



Trend of Onset Dates, Cessation Dates and Length of Growing Season Analysis in the Sudan Savanna Ecological Zone of Nigeria as a Way Forward to Agriculture and Food Security in Nigeria

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Abstract

This study analyzed the trend of onset dates, cessation dates and length of growing season in the Sudan Savanna ecological zone of Nigeria using daily rainfall data spanning from 1981 – 2010. Methods used for investigation include pentad and Julian day calendar, ogive of cumulative pentad rainfall, trend lines and linear trend lines equations using least squares statistical technique. Results obtained indicate late onset and earlier cessation dates of rains resulting shorter length of growing season in the study period. This trend will likely continue in the next decades in the study area. Based on these, it recommends that, farmers provide with early maturing seed varieties before onset date of growing season.

Keywords: *Trend; Onset; Cessation; growing season; Sudan Savanna.*

1.0 INTRODUCTION

Schneider *et al* (1990) and IPCC (1996) reported that, climate change would on the average result in a wetter world. Climate models consistently project an increase in global mean precipitation of between 3% and 15% as temperature increases from 1.5⁰C to 3.5⁰C (Schneider *et al.*,1990) . The global average, however, hides significant differences in regional precipitation patterns, with some regions showing increase, some decrease and considerable inter-annual variability.

Trend defined as a general direction that a situation is changing or developing (Hornby, 1948). In a study of rainfall trends in Kafanchan, Kaduna State, Nigeria, Abaje *et al.*,(2010) observed the sub-period 1974-1983 and 1999-2008 for the months of June and October respectively were significantly drier. The linear trend lines further revealed that there was a decline in the annual rainfall because of substantial decline in July, September, and October rainfall that are critical months for agricultural production in the area. The linear

trend lines for the period of study also demonstrated a general tendency towards a decrease in rainfall in the area. The study further compared sub-period means with long-term mean and observed the monthly rainfall was decreasing at the rate of 0.41% per year in July, 0.08% per year in August, 0.26% per year in September, and 1.56% per year in October. Although previous studies have reported a declining trend in the mean annual rainfall in Nigeria (e.g., Abaji, *et al.*, 2010, Tarhule and Woo; 1998), recent studies have confirmed an increasing trend in northwest region (e.g., Obot *et al.*, 2010, Oguntunde *et al.*, 2012)

Anyadike (1992), studied the regional variations of seasonal rainfall over Nigeria and observed the presence or absence of trends in the rainfall for a period of 72 years (1916 – 1987) using the Mann – Kendall statistic, mathematically expressed as:

$$\tau = \{4(\sum_{i=1}^{N-1} n_i / N(N - 1)) - 1\} \dots \dots \dots (1)$$

Where N is the number of years in the data set; n_i is the number of values greater than the (i)th value in the series subsequent to its position in the time series. The expected value of τ in a random series is zero, and its variance (δ²) provided by.

$$\delta^2 = (4N + 10) / 9N(N - 1) \dots \dots \dots (2)$$

He suggested that the ratio of τ to its standard deviation (δτ) is an indication of trend in the data. For the absence of trend in the series, the ratio lies within the limit of plus or minus 1.96 at 0.05 significance levels. He found out that the rainfall series in Nigeria exhibited some form of trends.

In another study, Obot *et al* (2010)) reported that, while other locations in Nigeria had no significant trend yet in annual rainfall, Maiduguri showed an increasing trend. Twenty percent of Nigeria experiences a Semi- arid climate which is characterized by increasing aridity since the 1960s, and in these areas, annual rainfall totals have been declining. There is a perception that the duration of growing season has been shorting (LeHou`erou, 1996). In these areas, the trend of the growing season follows the abrupt end of rains that occurs in

mid-September in the North and early October in the South (Kowal and Kassam, 1973).

Onset refers to the time a place receives an accumulated amount of rainfall sufficient for growing crops. Traditional farmers have several methods of determining the onset date of growing season rainfall. This involves the use of traditional weather lore, behavior of heavenly bodies like stars, change in wind direction, arrival of seasonal migratory birds and ``Ramadan`` month (Ati, 1995). These methods lack scientific backing as they based on poor knowledge of decision making of traditional farmers. The ones that have scientific backing and often used by various researchers are the semi-empirical and scientific techniques. The semi-empirical techniques based on accumulated rainfall totals, while the scientific techniques based on rainfall and evapotranspiration relationships. Both these techniques employed in determining the onset date of the growing season rainfall in various locations in Nigeria.

Cessation means termination of the effective rainy season. Walter (1967) defined the cessation date of the rains as the last date on which a threshold reached. The determination of cessation date of growing season according to Walter (1967) did the same way as the onset date accept that here, the working done backward from December. Based on Walter (1967), he said it is the number of days in the first month from December with cumulative monthly rainfall greater than 51mm multiplied by (51-Rainfall total of the previous month) divided by total rainfall of the first month with cumulative rainfall greater than 51mm. Odekunle (2004), stated that cessation date of the rainy season is when rainfall distribution may no longer sustain plant growth. It implies that cessation date is the stage when plants no longer grow well due to shortage of rainwater, and no need other means of water supply to sustain them.

Length of growing season defined as the period of the year during which rainfall distribution characteristics are suitable for crop germination, and full development (Odekunle, 2004). It is a period of the year categorized as rainy or wet season. The length of the growing season varies

spatially and temporally. The length of growing season can be determined by subtracting for each year, the date at which the rains start from the date that it ends (Madeoye, 1986; Zargina, 1987). Also Oladipo and Kyari (1993) in their study of growing season rainfall of Northern Nigeria indicated that the onset, cessation and length of growing season show latitudinal progress but with some disruptions due to orographic effect in the central area (Jos). Walter (1967) stated that the length of the growing season is the period between the onset and the cessation date that may be determined by calculating the number of days in between the onset date and the cessation date. Adefolalu (1993) stated that the length of the growing season obtained by subtracting the onset pentad from the cessation pentad and multiplying by five. Among authors that have emphasized linkages of the growing season with reliable onset of rains are Dagga (1965), Olaniran (1983 and 1984), Bello (1996), Ati, *et al* (2002), Sawa and Adebayo (2011).

2. 0 MATERIALS AND METHOD

2.1 Study Area

The study area is the Sudan Savannah ecological zone of Nigeria. It is approximately lies between Latitudes 10⁰ and 12⁰ N and Longitudes 4⁰ and 15⁰ E (Fig.1). It stretches from the Sokoto plains in the west through the northern section of the High Plains of northern Nigeria in the east to the Chad Basin. It thus includes the States of Kaduna, Katsina, Kano, Jigawa, Zamfara,

Based on these reviews observed, daily rainfall probability, which is the most direct method of reliability estimate neglected in analyzing the onset, cessation dates and the length of the growing season in the Sudan Savannah ecological zone of Nigeria. This is a research gap, which needs to bridge. This paper therefore, aimed at assessing onset dates, cessation dates and length of growing season in Kano, Katsina, Maiduguri, Potiskum, Sokoto and Gusau. The aim achieved by the following objectives:

- i. Determine onset dates, cessation dates and length of growing season
- ii. Analyze the trend of onset dates, cessation dates and length of growing season
- iii. Identify the expected mean of onset dates, cessation dates and length of growing season

Sokoto, Kebbi, and Borno

2. 2 Study Locations

Six (6) locations selected for this study. They include Kano, Katsina, Maiduguri, Potiskum, Sokoto and Gusau. The locations chosen based on availability of meteorological stations within the climatic zone. These meteorological stations are synoptic stations that have long period of daily rainfall records.

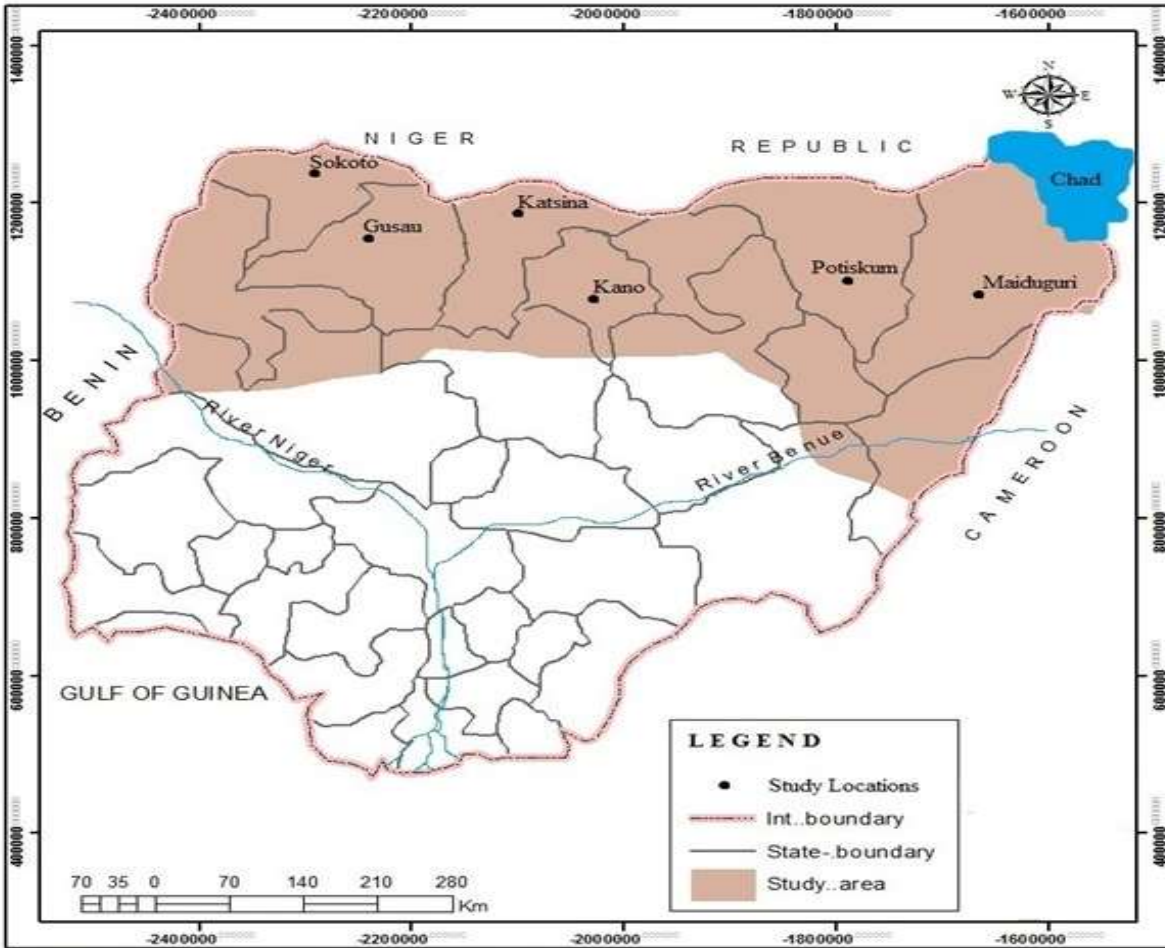


Fig. 1 : Study Area Showing the Location of Study Sites.
Source:- Les Editon (2006)

2.3 Derivation of Onset Dates, Cessation Dates and Length of Growing Season

Daily rainfall data from the period of 1981 – 2010 for the six selected locations sourced from Nigerian Meteorological Agency (NIMET) Oshode, Lagos and used in derivation of onset dates, cessation dates and length of growing season. A method of Adefolalu (1993) based on relative definition is adopted in this study. He reported that, the length of growing season be obtained by subtracting the onset pentad from the cessation pentad. He determined the onset and cessation dates of the growing season by dividing each year into pentads making 72 pentads, and using the pentad calendar, Pentad rainfall calculated for each pentad and cumulated. Pentads rainfall plotted against the number of pentad giving an ogive for each year

in the study area. The points on the pentad axis corresponding to the first and last points of the maximum inflexion on the rainfall ogive correspond to the onset and cessation pentads respectively. The last date in the onset pentad gives the exact onset date and the first date in the cessation pentad gives the cessation date of the rainy season. The gap between onset and cessation pentads gives the length of growing season.

The derived onset and cessation dates converted to Julian days using Julian day calendar and obtained the length of growing season of each year in the study period.

This method adopted in the derivation of onset and cessation dates of rains and length of

growing season in the study area. The method utilizes daily rainfall data, which makes it more accurate and precise method for determining the onset, cessation date and the length of growing season than other methods.

2.4 Trend in Onset Dates, Cessation Dates and Length of Growing Season

Trends in these rainfall parameters determined by trend lines and linear trend line equations using least squares statistical technique drawn with Excel Software.

2.5 The Expected Mean of Onset Dates, Cessation Dates and Length of Growing Season

The expected mean of onset and cessation dates for each location calculated using Julian Day Calendar Table. They obtained by converting onset and cessation dates for each location into Julian Days within the study period (1981 to 2010). The results of each location were summed and divided by thirty (30) and obtained the mean of both onset cessation date of growing season in each location respectively. The expected mean length of growing for each location in the study period was determined by calculating number of days between onset and cessation dates, summed the results and divided by the number of observations

3.0 RESULTS AND DISCUSSION

3.1 Onset Dates, Cessation Dates and Length of Growing Season

The typical results for onset dates, cessation dates and length of growing season in 1981 for Kano presented in Fig.2

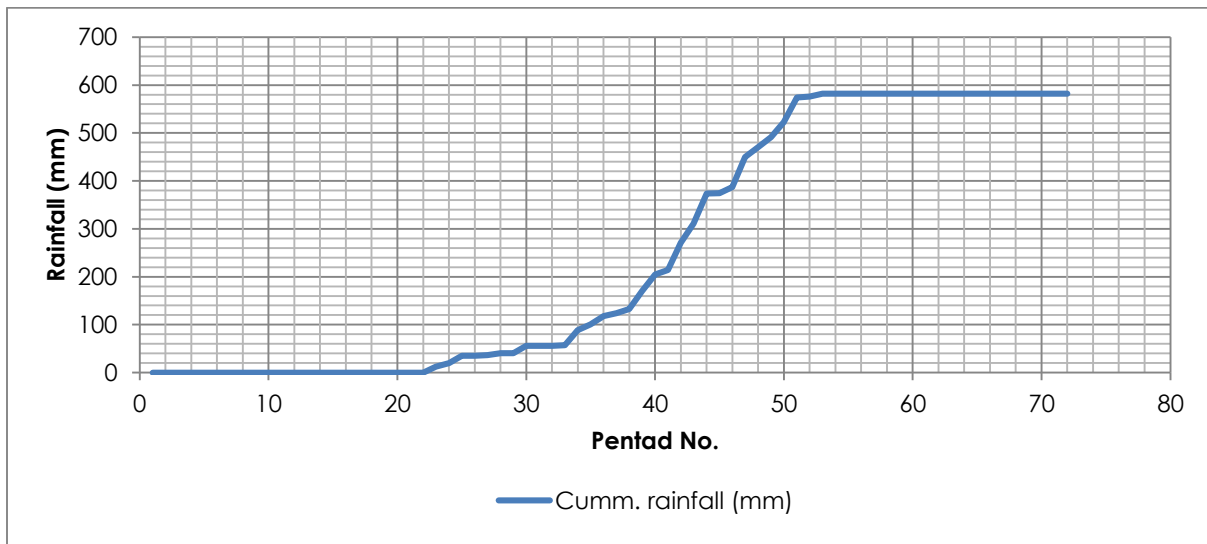


Fig. 2: Ogive of cumulative pentad rainfall at Kano (1981) for determination of Onset, cessation dates and length of growing season.

In Fig. 2 at Kano, the onset pentad falls on pentad 29. Using Pentad Calendar, the onset date of rainfall corresponds to 21-May in 1981. The cessation pentad falls on pentad 53 and the cessation date of rainfall corresponds to 25-September.

The other onset and cessation dates and length of growing season for the study period (1981-2010) for each location obtained using these methods with pentad calendar and Julian day calendar.

3.2 Trends in Onset and Cessation Dates of

Rains for the Study Area

The combined line trends and linear trend equations for onset and cessation dates of the

rains for each location in the study presented from figs. 3 – 8

3.3 Trends in Onset and Cessation Dates of Rains at Kano

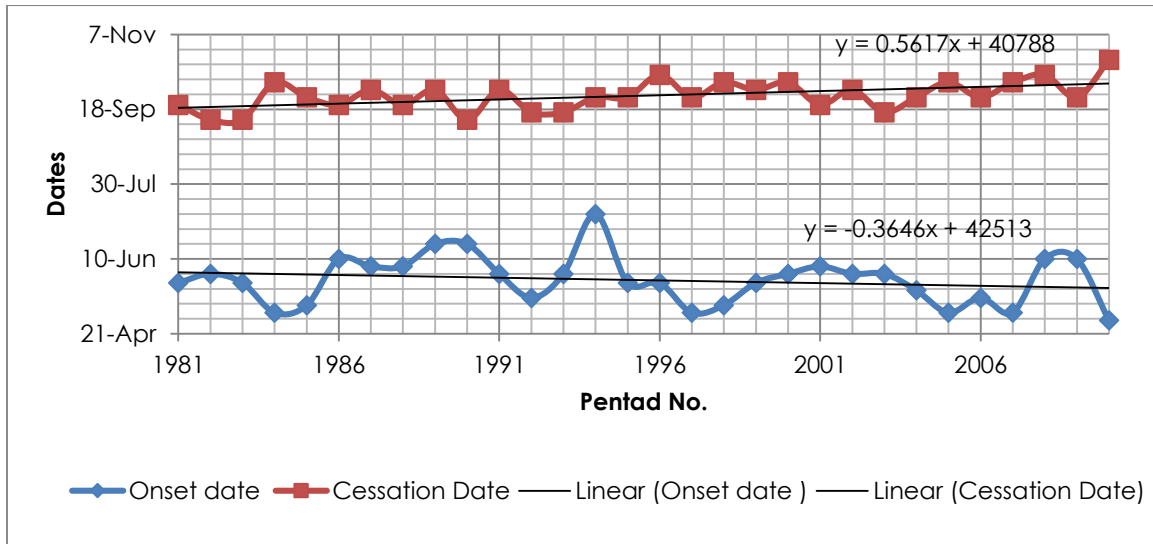


Figure 3: Trend of Onset and Cessation Dates at Kano (1981-2010).

As can be observed in Fig.3, the trend line of onset dates of rains indicated decreasing trend and cessation dates increasing at Kano. Onset date trend line equation is given as $Y = -0.3646x + 42513$ and cessation date is $Y = 0.5617x + 40788$. The perpendicular distance between each onset point to cessation on the two graphs indicates the length of growing season. It is seen that the longest length of growing at Kano from 1981 to 2010 was in 2010 and the shortest was in 1994. These findings indicate that onset date of rains at Kano is commencing earlier and cessation date of rains is occurring later. This implies trends in the onset and cessation dates of rains are increasing at Kano. These findings further supported by the higher frequency of onset dates in the month of May and higher

frequency of cessation dates in the month of September

3.4 Trends in Onset and Cessation Dates of Rains at Katsina

The combined trends of onset and cessation dates of rains at Katsina are determined and presented in Fig. 4. At Katsina (Fig.4), the trend line and linear trend line equations of onset and cessation dates of rains are in positive direction, which indicate late onset and late cessation. They are presented by the equations $Y = 0.0977x + 41602$ and $Y = 0.2699x + 41372$ respectively. It could be seen that the longest length of growing season was in 2009 and the shortest in 1993. These findings indicate Katsina is experiencing later onset dates and later cessation dates of rains.

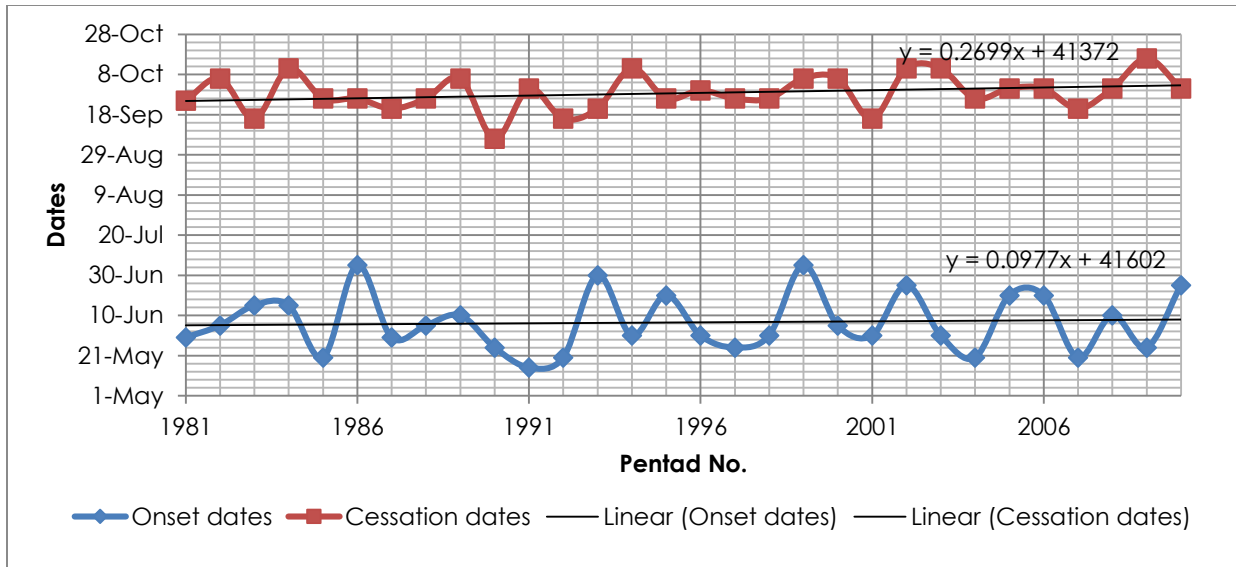


Figure 4. Trends of onset and cessation Dates at Katsina (1981 -20100).

3.5 Trends in Onset and Cessation Dates of Rains at Maiduguri

The trends line equation of onset dates rains at Maiduguri (Fig. 5) is $Y = 0.2928x + 4121$, and that of cessation dates is $Y = 0.7335x + 40446$.

The longest length of growing between the onset and cessation graphs was in 2005 and the shortest was in 1986. . This indicates that Maiduguri is experiencing later onset and cessation dates of rains.

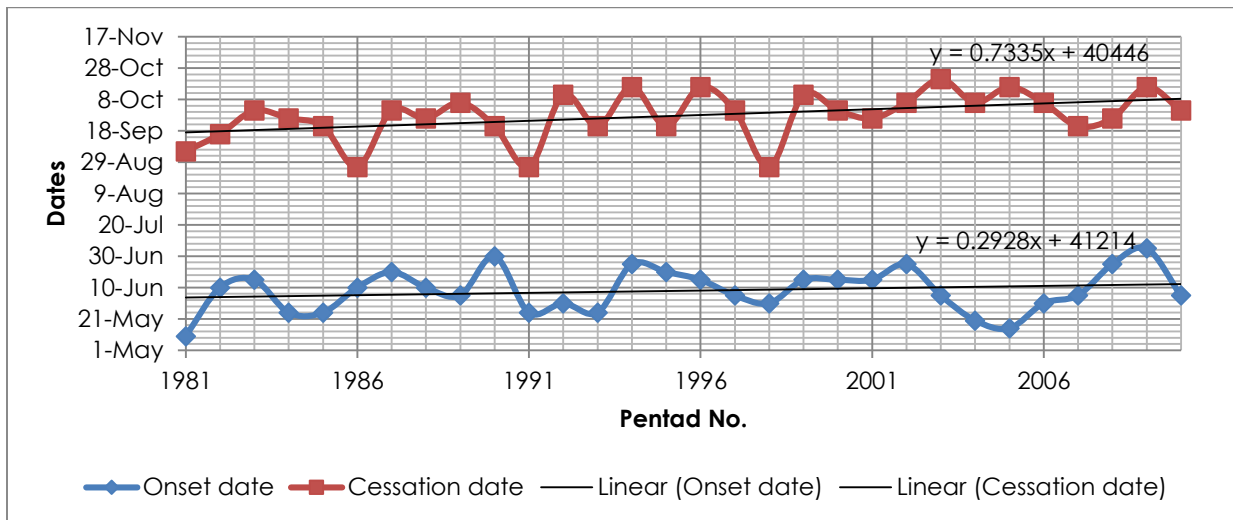


Figure 5: Trends of Onset and Cessation Dates at Maiduguri (1981-2010).

At Potiskum (Fig.6), the trend line equations of

the two variables are negatives. The trend line

equation of onset of rains is $Y = -0.212x + 4225$, and cessation dates of rains is $Y = 0.1907x + 41534$. These equations indicate decreasing trends in onset and increasing in cessation dates of rains. The longest length of

growing season was in 1981 and shortest in 1993. They estimated as 161 and 70 days respectively. These findings indicate that onset dates of growing season at Potiskum are commencing earlier and cessation dates later.

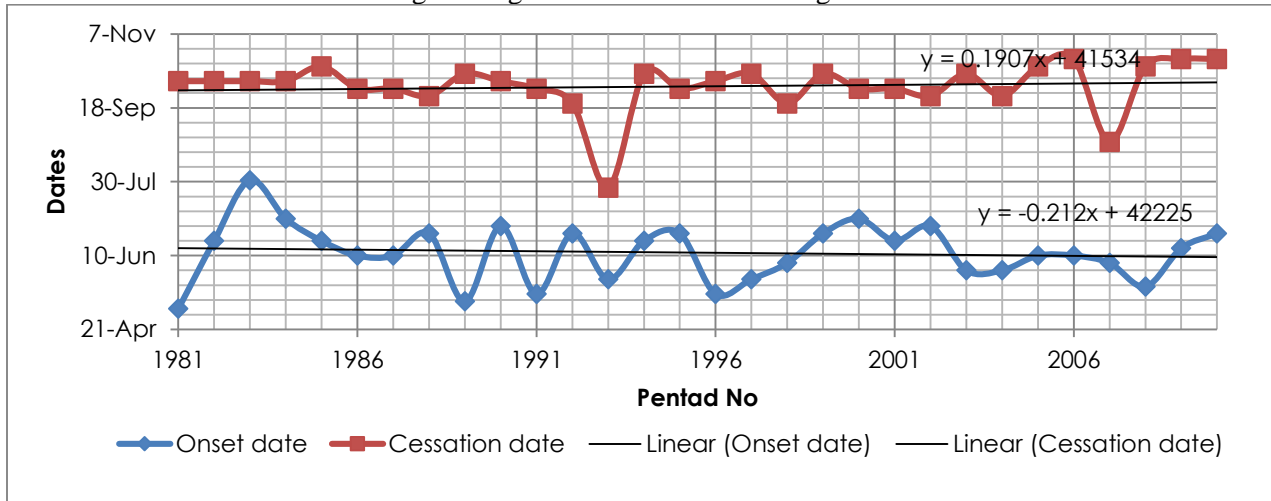


Figure 6: Trend of Onset and Cessation Dates at Potiskum (1981-2010).

3.6 Trends in Onset and Cessation Date of Rains at Sokoto

The trends in onset and cessation dates of rains at Sokoto presented in Fig.7

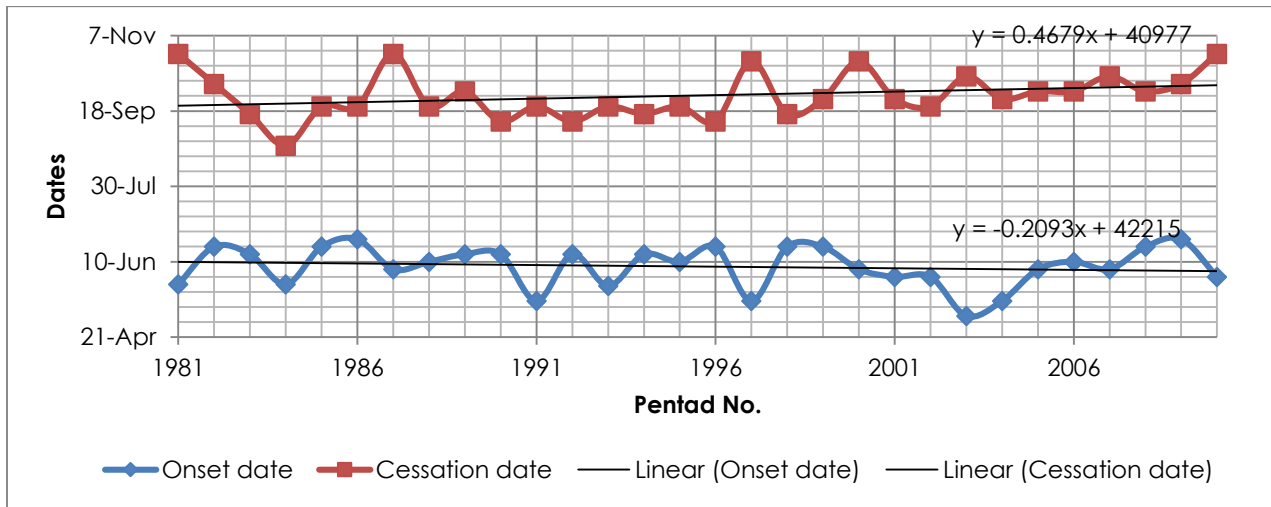


Figure 7: Trend of Onset and Cessation Dates of Rains at Sokoto (1981-2010).

In Fig. 7 (Sokoto), it was observed that the line equation of onset dates of rains at Sokoto is $Y = -0.2093x + 42215$ and for cessation dates of rains is $Y = 0.4679x + 40977$. This indicates decreasing trends (earlier onset) in the onset date of rains and increasing (later) in the cessation

dates of rains at Sokoto. The longest length of growing season was in 1997 with 166 days and the shortest in 1996 with 90 days. These findings indicate earlier occurring of onset and late cessation dates of rains at Sokoto.

3.7 Trends in Onset and Cessation Dates of Rains at Gusau

The trends in onset and cessation dates of rains at Gusau are determined and presented in Fig. 8.

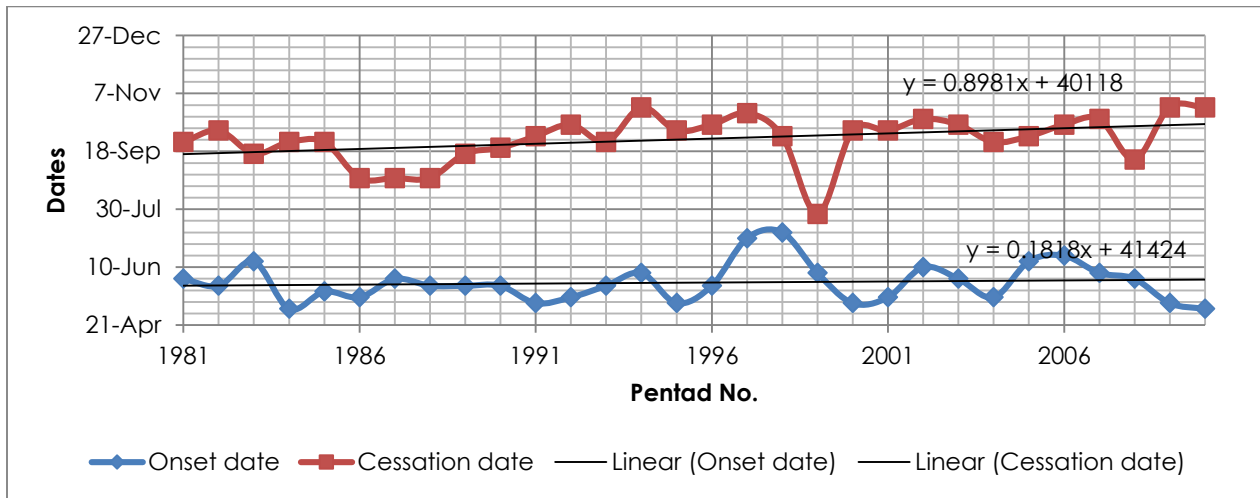


Figure 8: Trend of Onset and Cessation Dates of Rains at Gusau (1981-2010).

At Gusau in Fig. 8, it was observed that the linear trend line equation of onset dates of rains ($Y = 0.1818x + 41424$) and cessation ($Y = 0.8981x + 40118$) are in positive direction. This implies that both onset and cessation dates of rains occur later at Gusau. The longest length of growing season was in 2010 and corresponds to 182 days. The shortest length of growing season was in 1999 and corresponds to 59 days.

3.8 Trends in Length of Growing Season for the Study Area

Trends in length of growing season for each of the study locations are determined and presented from Figs.9 – 14

3.9 Trend in Length of Growing Season at Kano

Trend in length of the growing season (LGS) at Kano presented in Fig.9

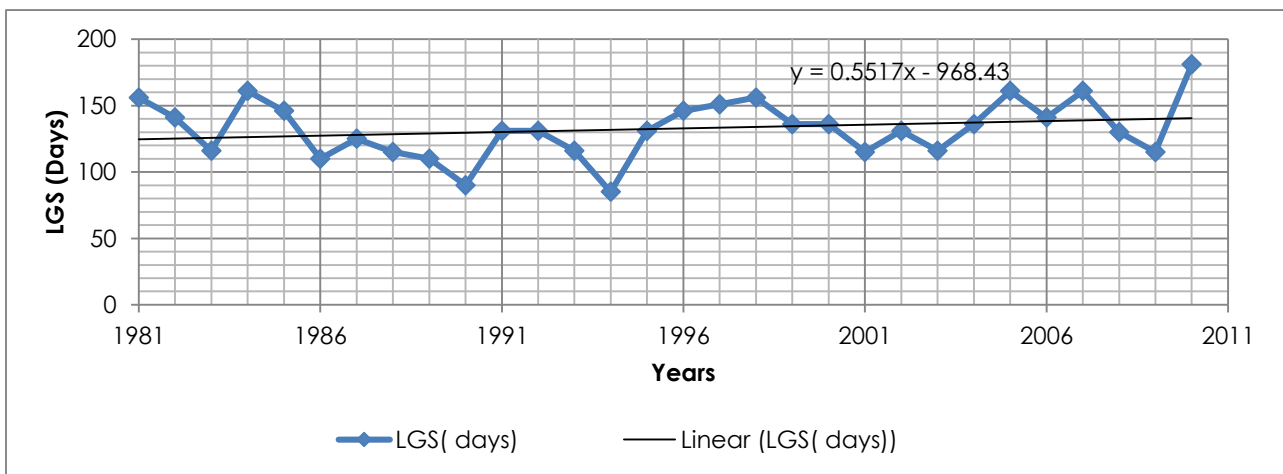


Figure 9: Trend in Length of Growing season in Kano (1981-2010).

Figure 9 shows that the linear trend equation of length of growing season at Kano is $Y =$

$0.551x - 968.4$ and indicates an increase trend in the length of growing season. The longest length

of growing season was in 2010 and estimated as 181 days. The shortest length of growing season was in 1994 and corresponded to 85 days. It observed that in Fig.9 more points on the graph deviated below than above the linear (LGS) indicating shorter length of growing season in Kano from 1981 -2010.

3.10 Trend in Length of Growing Season at Katsina

The line and linear trend line equation of length of growing season at Katsina presented in

Fig.10. It observed that the slope of the linear trend line equation of length of growing season ($Y = 0.127x - 134.7$) at Katsina indicates positive direction. This implies increasing trend in the length of growing season. The longest length of growing season was in 2009 corresponded to 151days. The shortest length of growing season was in 1986 and 1993 having 90 days respectively. More points deviated below than above the linear (LGS) in Fig.10, meaning shorter length of growing season at Katsina during the period of study.

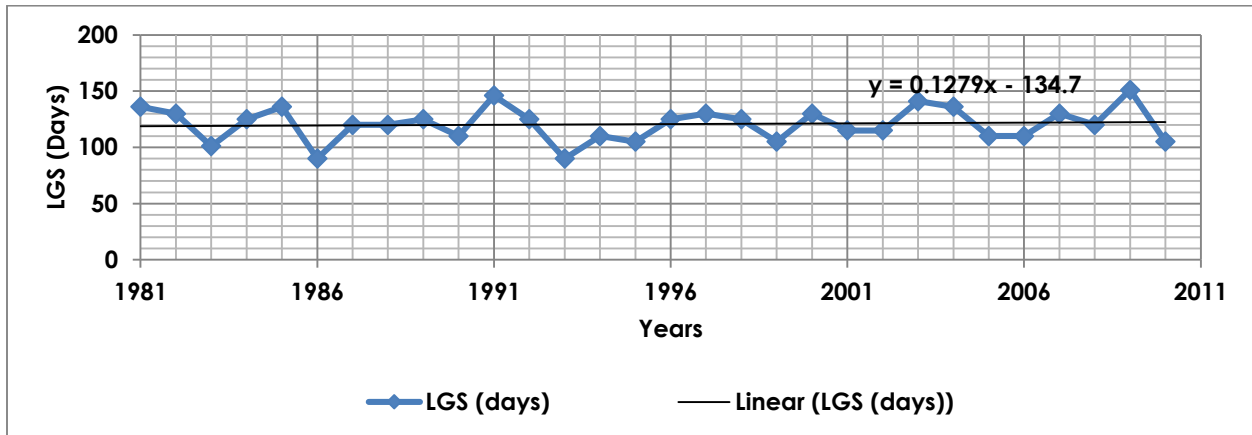


Figure 10: Trend in Length of Growing season at Katsina (1981-2010).

3.11 Trend in the Length of Growing Season at Maiduguri

Trend line and linear trend line equation of length of growing season at Maiduguri presented in Fig.11.

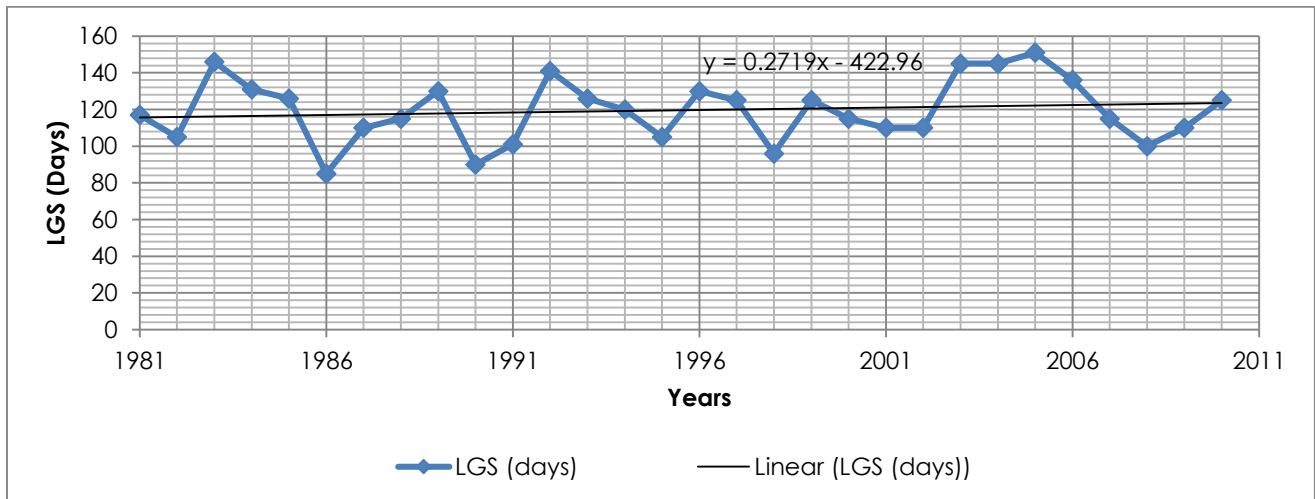


Figure 11: Trend in Length of Growing season at Maiduguri (1981-2010).

At Maiduguri in (Fig.11) it could be observed that the linear trend line equation of the length of growing season is positive ($Y = 0.271x - 422.9$) and it indicates increasing trends in the length of growing season. The longest length of growing season was in 2005 and corresponded to 151

days. The shortest length of growing season was in 1986 and corresponded to 85 days. It seen there are more points below than above the Linear (LGS) indicating shorter length of growing season in this location.

3.12 Trend in Length of Growing Season at Potiskum

Trend in the length of growing season at Potiskum presented in Fig.12

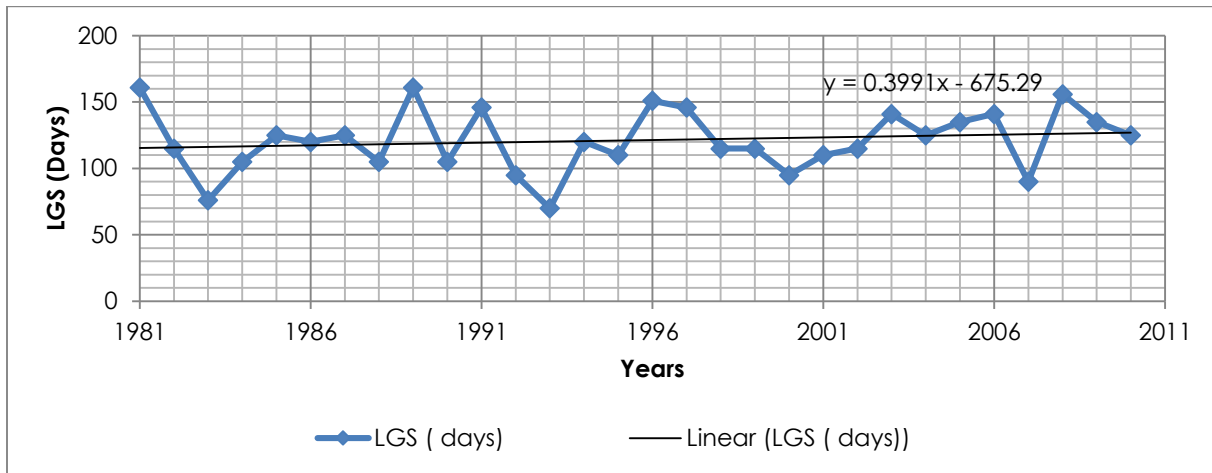


Fig.12: Trend in Length Growing Season at Potiskum (1981-2010)

In Potiskum (Fig.12), indicates that the linear trend line equation of length of growing season is also positive ($Y = 0.3991x - 675.29$). This equation indicates increasing trends in the length of growing season. The longest length of growing season occurred in 1981 and the shortest in 1993. They correspond to 161 and 70 days respectively. More points on the graph also

deviated below than above the linear (LGS) resulting shorter length of growing season.

3.13 Trend in Length of Growing Season at Sokoto

The line and linear trend line equation of length of growing season presented in Figure 13.

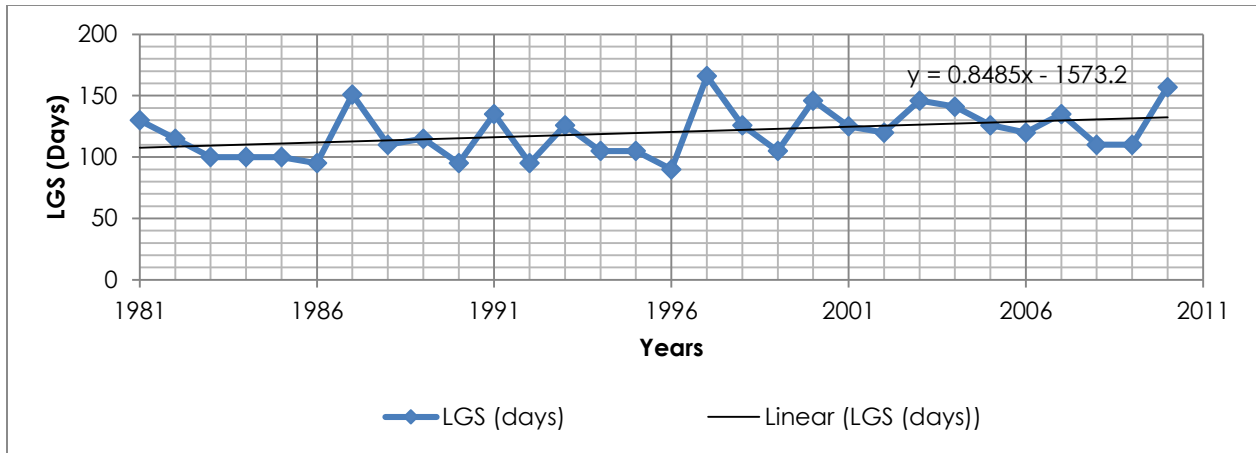


Figure 13: Trend in Length of Growing Season at Sokoto (1981-2010).

At Sokoto in Figure13, it could be seen that the linear trend line equation of length of growing season is $Y = 0.848x - 1573.2$. This finding indicates increasing trend in length of growing season in this location. The longest length of was in1997 and the shortest in 1996. They correspond to 166 and 90 days respectively. More points on the graph deviated below than

above the linear LGS. This finding indicates shorter length of growing season at Sokoto in the period of study (1981 – 2010)

3.14 Trend in Length of Growing Season at Gusau

Trend in the length of growing season at Gusau determined and presented in Fig.14

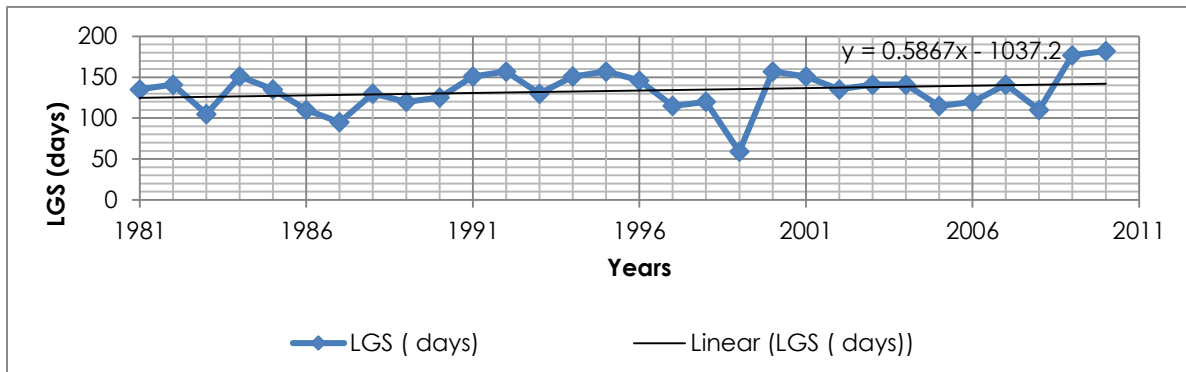


Figure 14: Trend in Length of Growing Season at Gusau (1981 – 2010).

It could be observed from Fig.14 that the linear trend line equation for length of growing season rainfall at Gusau is $Y = 0.5867x - 1037.2$ and indicates increasing trends. The longest LGS was in 2010 and shortest in 1999. They correspond to 182 and 59 days respectively.It could see there are more points below than above the linear LGS indicating shorter length of growing season. The findings of Figs.9 - 14

indicate general increasing trend resulting shorter length of growing season in the study area during the study period.

3.15 The Expected Mean of Onset and Cessation Dates

The expected mean of onset and cessation dates for each location in the study area are determined and presented. At Kano, the expected mean of onset date of growing season

was on 22-May, and cessation date on 30-September. In Katsina, the expected mean of onset date of growing season was on 1 -June and cessation date on 2-October. At Maiduguri the expected mean onset date of growing season was on 5-June and cessation date on 2-October. At Potiskum, the expected mean of onset date of growing season was on 10-June and cessation date on 7-October. In Sokoto, the expected mean of onset date of growing season was on 3-June and cessation date on 4-October. At Gusau, the expected mean of onset date of growing season

was on 23-May, and cessation date on 3-October.

3.16 The Expected Mean Length of Growing Season

Results obtained on the expected mean length of growing season vary among the study locations. At Kano, the mean length of growing season was 133 days and 121 days in Katsina. In Maiduguri, the mean length of growing season was 120 days and 121 days in Potiskum. At Sokoto, the mean length of growing season was 120 days and 133 days in Gusau.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Onset dates, cessation dates, length of growing season, the expected mean of onset dates, cessation dates and length of growing season have been determined using pentad, Julian day calendar and ogive of cumulative pentad rainfall in the Sudan Savanna ecological zone of Nigeria. Temporal and spatial variability of these rainfall parameters have been observed in the study period (1981 – 2010) and among the study locations. The trend of onset dates, cessation dates and length of growing season was also identified using trend lines and linear trend lines equations by least squares statistical technique. Late onset and earlier cessation dates of rains witnessed in the study area. There was also shorter length of growing season in each study location. The expected mean of onset and cessation date of (22-May) and (30- Sept) at

Kano, (1-June) and (2 -Oct) at Katsina; (5-June) and (2- Oct) at Maiduguri; (10 -June) and (7- Oct) at Potiskum; (3- June) and (4 -Oct) at Sokoto; (23 – May) and (3- Oct) at Gusau are respectively likely to continue in the next decades. Similarly, the expected mean length of growing season of 133 days at Kano, 121 days in Katsina, 120 days in Maiduguri, 121 days in Potiskum, 120 days in Sokoto and 133 days are also likely to continue in the next decades in the study area.

4.2 Recommendations

The findings of this study revealed empirically onset date, cessation date and length of growing season are critical rainfall variables influencing agricultural activity in the Sudan Savanna Ecological Zone of Nigeria. Based on these, it recommends that farmers provide with early maturing seed varieties before onset of growing season.

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