

## Research Article

### Dynamics of Hydrological Growing Season at Kano as Evidence of Climate Change

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**Abstract:** The semi arid region of Nigeria is experiencing the impact of climate change. Daily rainfall records from 1976-2011 were used to examine the impact of climate change on the hydrological growing season at Kano. The onset, cessation and length of rainy season at Kano were determined. The estimated parameters were subjected to time series analysis. Trend lines and fitted linear trend line equations for each of the parameters were produced. The Mann-kendall tau ( $\tau$ ) statistic was used to investigate the significance of these trends. The results show that the rainy season has progressively been starting late as signified by the positive trend line equation of  $y = 0.183x + 41054$ . Trend analysis showed that the rains ceases earlier in recent decades. This is corroborated by the negative linear trend line equation ( $y = -0.438x + 41184$ ). The results also indicated that the hydrological growing season is progressively shortening. The implication of late onset and early cessation is the decreasing length of the hydrological growing season as indicated by a negative linear trend line equation ( $y = -0.395x + 1289$ ). The length of the hydrological growing season has decreased from an average of about  $140 \pm 5$  days to about  $120 \pm 5$  in the state. The Mann-kendall tau ( $\tau$ ) statistic showed significant trends for all the parameters at 0.05 level. The results of this study have great implications for both surface and underground water resource management, agriculture and sustainable food security not only for the Kano region but Nigeria at large. Increased irrigation agriculture is eminent in this environment.

**Keywords:** Cessation, growing season, intermittent, onset, trends

## INTRODUCTION

Climate, particularly rainfall is a limiting factor in agricultural production in the arid region of the tropics, northern Nigeria inclusive. A shift in the average climatic conditions of an area would, therefore, lead to a shift in the pattern of agricultural activities in the area. Global warming has and is still altering the global rainfall regime. Extremes of this climatic parameter are on the increase in some areas while its average is on the decrease at some.

The Inter Government Panel on Climate Change (Intergovernmental Panel on Climate Change, 2007) reported that by 2020, agricultural production including access to food in many African countries will be compromised by climate change. The area suitable for agriculture, the length of the growing season and yield potential, particularly along the margins of the arid and semi arid areas of Africa are expected to decrease. In some countries in Africa, yields from rain-fed agriculture could be reduced by up to 50%. Rainfall is the most critical factor in the estimation of the Hydrological Growing Seasons (HGS) in the tropics.

Hydrological growing season is the period between the Onset Date (OD) of the rains and the end of the

rainy season. According to the agriculturalist, this is the period between the time crops are planted and the time they fully mature to harvesting stage. It is also referred to as the Length of the Rainy Season (LRS). This is the number of days between the effective start (onset) of the rainy season and the termination (Cessation) of the rainy season. Length of the rainy season determines the type of crop (s) that can be grown at a place due to the varied crop water requirements (Mavi, 1986).

Kano state is rated among the top 5 states that produce millet, ground nuts and Guinea corn, crops that are largely rain-fed in Nigeria. However, the production of these major grain crops today is faced with climatic challenges, one of which is the length of the hydrological growing season.

The purpose of the study therefore is to examine the impact of climate change on the hydrological growing season at Kano. The objectives of the study include:

- To examine the trend in the onset and cessation of the rains and length of the growing season in the study area.
- To establish statistically whether the trend is significant or otherwise.

**MATERIALS AND METHODS**

Kano is located between latitudes 10° 38' N-12° 38'N and longitudes 08° 02'-09°03'E on the high plains of northern Nigeria, bounded to the north and north-east by Jigawa state, to the south and south-west by Kaduna state, to the north-west by Katsina state and to the south east by Bauchi State see Fig. 1.

Kano is found within the Sudan Savanna vegetation and the A<sub>w</sub> (tropical continental climate) characterized by distinct wet and dry seasons. The rainy season starts in June and ends in September, giving only four months of rainy season with a mean annual rainfall of about 800-900 mm. The average duration of the hydrological growing season at Kano according to NIMET, 2008 is between 90-120 days. Temperatures are high throughout the year but highest in April (over 30°C) December is the coolest month with mean temperature of about 26°C.

**Type and source of data:** Daily rainfall records for three and half decades (1976-2011) were sourced from the Nigerian Meteorological Agency, Lagos and used to

examine the impact of climate change on the hydrological growing season at Kano. Discussion of HGS is almost impossible without reference to the onset and cessation dates of the rainy season. The onset and cessation dates, on which the length of Hydrological Growing Season (HGS) depends, were therefore first determined before the HGS was calculated for the study area.

**Data analysis:** The definition of Onset, Cessation and the HGS in tropical climates has been a problematic one because of the intermittent nature of rainfall in the region. These three terms have been defined in various ways for different purposes by researchers. Onset refers to the time a place receives an accumulated amount of rainfall sufficient for growing of crops. It is not the first day the rain falls. Cessation means termination of the effective rainy season. It does not imply the last day rain fell, but when rainfall can no more be assured or be effective. Hydrological Growing Season (HGS) is the number of days between the onset and cessation dates. Various methods have been used for the estimation these three rainfall parameters (Walter, 1967; Ilesanmi,

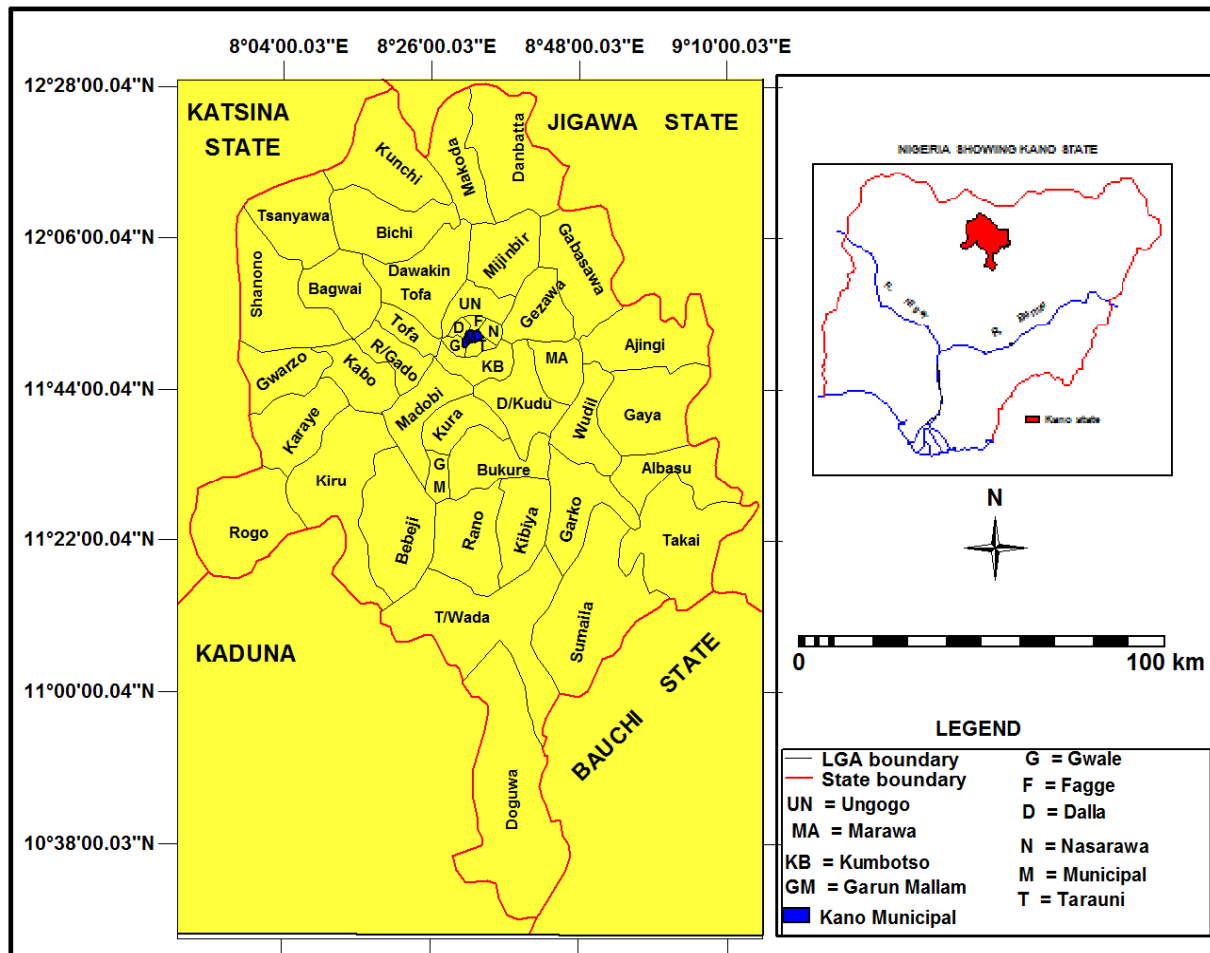


Fig. 1: Kano state: Lands and surveys, Kano state

1972; Kowal and Knabe, 1972; Stern *et al.*, 1982b; Olaniran, 1984; 1988; Sivakumar, 1988; Adefolalu, 1993).

Walter (1967), Olaniran (1984) and Adefolalu (1993) applied the ogive method and determined the start of the growing season for some places in northern Nigeria. Here, the number of days in the year is divided into pentads using the pentad calendar. This gives a total of 72 pentads. Total rainfall was calculated for each pentad and cumulated for the year; and an ogive was then constructed from this for each year. The points on the pentad axis corresponding to the first and the last points of maximum inflexion on the ogive gave the onset and cessation pentads, respectively. While the last date in the onset pentad gives the exact date of onset of the rainy season, the first date in the cessation pentad gives the exact date of the cessation of the rainy season. The hydrological growing season is obtained by subtracting the onset pentad from the cessation pentad and multiplying the difference by 5 (Adefolalu, 1993). This method was adopted and used for the determination of onset, cessation and hydrological growing season in this study.

The estimated onset, cessation dates and length of the HGS were subjected to time series analysis. Trend lines and fitted linear trend line equations for each of the parameters were plotted to visualize the direction and magnitude of impact of climate change on these rainfall parameters in the state. The Mann-kendall tau ( $\tau$ ) statistic was used to investigate the significance of the trends in the three parameters.

## RESULTS AND DISCUSSION

**Onset dates of the rainy season:** The linear trend and trend line equation for the onset dates of the rainy season in the study area are shown in Fig. 2. It is very clear from Fig. 2 that the onset of the rainy season is characterized by more marked 'noises' (variability) from year to year unlike in its cessation and duration. This figure clearly indicates an increasing trend line in the onset dates. The best fit line equation is positive ( $y = 0.813x + 41054$ ). This implies progressively late start of rainfall in recent years in the study area. This agrees with the findings of Sawa and Adebayo (2011a). Figure 2 shows that on the average, the rainy season starts from the 20<sup>th</sup> of May in this region as against the earlier dates in April as it used to be in earlier periods.

**Cessation dates of the rainy season:** Trend in the cessation dates of the rainy season during the study period in Kano is presented in Fig. 3. Figure 3 indicates that the mean cessation date of the rains in this region of northern Nigeria is about 27<sup>th</sup> of September. From Fig. 3, it is observed that the trend in cessation dates of the rains is on the decline. The linear trend line equation is negative ( $y = -0.438x + 41184$ ). This further indicates that in the study area, the rains progressively

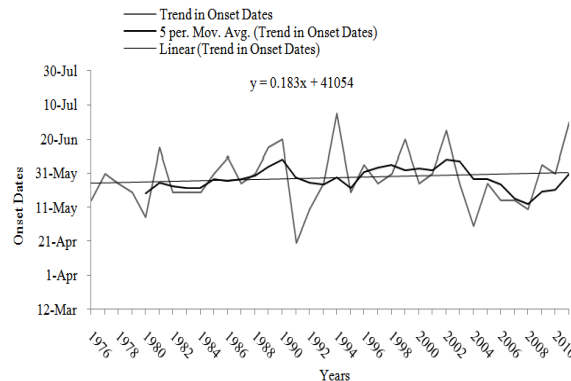


Fig. 2: Trend in onset dates at Kano (1976-2011)

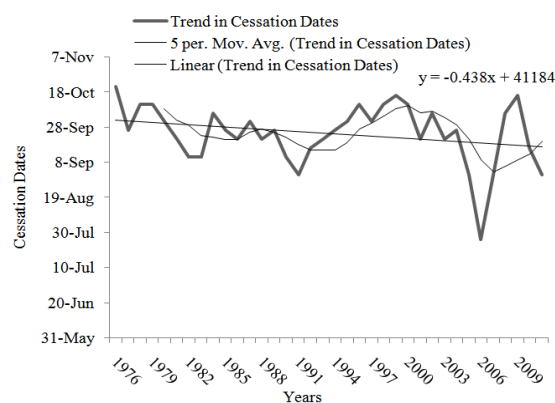


Fig. 3: Trend in cessation dates at Kano (1976 - 2011)

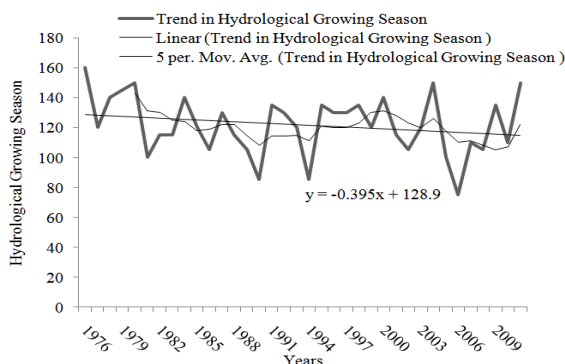


Fig. 4: Trend in hydrological growing season at Kano (1976-2011)

stop earlier in recent times. This is corroborated by the findings of Sawa and Adebayo (2011b).

**Length of the Hydrological Growing Season (HGS):** The pattern of progressive length of HGS in Kano is shown in Fig. 4. Figure 4 indicates a downward trend in HGS in the area. A negative trend line equation of  $y = -0.395x + 128.9$  implies that the length of the growing season is progressively declining in the area. The average HGS length in the Kano region is about 130 days. This is in concordance with Ojo (2003) and Sawa and Adebayo (2011a, b). Figure 4 shows that the

Table 1: Results of Mann-Kendall's test of significance in trends

Rainfall parameter	Mann-kendall tau ( $\tau$ )
Onset	0.23**
Cessation	0.05*
HGS	0.18*

\*: Significant at 0.05 level of significance; \*\*: significant at 0.01 level of significance

variability ('noise') in duration of the hydrological growing season is not as marked as the variability in onset and cessation of the rains. This signifies that the duration of the rainy season in the study area is gradually shortening over the years.

**Significance of the observed trends:** Results of the Mann-kendall tau ( $\tau$ ) statistic that was used to test the significance of the observed trends in the onset and cessation dates and length of the hydrological growing at Kano are presented in Table 1.

Table 1 indicates that, the trend in onset dates is significant at 0.01 level of significance while the trends in cessation dates and length of hydrological growing season are only significant at 0.05 level of significance. This implies that the late onset of the rainy season is more pronounced than the trends in the cessation and hydrological growing season length. The implication of the late onset of the rainy season in this region and early cessation is the shortening of the hydrological growing season with its attendant consequences.

### CONCLUSION

This research has brought to the fore that the rainy season has of recent been starting late but ending earlier, consequently progressively shortening the duration of the hydrological growing season at Kano. The findings of this study have great implications for both surface and underground water resource management and agriculture and sustainable food security not only for the Kano region but Nigeria at large. The late onset and early cessation of the rains and consequently the decreasing trend in the length of the hydrological growing season at Kano are diminutive to agriculture and water resources as well as the biodiversity of the region. This is a threat to rain-fed agriculture, food security and sustainable development. There is therefore, the urgent need for the Nigerian

government to come up with a implimentable action plan to face this reality of climate change.

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