-65.7	5.6
Minna	April	61.8	64.6	2.8	4.5
	May	129.8	143.7	13.9	10.7
	June	166.3	174.1	7.8	4.7
	July	218.6	213.7	-4.9	2.2
	August	255.8	273.4	17.6	6.9
	September	276	220.7	-55.3	20
	October	131	112.4	-18.6	14.2
	Growing season	1239.2	1202.4	-36.8	3
Bida	April	66.9	74.4	7.5	11.2
	May	148.8	142.6	-6.2	4.2
	June	163.8	180.2	16.4	10.1
	July	216.9	218.4	1.5	0.7
	August	196.4	222.8	26.4	13.4
	September	240.9	210.4	-30.5	12.7
	October	98	86.6	-11.4	11.6
	Growing season	1131.7	1135.4	3.6	0.3
Lokoja	April	87.6	105.9	18.3	20.9
	May	155	162.4	7.4	4.8
	June	160.7	175.6	14.9	9.3
	July	177	182.5	5.5	3.1
	August	171	200.5	29.5	17.3
	September	214.9	210.6	-4.3	2
	October	118.1	128.8	10.7	9.1
	Growing season	1084.3	1166.2	82.0	7.6
Enugu	April	160	145.8	-14.2	8.9
	May	229.8	238.7	8.9	3.9
	June	251.6	262.8	11.2	4.5
	July	226.6	260.4	33.8	14.9
	August	176	246	70.0	39.8
	September	312.1	287.3	-24.8	7.9
	October	233.6	208.3	-25.3	10.8
	Growing season	1567.2	1642.4	75.2	
Makurdi	April	130.7	85.8	-44.9	34.4
	May	189.9	143	-46.9	35.9
	June	197.6	202.3	4.7	2.4
	July	174.5	181.1	6.6	3.8
	August	222.4	219.4	-3.0	1.3
	September	252.8	212.3	-40.5	16
	October	122.5	107.6	-14.9	12.2
	Growing season	1291.5	1152.4	-139.1	10.8
Jos	April	98.2	89.4	-8.8	9
	May	179	175.7	-3.3	1.8
	June	210	205.6	-4.4	2.1
	July	329.2	256.3	-72.9	22.1
	August	287.4	266.8	-20.6	7.2
	September	219.7	170.8	-48.9	22.3
	October	39.6	52.7	13.1	33.1
	Growing season	1361.9	1204.8	-157.1	11.5
Kaduna	April	66	45.6	-20.4	30.9
	May	144.8	113.8	-31.0	21.4
	June	173.9	182.3	8.4	4.8
	July	217.7	225.3	7.6	3.5
	August	289.7	300	10.3	3.6
	September	272.8	227.4	-45.4	16.6
	October	71.3	76.9	5.6	7.9
	Growing season	1236.3	1171.2	-65.1	5.3

Table 2 shows the results of the *t*-test analysis of comparison of rainfall between 1941-1975 and 1976-2010. Only Makurdi and Jos show statistical significant change in rainfall between the two time slices at 0.05 confidence level. It is remarkable to note that the two synoptic stations lie somewhat toward the eastern part of

the country at the middle belt.

Table 2: T-test of changes in mean rainfall between 1941-1975 and 1976-2010

S/N	Pair Samples	Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
1	Ilorin[a] - Ilorin[b]	65.6514	282.24	47.7073	-31.301	162.604	1.376	34	0.178
2	Minna[a] - Minna[b]	34.9086	259.376	43.8426	-54.19	124.007	0.796	34	0.431
3	Bida[a] - Bida[b]	-3.6166	267.155	45.1575	-95.388	88.1545	-0.08	34	0.937
4	Lokoja[a] - Lokoja[b]	-81.963	316.224	53.4515	-190.59	26.6637	-1.533	34	0.134
5	Enugu[a] - Enugu[b]	-79.716	360.745	63.7713	-209.78	50.3467	-1.25	31	0.221
6	Makurdi[a] - Makurdi[b]	139.106	344.898	58.2984	20.6292	257.582	2.386	34	0.023
7	Jos[a] - Jos[b]	157.083	234.636	39.6607	76.4825	237.683	3.961	34	0.000
8	Kaduna[a] - Kaduna[b]	65.0857	272.164	46.0041	-28.406	158.577	1.415	34	0.166

a and b represent 1941-1976 and 1976-2010 periods respectively

Tables 3 and 4 show the annual intensities of the growing season drought and the summary of the drought types respectively among the synoptic weather stations. The highest and lowest frequencies of slight droughts occurred in Lokoja (19) and Minna (8) respectively while the highest and lowest frequencies of droughts of moderate intensities occurred in Makurdi (8) and Enugu (1). As earlier noted, the only incidence of drought of severe category during the period under review occurred in Enugu. Overall, Lokoja and Minna, witnessed the highest frequency of drought irrespective of intensities.

Table 3: Drought Intensities in the Guinea Savanna Belt of Nigeria

Year	Ilorin	Drought type	Minna	Drought type	Bida	Drought type	Lokoja	Drought type	Enugu	Drought type	Makurdi	Drought type	Jos	Drought type	Kaduna	Drought type
1941	11.03	Slight	-	-	11.24	Slight	24.48	Slight	-	-	-	-	-	-	-	-
1942	19.67	Slight	-	-	19.36	Slight	39.67	Moderate	-	-	-	-	-	-	-	-
1943	13.35	Slight	-	-	18.5	Slight	24.24	Slight	12.23	Slight	-	-	-	-	-	-
1944	-	-	28.27	Moderate	-	-	13.03	Slight	-	-	-	-	-	-	22.16	Slight
1945	17.07	Slight	-	-	-	-	11.26	Slight	14.34	Slight	-	-	-	-	-	-
1946	28.79	Moderate	-	-	25.33	Moderate	24.97	Slight	-	-	20.09	Slight	-	-	-	-
1948	14.67	Slight	12	Slight	-	-	-	-	-	-	-	-	-	-	-	-
1949	-	-	-	-	14	Slight	-	-	-	-	-	-	-	-	26.24	Moderate
1950	-	-	-	-	-	-	18.56	Slight	-	-	-	-	15.3	Slight	-	-
1951	-	-	-	-	-	-	13.64	Slight	16.34	Slight	-	-	-	-	-	-
1952	-	-	-	-	-	-	26.16	Moderate	-	-	12.84	Slight	-	-	-	-
1953	-	-	11.3	Slight	-	-	-	-	16.02	Slight	-	-	-	-	-	-
1956	-	-	23.48	Slight	26.74	Moderate	36.32	Moderate	13.73	Slight	-	-	15.5	Slight	22.31	Slight
1958	16.79	Slight	18.71	Slight	-	-	13.98	Slight	22.52	Slight	24.99	Slight	-	-	13.28	Slight
1959	-	-	-	-	-	-	19.84	Slight	14.83	Slight	-	-	-	-	14.72	Slight
1960	-	-	-	-	-	-	-	-	-	-	15.97	Slight	-	-	-	-
1961	26.67	Moderate	-	-	-	-	-	-	16.88	Slight	-	-	28.4	Moderate	16.87	Slight
1963	-	-	13.01	Slight	-	-	-	-	-	-	-	-	-	-	-	-
1964	20.9	Slight	-	-	-	-	-	-	12.84	Slight	13.93	Slight	-	-	-	-
1965	-	-	-	-	23.82	Slight	-	-	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-	46.31	Severe	-	-	-	-	-	-
1967	35.83	Moderate	-	-	-	-	16.08	Slight	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	27.64	Moderate	-	-	-	-
1970	23.09	Slight	-	-	-	-	-	-	-	-	-	-	17.2	Slight	16.87	Slight
1972	-	-	-	-	28.5	Moderate	-	-	-	-	-	-	-	-	-	-
1973		-	18.78	Slight	20.93	Slight	17.51	Slight	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	16.74	Slight	27.82	Moderate	-	-	-	-
1976	14.43	Slight	-	-	-	-	17.67	Slight	-	-	-	-	-	-	-	-
1977	20.18	Slight	-	-	-	-	19.78	Slight	-	-	-	-	-	-	18.38	Slight
1978	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.15	Slight
1979	-	-	-	-	-	-	13.15	Slight	-	-	13.04	Slight	-	-	19.12	Slight
1980		-	-	-	-	-	-	-	-	-	-	-	16.2	Slight	-	-
1981	-	-	13.31	Slight		-	-	-	-	-	-	-	-	-	-	-

Table 3: Ctd.

1982	-	-	-	-	18.21	Slight	26.88	Moderate	-	-	23.67	Slight	-	-	-	-
1983	13.05	Slight	30.73	Moderate	22.74	Slight	30.05	Moderate	43.58	Moderate	23.61	Slight	17	Slight	25.03	Moderate
1984	-	-	30.59	Moderate	-	-	-	-	-	-	-	-	14.3	Slight	-	-
1985	-	-	-	-	-	-	18.3	Slight	-	-	30.04	Moderate	17.2	Slight	-	-
1986	-	-	-	-	-	-	-	-	21.84	Slight	-	-	-	-	-	-
1987	-	-	33.71	Moderate	-	-	-	-	11.7	Slight	15.82	Slight	-	-	-	-
1988	-	-	-	-	-	-	-	-	12.39	Slight	30.91	Moderate	-	-	-	-
1989	33.87	Moderate	-	-	-	-	-	-	-	-	-	-	-	-	17.2	Slight
1990	15.91	Slight	-	-	-	-	-	-	-	-	-	-	-	-	15.1	Slight
1991	-	-	-	-	-	-	-	-	-	-	11.89	Slight	-	-	-	-
1992	22.56	Slight	-	-	14.99	Slight	-	-	-	-	-	-	-	-	-	-
1993	-	-	13.57	Slight	-	-	16.34	Slight	11.9	Slight	-	-	13.1	Slight	-	-
1994	-	-	-	-	13.9	Slight	-	-	12.08	Slight	34.77	Moderate	-	-	12.31	Slight
1995	-	-	-	-	-	-	-	-	-	-	-	-	36.5	Moderate	12.89	Slight
1996	21.94	Slight	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	20.12	Slight	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-	11	Slight	-	-
2000	17.26	Slight	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	39.4	Moderate	-	-	-	-	11.23	Slight	-	-	11.94	Slight	-	-	-	-
2002	23.9	Slight	-	-	21.34	Slight	-	-	-	-	-	-	-	-	-	-
2003	11.59	Slight	-	-	19.96	Slight	-	-	-	-	39.68	Moderate	-	-	-	-
2004	-	-	-	-	-	-	-	-	-	-	26.03	Moderate	16.7	Slight	-	-
2005	-	-	-	-	-	-	19.73	Slight	-	-	31.33	Moderate	-	-	16.81	Slight
2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25.42	Moderate
2007	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28.14	Moderate
2008	-	-	-	-	-	-	-	-	-	-	14.4	Slight	-	-	29.48	Moderate
2009	-	-	-	-	-	-	14.92	Slight	13.41	Slight	-	-	-	-	-	-
2010	19.31	Slight	-	-	-	-	-	-	-	-	11.72	Slight	35.2	Moderate	-	-

Table 4: Summary of Drought Frequencies

Drought type	Ilorin	Minna	Bida	Lokoja	Enugu	Makurdi	Jos	Kaduna
Slight	18	8	13	19	16	13	10	14
Moderate	5	4	3	5	1	8	3	5
Severe	-	-	-	-	1	-	-	-
Disastrous	-	-	-	-	-	-	-	-
Total	**23**	**12**	**16**	**24**	**18**	**21**	**13**	**19**

5. Implications on Agriculture

The lower mean rainfall in the months of September and October in all the synoptic stations selected in this study during the 1976-2010 period affirms the decline of rainfall frequencies and early rainfall cessation in the northern parts of the country as reported in Olaniran (2002). This, coupled with delayed rainfall onset, could lead to the shortening of the growing season. The constriction of the growing season requires the cultivation of early maturing crops and the streamlining of farming calendar with prevailing rainfall regime by local farmers. This agrees with Olaniran (2002) and Atedhor (2014). The marked negative deviation of rainfall from the normal particularly in the early 1980s coincides with the 1983-4 drought which have been described as being worst than the 1972-3 drought in Nigeria (Oguntoyinbo, 1991). Some of the hypotheses for the explanation of drought phenomena in Nigeria and indeed over West Africa, include limited northward migration of the ITD (Olaniran, 2002), El nino/Southern Oscillation (ENSO) (Adebayo, 1999; Ati *et al*., 2010; Umar, 2012). Since drought is a period of rainfall deficiency, it may have exacerbated crop moisture requirement in the Guinea savanna region. Thus, as Odeyemi and Ogunkoya (2006) noted, although diverse socio-economic factors account for vulnerability to food insecurity in the Guinea savanna region which has been identified as a 'bread basket' to the nation, these factors are superimposed on environmental change occasioned by unfavorable persistent trends in the prevailing climate. Considering the prevalence of root and grain agricultural production under heavy reliance on rainfall, alteration of the rainfall pattern in the form of drought and high degree of variability could accentuate crop-moisture stress particularly for the root crops with their water needs often is only marginally met. For instance, deficiency in rainfall can be unfavorable to cassava tubers which mature within the rainy season (Ayanlade *et al*., 2009). Also notable in the Guinea savanna region is poor soil fertility which is complicated by repeated incidence of drought at diverse phases of crop development (Kamara, 2013). Despite the declining rainfall trends already being observed in some of synoptic weather stations in the Guinea savanna, climate

models point to a future general increase in drought related to a decrease in precipitation (Vicente-Serrano *et a*l., 2004), which suggest the need to be proactive in adjusting to climate change. Unfortunately, there are enormous obstacles to applying adaptation which include both the inability of natural systems to adjust to the pace and degree of climate change, as well as technological, financial, and socio-cultural constraints (Adger *et al*., 2007). Compared to other regions of the globe, Africa has very small percentage of irrigated land of approximately 4 percent in Sub-Saharan Africa (ACPC, 2011) owing to the fact that most farmers are poor and have no access to resources required to enhance their agricultural production (DFID, 2009). The significance of the variation of rainfall in Makurdi (Benue) and Jos (Plateau) between the 1941-1975 and 1976-2010 is a pointer towards drying. The states covered by these synoptic stations, that is, Benue and Plateau States that are cardinal sources of tubers and vegetables respectively to the nation. The change in growing season rainfall, especially in Makurdi and Jos, as well as the drought incidences could pose negative implications on Nigeria's food security if measures such as irrigation, cultivation of drought resistant varieties as well as alignment of cropping schedules with unfolding climatic patterns are not adopted.

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