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Rainfall Variability during Onset and Cessation of the Growing Season in the Sudano-Sahelian Region of Nigeria

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Abstract

Onset and cessation of rainfall is fundamental to crop production, especially in areas with variable climate and predominance of rain-fed farming practice. This paper, therefore, examined rainfall trends during onset and cessation of the growing season in the Sudano-Sahelian region of Nigeria using 64 years (1951-2014) rainfall data for 8 synoptic weather stations (Sokoto, Gusau, Katsina, Kano, Potiskum, Nguru, Maiduguri and Yola). Simple regression was used to analyse the trends of rainfall during the onset and cessation. The results revealed that rainfall declined in Katsina, Nguru and Yola at annual rates of -0.036 mm, -0.197mm and -0.143 mm respectively during the onset while Sokoto, Kano, Potiskum and Maiduguri witnessed increase at annual rates of 0.040 mm, 0.188 mm, 0.269 mm, 0.026 mm and 0.025 mm respectively. Sokoto, Katsina, Potiskum, Nguru and Yola experienced decreasing rainfall trend at annual rates of -0.232 mm, -0.112 mm, -0.082 mm, -0.153 mm and -0.360 mm respectively during cessation while Kano and Maiduguri recorded increase at annual rates of 0.180 mm, 0.246 mm and 0.037mm respectively. Rainfall trends were significant in Kano and Yola during onset and cessation respectively. The mean rainfall of 1983-2014 negatively deviated from that of 1951-1982 in Kano during onset and cessation while the negative deviation in Sokoto and Potiskum was only recorded during onset. While the rainfall pattern shows increasing spatial variation during onset of the growing season, generally it is more varied during cessation. The paper recommends early maturing crops, irrigation and/or staggering of planting in line with prevailing rainfall trends during onset and cessation, especially in Sokoto, Katsina, Potiskum, Nguru and Yola.

Key Words: Rainfall, onset, cessation, Sudano-Sahelian, Nigeria

Introduction

Rainfall amount and its distribution greatly influence environmental conditions and a wide range of socio-economic activities. Rainfall amount during the growing season is critical to development and yield of crops (Umar, 2010; Odjugo, 2010; Mawunya*et al*., 2011; Sobowale*et al*., 2016). The prevalence of rain-fed agriculture, especially in sub-Saharan Africa makes the region to be fraught with food insecurity amid rising population.

In Nigeria, the northward excursion and retreat of the inter-tropical discontinuity (ITD) largely dictates the pattern of rainfall (Ilesami, 1971; Anyadike, 1985; Olaniran, 2002). Besides the ITD and the associated moisture bearing tropical maritime air mass and the characteristically dry and dusty tropical continental air mass, other factors such as Sea Surface Temperature Anomaly (SSTA), Tropical Jet Stream (TJS) and El Nino/Southern Oscillation (ENSO), are also relevant in explaining spatial pattern of rainfall distribution over the region (Adejuwon, 1991; Olaniran, 2002). Generally, rainfall amount decreases from the coastal belt of Nigeria to the northern fringe with the exception of places with relief modification. Of significance is the characteristic variability of rainfall in the Sudano-Sahelian region of Nigeria (Owonubi, 1994) which is located in north extreme of the country.

Analysis of rainfall trends in Nigeria has been carried out largely on annual basis (Odekunle, 2010; Umar, 2010; Atedhor, 2014; Atedhor and Enaruvbe, 2016). Agriculturally however, it is the specific pattern of rainfall at the different stages of the cropping calendar that is more important (Atedhor and Ayeni, 2017; Atedhor, 2019). Although, studies have reported late onset and early cessation of rainfall, especially in the Sudano-sahelian region of Nigeria (Odekunle, 2004; Umar, 2010), trends of rainfall amount during the periods of onset and cessation have not been specifically examined. This paper, therefore, examines trends of rainfall amount during the onset and cessation over the Sudano-Sahelian region of Nigeria.

Materials and Methods

Study Area

The Sudano-Sahelian belt of Nigeria (Figure 1) encompasses the Sudan and Sahel savanna vegetation belts of Nigeria. It is situated at latitude 10˚N and 14˚N and longitude 4˚E and 14˚E (Fabeku and Okogbue, 2014). The vegetation is progressively less woody from the southern boundary of the region to the northern limit of the country. The northern fringe is shrubby due to relatively low rainfall amount. Rainfall declines from about 1000 mm to approximately 500mm in Nguru in the north-eastern axis. Rainfall in the region is unimodal. The area is fraught with drought incidences of varying intensities (Abaje*et al*., 2013; Atedhor, 2014). The ecological zone, especially the northern fringe is besieged by desertification (Sayne, 2011). Among the prominent rivers that drain the area are Goronyo, Hadeija, Komadugu and Yobe. Apart from the prevalence of rearing of livestock in the region, the cultivation cereals thrives (Atedhor, 2019).

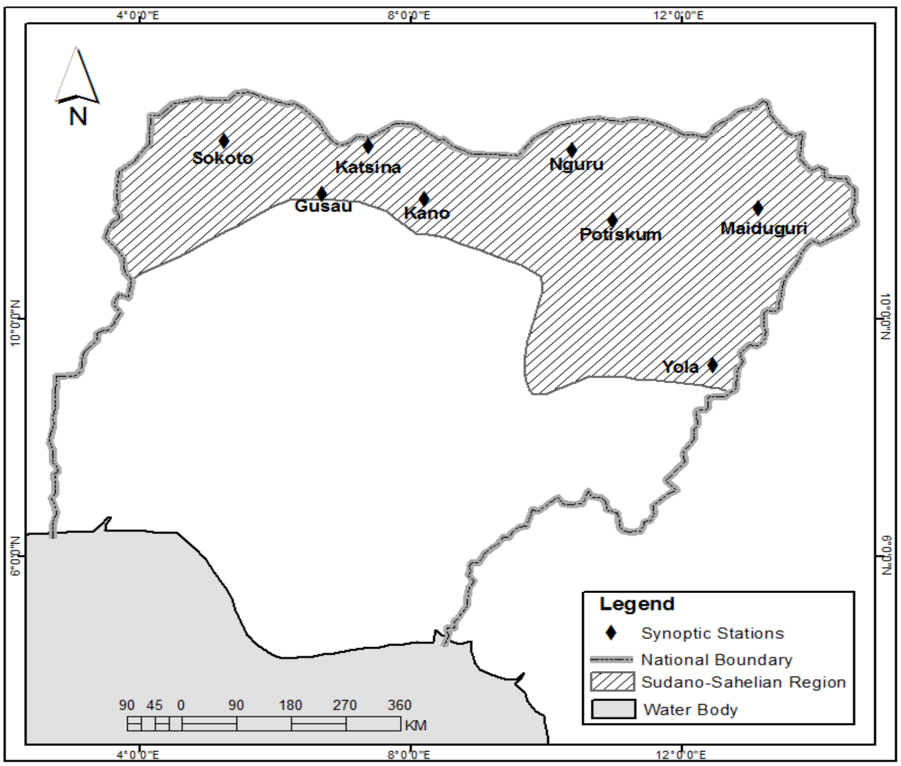

Figure 1: Sudano-Sahelian Region and Selected Synoptic Weather Stations

The growing season lasts from June to September in the Sudano-Sahelian region of Nigeria (Odekunle, 2004). Consequently, rainfall data for the months of June and September which respectively mark the onset and cessation of rainfall in the Sudano-sahelian region of Nigeria were sourced from the archives of the Nigerian Meteorological Agency. Eight synoptic weather stations (Sokoto, Gusau, Katsina, Kano, Potiskum, Nguru, Maiduduri and Yola) were selected for this study based on spread and uninterrupted availability of data. The data covered 64 years (1951-2014). Simple linear regression was used to examine linear trends of rainfall during onset and cessation of the growing season. The simple linear regression equation is expressed as:

$$Y = \beta_0 + \beta_1 X + \varepsilon \text{...} (1)$$

Where β_0 is the Y-intercept, $\beta_1$is the change in the mean value of Y (rainfall amount) associated with a unit increase in X (years), while Ɛ is an error term that describes the effects on y of all factors other than the value of the independent variable X. The decadal rainfall amount for the selected synoptic weather stations was computed for the onset and cessation. This was used to examine the decadal variation of rainfall during the onset and cessation of the growing season. The spatial variations of rainfall during the onset and cessation during the 1951-1982 and 1983-2014 time slices were computed as:

$$\textit{Spatial Variation of Rainfall} = \frac{HighestRainfall - LowestRainfall}{AverageRainfallovertheregion} \text{........................} (2)$$

Results

Rainfall trends during the onset and cessation of the growing season are depicted in Figures 2-9. While rainfall witnessed negative trends in Katsina, Nguru and Yola during the onset of the growing season, Sokoto, Gusau, Potiskum, Kano and Maiduguri experienced positive trends during the same season. The annual rates of decrease in rainfall in Katsina, Nguru and Yolawere -0.036 mm, -0.197 mm and -0.143 mm respectively during the onset of the growing season while Sokoto, Gusau, Kano, Potiskum and Maiduguri witnessed increase at annual rates of 0.040 mm, 0.188 mm, 0.269 mm, 0.026 mm and 0.025 mm respectively (Table 1). Rainfall in Sokoto, Katsina, Potiskum, Nguru and Yola witnessed negative trends at annual rates of -0.232 mm, -0.112 mm, -0.082 mm, -0.153 mm and -0.360 mm respectively during cssation of the growing season while the trends in Gusau, Kano and Maiduguri was positive at annual rates of 0.180 mm, 0.246 mm and 0.037 mm respectively.

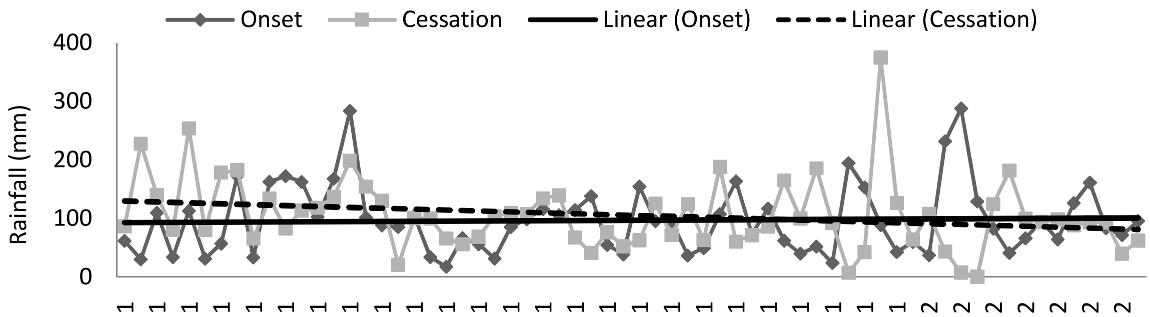

Figure 2: Annual trends of rainfall amount in Sokoto during onset and cessation

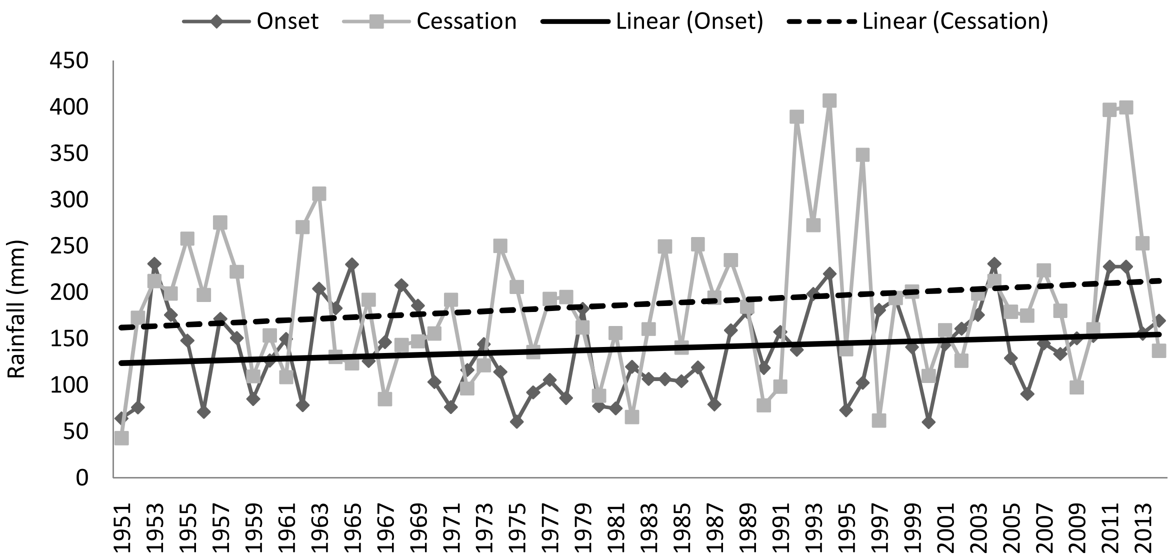

Figure 3: Annual trends of rainfall amount in Gusau during onset and cessation

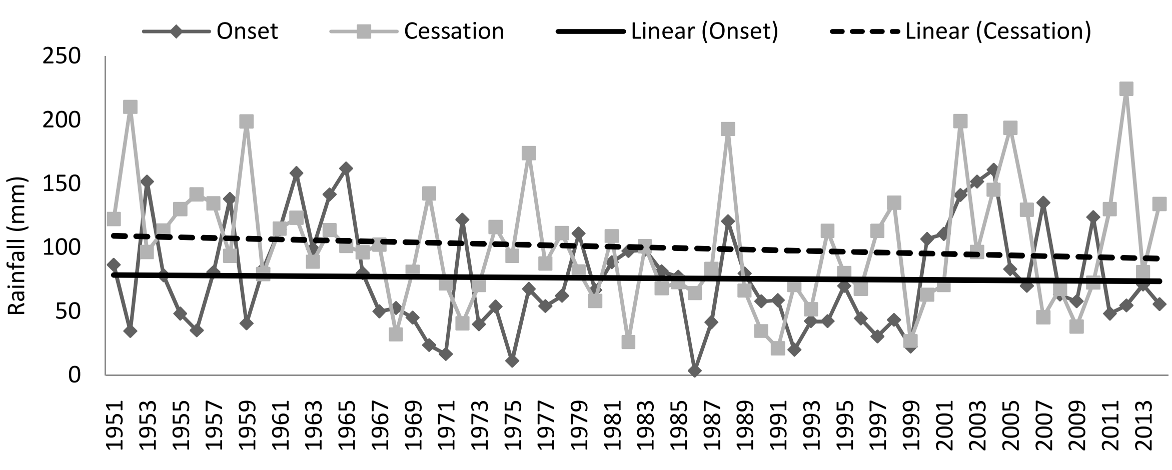

Figure 4: Annual trends of rainfall amount in Katsina during onset and cessation

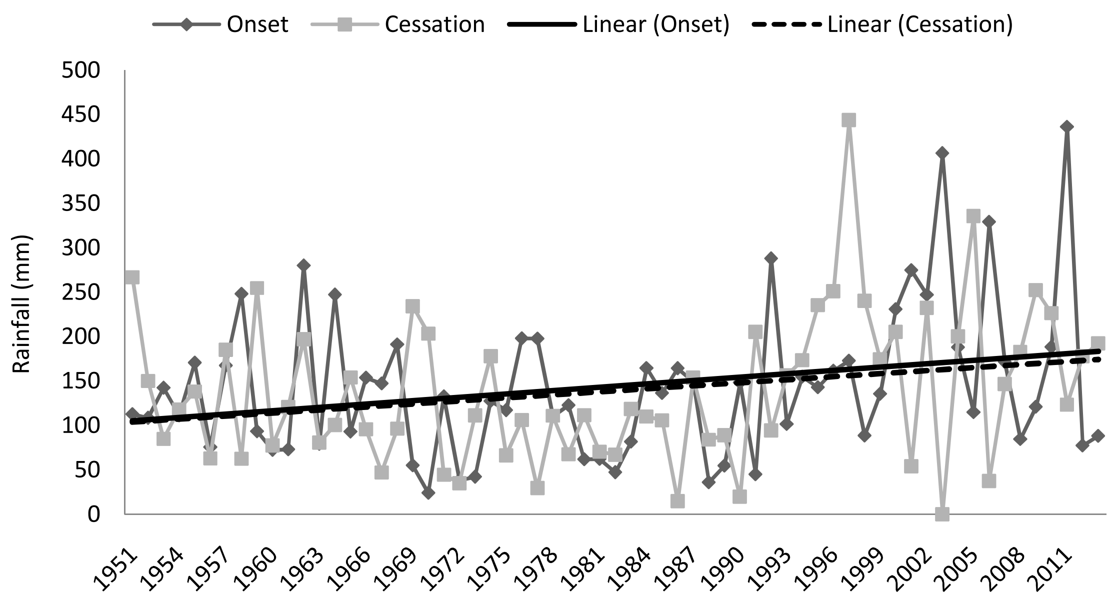

Figure 5: Annual trends of rainfall amount in Kano during onset and cessation

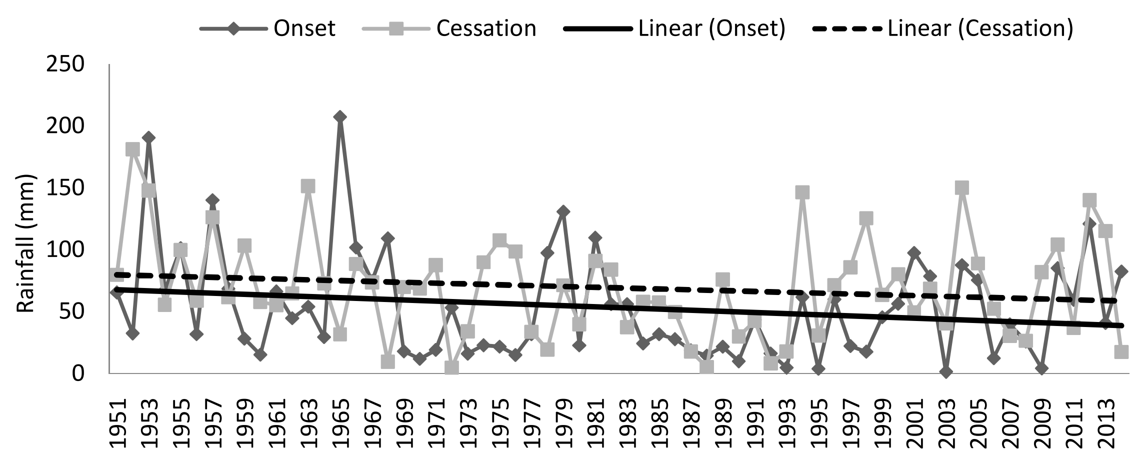

Figure 6: Annual trends of rainfall amount in Nguru during onset and cessation

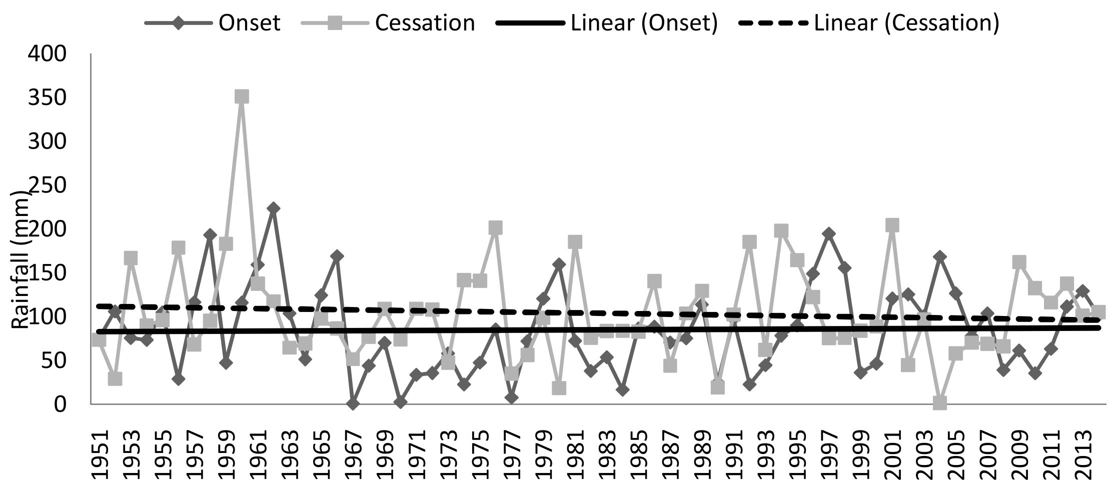

Figure 7: Annual trends of rainfall amount in Potiskum during onset and cessation

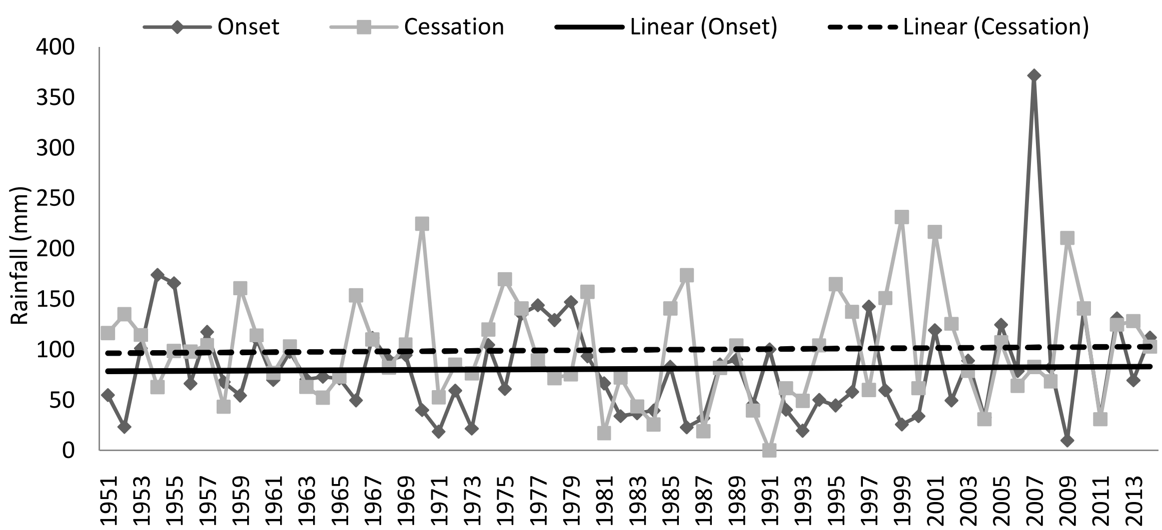

Figure 8: Annual trends of rainfall amount in Maiduguri during onset and cessation

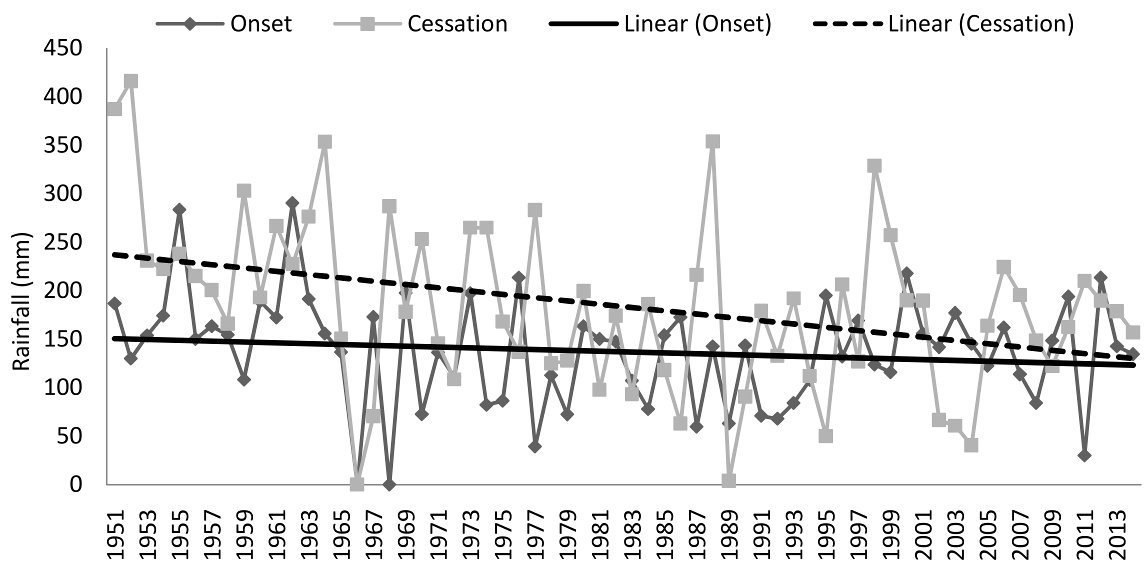

Figure 9: Annual trends of rainfall amount in Yola during onset and cessation

Table 1: Annual rate of change, intercept and correlation coefficients of rainfall during onset and cessation.

Synoptic weather Station	Annual rate of change (onset)	Intercept (onset)	Annual rate of change (cessation)	Intercept (cessation)
Sokoto	0.127	92.75	-0.775	130.4
Gusau	0.490	123.2	0.800	161.4
Katsina	-0.079	78.58	-0.282	109.4
Kano	1.261	104.0	1.137	102.8
Potiskum	0.070	83.00	-0.249	112.1
Nguru	-0.459	68.12	-0.332	79.99
Maiduguri	0.073	78.53	0.103	96.56
Yola	-0.436	151.0	-1.699	238.6

The decadal variations of rainfall during onset and cessation of the growing season are presented in Figure 10. Although decadal pattern of rainfall reveal spatial variability among the selected synoptic weather stations during the onset and cessation of the growing season, the 1951-60, 1981-90 and 1991-00 clearly depict a period of relatively lower rainfall.

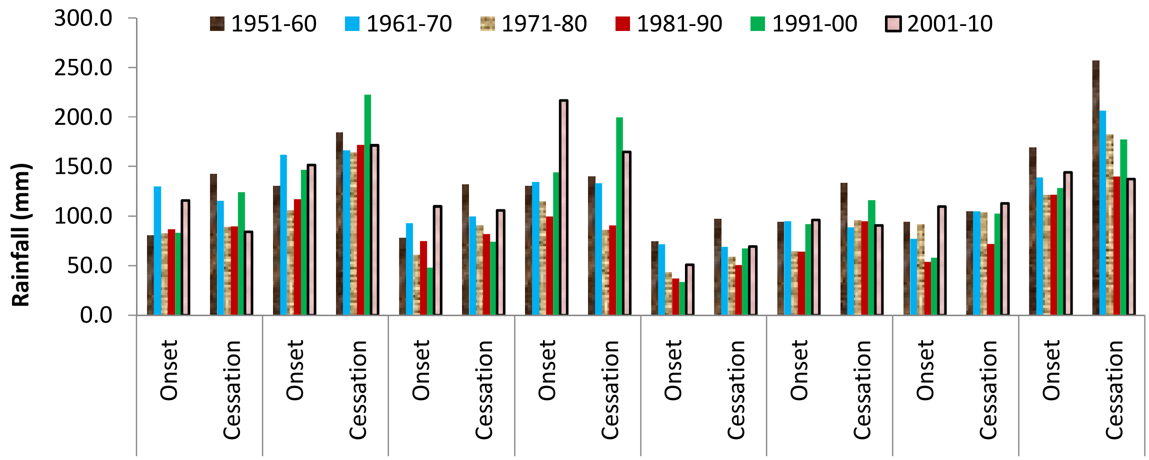

Figure 10: Decadal mean rainfall during onset and cessation

Figure 11 shows the mean rainfall amount of the selected synoptic weather stations during onset and cessation of the growing season for the 1951-1982 and 1983-2014 periods. Kano experienced wetter onset of the growing season with mean rainfall amount of 144.4 mm while Nguru was drier with mean rainfall amount of 53.2 mm during the 1951-1982 period. Gusau witnessed wetter cessation of the growing season with mean rainfall of 187.4 mm while Nguru was drier with mean rainfall amount of 69.2 mm.

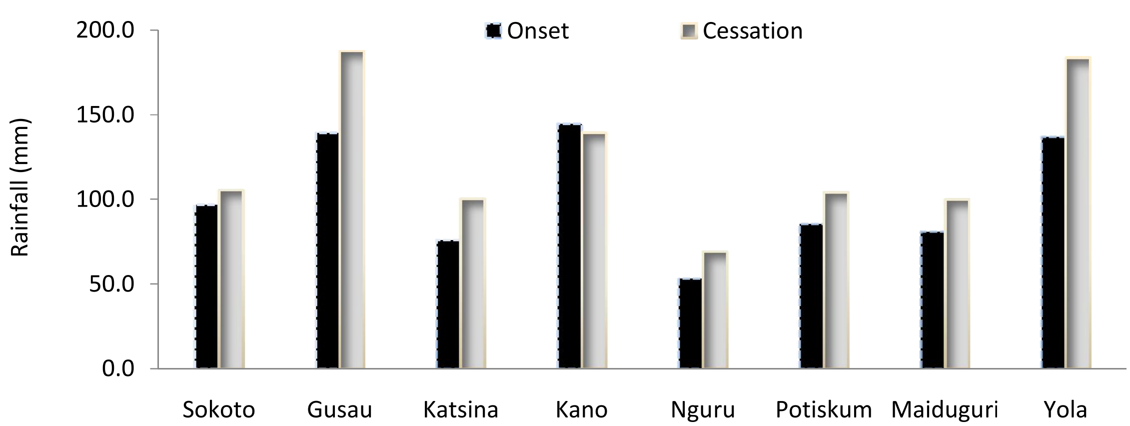

Figure 11: Mean rainfall during onset and cessation in the Sudano-Sahelian region

The deviation of the mean rainfall amount of 1983-2014 period from that of the 1951-1982 period during the onset and cessation of the growing season are presented in Figure 12. While the deviation was negative in Gusau and Kano during onset and cessation of the growing season, negative deviation occurred during onset only in Sokoto and Potiskum. Positive deviations occurred during onset and cessation of the growing season in Kano, Nguru, Maiduguri and Yola.

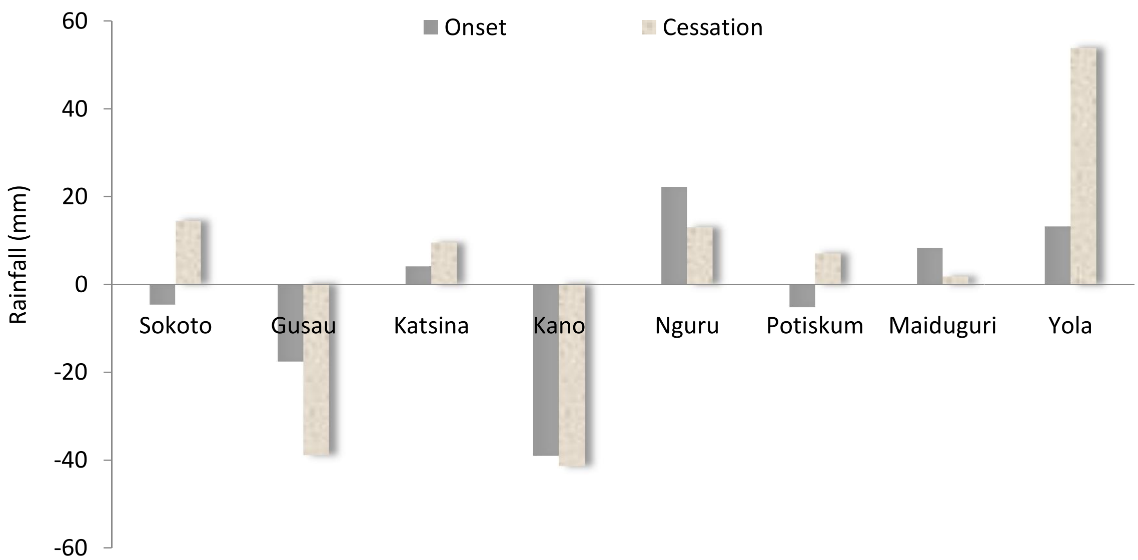

Figure 12: Change in rainfall between the 1951-1982 normal and 1983-2014 normal during onset and cessation

The spatial variation of rainfall during onset and cessation of the growing season (1951-1982 and 1983-2014) are presented in Table 2. During the 1951-1982 and 1983-2014 time frames, rainfall varied more spatially during cessation than onset. The spatial variation of rainfall during onset and cessation between the 1951-1982 and 1983-2014 time frames, shows increasing spatial variation over the Sudano-Sahelian region during onset of the rains while rainfall show no change in spatial variation during cessation.

Table 2: Spatial variation of rainfall in the Sudano-sahelian region during onset and cessation

Period	**Highest rainfall (onset)**	**Lowest rainfall (onset)**	**Mean rainfall**	**Spatial variation (onset)**	**Highest rainfall (cessation)**	**Lowest rainfall (cessation)**	**Mean rainfall**	**Spatial variation (cessation)**
1951-1982	210.3	64.2	100.4	0.79	163.6	42.2	124.7	1.18
1983-2014	210.3	75.7	102.8	1.08	206.9	62.7	122.4	1.18

Discussion

Rainfall trends of rainfall reveal decline in some of the synoptic weather stations during onset (Katsina, Nguru and Yola) and cessation (Sokoto, Katsina, Potiskum, Nguru and Yola). The decreasing rainfall trends in most of the synoptic weather stations during cessation highlight early retreat of the ITD. Declining rainfall trends during onset and cessation could induce crop moisture stress and forced maturation of crops, especially under rain-fed agricultural practice. Variability in rainfall during the time of planting is key issue in crop production (Shumetie and Yismaw, 2018). Variability in rainfall could be portrayed in the yield of farming schemes and marked fluctuation may create unfavorable effects on output (Mubiru*et al*., 2012). Generally, a lag in the commencement of wet season, results to a productivity loss for nearly all dry locations in the West African sub-region (Guan *et al*., 2015).

Late onset and early cessation of rainfall could induce poor crop yields despite above normal annual rainfall amount (Mugo*et al* (2016). The relatively lower decadal rainfall during onset and cessation of the growing season between 1971-80 and 1991-00 among the selected synoptic weather stations could be attributed to droughts (Atedhor, 2014). The increasing spatial variation of rainfall during the onset and high variation during cessation could be attributed to local factors such as land use/cover change due to intensifying anthropogenic factors such as urbanization, grazing and farming.

Conclusion

The paper examined rainfall trends during the onset and cessation of the growing season in the Sudano-Sahelian region of Nigeria. Results revealed that rainfall declined in Katsina, Nguru and Yola during the onset while Sokoto, Gusau, Kano, Potiskum and Maiduguri witnessed increase. Sokoto, Katsina, Potiskum, Nguru and Yola experienced decreasing trend during cessation while Gusau, Kano and Maiduguri recorded increase. The spatial variations of rainfall over the region was more pronounced during cessation during the 1951-1982 and 1983-2014 time slice while the onset of the rains show increasing spatial variation. The mean rainfall of 1983-2014 negatively deviated from that of 1951-1982 in Gusau and Kano during onset and cessation while the negative deviation in Sokoto and Potiskum was only recorded during onset. It is concluded that rainfall trends in the Sudano-Sahelian region of Nigeria is diverse during onset and cessation of the growing season. Since the date of the onset of rain is more significant than the cessation date and the main predicament farmers are encountering is at what time to commence plowing and cultivation (Ojo and Ilunga, 2018), irrigation measures should particularly target the onset period. In addition, cultivation of early maturing crops, staggering of planting in line with prevailing rainfall trends during onset and cessation, especially in Sokoto, Katsina, Potiskum, Nguru and Yola are recommended.

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