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DETERMINATION OF ONSET, CESSATION OF RAINS AND HYDROLOGICAL GROWING SEASON IN DADIN KOWA AND GOMBE FOR AGRICULTURAL PLANNING

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ABSTRACT
This study determined the onset, cessation of rains and length growing season (HGS) in the Sahel Sudan of northeastern Nigeria. Two stations were selected for the study; Gombe town in Gombe LGA and Dadin Kowa in Yamaltu Deba LGA of Gombe State. Daily rainfall data was obtained from NIMETS and Upper Benue River Basin, Dadin Kowa, Gombe State. The rainfall cumulative model was adopted for this study. The first step of the method was to derive the daily rainfall that occured at each five-day interval in a year. A rainy day in this study is a day with zero point two five millimeters that occured within twenty-four hours. This is followed by computing the total of the five-day period. Finally, when the cumulative rainfall total is plotted against time through the year, the first point of maximum positive curvature on the graph corresponds to the time of rainfall onset, while the last point of maximum negative curvature corresponds to rainfall cessation. The difference between the onset and cessation in days is hydrological growing season (LGS). Result shows that onset dates for Gombe town and Dadin Kowa are 25 and 30 May, with a variability of ±10 and ±15 days, respectively. While cessation dates, is 12 October, for Gombe town and Dadin Kowa with a variability of ± 10 days. The hydrological growing seasons is 140 days with a variability of ± 10 days for Gombe town and 137 days with a variability of ± 15 days for Dadin Kowa. A radar diagram was used to compare onset, cessation and length of growing season in the two locations temporally from 2001 to 2017. Results revealed that onset and length of growing season followed same trend with Gombe town having the dominant late onset while Dadin Kowa had the longest length of rainy season between 2001 and 2017. In terms of cessation from 2001 to 2017, Dadin Kowa on the average had late cessation. The results of this study would be useful to farmers and other stakeholders in planning agricultural calendars.

Keywords: Onset, Cessation, Hydrological Growing Season (HGS) and radar diagram

Introduction

In any economy that is driven by primary production and agriculture in particular, rainfall occupies a central place especially in the tropical region. Rainfall, one of the forms of precipitation, is not only an important form of atmospheric moisture that falls on the earth surface but also the most variable meteorological element. Not only does it recharge ground water and determine the regime of channelized water in rivers harnessed for irrigated agriculture (NOUN, 2004), it is also the principal operator in rain-fed agriculture in the tropics

In a tropical country like Nigeria, rain falls in different months of the year at different places with varying amount and duration. As the rain belt appears to follow closely the relative northwards movement and southwards retreat of the Inter Tropical Discontinuity (ITD), in response to the apparent movement of the overhead sun on its journey between Tropic of Cancer and Capricorn occasioned by the revolution of the earth. This sets up heat and pressure differences between the two hemispheres. The atmospheric environment in Nigeria due to its location within the tropics is characterized by high temperature, high relative humidity and high but variable rainfall (Nieuwolt, 1977; Oguntoyinbo, 1983). An early planting encouraged by a false onset of the rains, followed by a prolonged dry spell of two or more week's duration, may also spell doom for the healthy

germination of planted seeds, their optimal growth and development (Olaniran, 1983). A a well-defined onset of the rains with no significant break within the hydrological growing season encourages bumper harvest, increase income and support food sufficiency and sustainability. It is against this background that this paper seeks to determine the onset, cessation of rainfall and hydrological growing season in Gombe and Dadin Kowa, Gombe State.

Materials and Methods

The study area Gombe metropolis is located between latitudes 10º 15'N and 10º 19'N and between Longitudes 11º 07' E and 11º 15' E. It is bounded by Kwami LGA to the North, Akko LGA to the Southwest and Yamaltu Deba LGA to the East. Gombe is the administrative capital of Gombe State and has a tropical continental type of climate, classified as Koppen's Aw. It is characterized by strong rainfall seasonality with distinct wet and dry seasons (Oladipo, 1995). The rainfall is concentrated between the months of May and September with a single maximum in August (Amos, Musa, Abashiya, and Abaje, 2015). The average annual rainfall totals is about 863.2 mm. The study made use of daily rainfall data for the period of 30 years (2001 – 2017). A rainy day was adopted after Ayoade (1988) to be a period of 24 hours in which at least 0.2mm of rainfall is received. Dadin-kowa town is located between latitudes 10 to 10º 20º N and longitudes 11º 01ºE and 11º 19ºE it shares common boundary with Akko L.G.A in both the south and west, Yamatu-Deda to the East and Kwami to the North (Ibeje and Okoro, 2013). The climate of Dadin-kowa is characterized by a dry season of six months, alternating with a six months rainy season. As in other parts of the savanna, the precipitation distribution is mainly triggered by a seasonal shift of the inter-tropical Convergence Zone (ITCZ). For the years 1977 to 1995, the mean annual precipitation is 835mm and the mean annual temperature is about 26ºC, whereas relative humidity has same pattern being 94% in August and dropping to less than 10% during the harmattan period (Ibeje and Okoro, 2013). The relief of the town ranges between 650m in the western part to 370m in the eastern parts (Ibeje and Okoro, 2013). Daily rainfall is particularly suitable for this study because it enabled the analysis of onset and cessation period of rainfall. It is this parameter that will be used for the determination of onset, cessation of rains and length of growing season in the study area. For the determination of onset, cessation and the length of growing season or hydrological growing season of Gombe and Dadin Kowa, a 5 day pentade was used to compute the running sum for each year from 2001 – 2017. The cumulative rainfall associated with each pentad was then calculated and plotted. The major point of 1st and last inflexion automatically constitute the onset and cessation periods. The precise date is determined by considering the first date in the pentad number for onset and the last date in the pentad number for the cessation. This method has been successfully used by Walter (1967), Olaniran (1984) and Audu *et al* (2012). The research further used the measure of dispersion and central tendency to compute the mean LGS and its standard deviation in days.

Results and Discussion

Determination of Onset of the Rains in Gombe town and Dadin Kowa

The onset dates in Gombe town and Dadin Kowa are on 25 and 30 May which correspond to pentad 29 and 30 respectively and with a standard deviations of 2.0 (10) and 3 (15) days for Gombe and Dadin Kowa respectively. This implies that the onset of the rains can vary between 25, May ± 10 days in Gombe while in Dadin Kowa can vary between 30 May ±15 days . This implies that the variability of the onset dates for Gombe town sway between 15, May, on its lower limit to 5, June, on upper limit. While in Dadin Kowa, it sways between 15 May at the lower limit and 14 June at the upper limit. The implication is that any date of the onset of the rains that lies within these lower and upper limits of the onset is considered normal since it lies within the deviation of the onset (Table 1).

Onset Annual Variability in Gombe town and Dadin Kowa

The long-term onset of rains in Gombe town is 25 May, with a variability of ± 10 days. While in Dadin Kowa is 30 May with a variability of ±15. A close look at Fig.1 reveals that in the years 2002, 2003, 2004, 2011, 2013 and 2016 were characterized by early onset of rains in Gombe town, while 2001, 2005, 2007, 2010, and 2014 were years of late onset. The years 2009 have zero deviation from the established onset date of rains. The years that had abnormal onsets that falls outside the standard deviation of ten (±10) days in Gombe towns are 2001, 2002, 2005, 2010, 2011, 2012, 2013 and 2014. Similarly, in Dadin Kowa, 2002, 2003, 2011, 2013 and 2016 were all years of early onset. Conversely, the years 2001, 2004, 2005, 2006, 2008, 2010 and 2014 were characterized by late onset of rains. The onset did not vary from the established onset in 2007, 2009, 2015 and 2017. However, 2002, 2008 and 2014 were the only years that were outside the fifteen (±15) days standard deviation (Fig. 1).

Determination of Cessation Dates in Gombe town and Dadin Kowa

Table 2 and shows the computed cessation dates of the rains and their inter-annual deviations from the mean cessation date for Gombe town and Dadin Kowa From Table 2 and Figure 1. shows that the pentade cessation dates for Gombe town and Dadin Kowa did not vary. The mean Pentade cessation number is fifty-seven (57) for both stations with a standard deviation of ± 10 days.

This implies that the cessation dates for Gombe town and Dadin Kowa is 12 October with ten (10) days or two points zero standard deviation. While the cessation date of the rains at Gombe town and Dadin Kowa range between 2, and 22 October. This implies that any of these days between 2 and 22 October cessation of the rains in Gombe town and Dadin Kowa is considered normal since it is within the range (Table 2). The lower limit for the two locations lies between 2 and 12 October, and upper limit of 12 and 22 October, with a variability of plus or minus ten (10) days. Despite their same cessation, Gombe town had early onset than Dadin Kowa. This may be based on urban and rural location of the two areas. The urban area generates heat that triggers high evapo-traspiration that condenses and comes back as rains. In addition, the slight difference in latitude may also account for the difference in length of rainy season.

Annual Variability of Cessation dates in Gombe town and Dadin Kowa

A close look at the variability of cessation dates from 2001-2017 reveals that the deviation follows the same pattern in the two locations. The first seven years in Gombe town was dominated by late cessation in the following years; 2001, 2002, 2003, 2004, 2005, 2006 and 2007 and the later years of the studies (2010 and 2014) recorded late onset. While 2009, 2011 and 2017 were the years of early cessation, which might have shortened the hydrological growing season depending on the onset Appendix I, Table 2 In Dadin Kowa, the same trend was observed in all the years as seen in Fig. 2. The early part of the studies witnessed normal cessation in 2003 and 2005 while 2001, 2002, 2006, 2007, which were the years with the longest variability of the cessation. Other years of late cessation were 2010 and 2014. The earliest cessation of the rains was in 2009 while other early cessations were recorded in 2008, 2011 and 2012 (Fig.2)

Determination of Hydrological Growing Season in Gombe town and Dadin Kowa

Table 3 shows the calculated mean length of growing season (HGS) in Gombe town and Dadin Kowa respectively between 2001 and 2017. It shows that while Gombe town has LGS of 140 days, Dadin Kowa has a mean LGS of 137 days. Thus, the two locations have difference of three days. The two locations of the study area have an LGS standard deviation of 10 and 15 days for Gombe town and Dadin Kowa respectively. This implies that the actual length of the LGS for the two locations can be as long as 150 ± 10 days and 152 ±15 or as short as 130 and 122 days for Gombe town and Dadin Kowa respectively. This undoubtedly depicts a crop ecological zonation that will be favourable for crops whose life cycle lies within the lower limit of 130 and 122 days can do better in this zone. Empirically, it has been observed that this environment is by far much more suitable for cereals and leguminous crops such as maize, guinea corn, rice, groundnut and beans whose life cycle do not exceed one hundred and twenty (120) days (Chukwu, 2004). This is because the reproduction and maturity of every crop must be met with its unique optimum crop water requirement, for anything that exceeds such limits lead to serious decline in yields (Chukwu, 2004).

Annual Variability of Length of Growing Season (LGS) in Gombe town and Dadin Kowa

A close look at the deviations from the long-term means (2001-2017) in Table 3 reveals that the fluctuations follow the same pattern in the two locations. However, Gombe town reveals that 2005, 2008, 2009, 2012, 2014, 2015 and 2017 were years of longer LGS. The years 2001 and 2011 had zero normal deviation, and 2002 is the year with the shortest length of growing season (115) days (see Figure 3). Similarly, in Dadin Kowa, the years 2004, 2005, 2006, 2008, 2009, 2010, 2012 and 2014 also recorded longer length of rainy season above the established, and 2002 and 2012 have shortest LGS, which is detrimental to crop production; while 2012 and 2014 where the years with longer LGS (Fig. 3).

The difference between Pentade onset in Gombe town and Dadin Kowa

Fig. 4 (radar diagram) shows the pentad onset of Gombe town in blue and Dadin Kowa in red colors from 2001 to 2017. The diagram shows that the two locations had a similar trend in terms of onset dates in all the years. Gombe in 2001, 2002, 2005, 2007, 2009, 2010, 2011, 2012, 2013, 2015, 2016 and 2017 had earlier onset despite being located almost on the same latitude. In twelve years, out of 17 years of the determined onset, Gombe town had earlier onset than Dadin Kowa. The slight difference in the onset dates could be because of urban rural location factors. Gombe town being an urban centre tend to generate urban heat and other pollutants that aid in condensation of the evaporated moisture than Dadin Kowa that is rural in nature. This result agrees with the result obtained between Uyo town in Akwa Ibom state and Umudike in Abia State (Audu, 2012), where he found out that Umudike being a rural area had late onset to Uyo that is urban in nature. Dadin Kowa had earlier onset than Gombe town only in 2004, 2008, and 2014.

The difference between Length of Growing Season in Days in Gombe town and Dadin Kowa

The trend is the same as earlier seen in the onset (Fig. 5) comparing the length of growing season in Gombe town and Dadin Kowa from 2001 to 2017. Result indicate that all the longest length of growing season are in Dadin Kowa in the following years; 2008, 2012 and 2014 with 165 days, while 2013 had the shortest length of rainy season in the study area. In Gombe

town, years 2001, 2002, 2005, 2007, 2009, 2011, 2013, 2015, 2016 and 2017 had longer length of growing season than Dadin Kowa. The two locations had same length of growing season in 2003 and 2010. The influence of proximity to water body and vegetation in Dadin Kowa might have helped in some years where on the average it has the longest length of growing season. Audu, (2012) observed the same trend between Uyo and Umudike on proximity to water bodies where Uyo had longer length of rainy season than Umudike whose location was influenced by continentality.

The Difference between Cessation Dates in Days in Gombe and Dadin Kowa

The behaviour of the cessation dates was not like onset and length of growing season where in all the years it follows a singular trend. However, for cessation in Gombe town and Dadin Kowa in the first decade, it maintained a similar trend, but from 2011 to 2014, they were in opposite directions as depicted in Fig. 6. In 2011 and 2013, Gombe town had late cessation while in 2012 and 2014 Dadin Kowa had late onsets. The cycle from 2015 to 2017 returned to the one earlier observed in the first decade (2001 to 2010). The cessation dates from 2001 to 2004 shows that Dadin Kowa seems to have late cessation than Gombe town, but in 2005, they all had same cessation dates. In the years 2006 and 2007, also the same trend for Dadin Kowa with the late cessation was observed. Conversely, in 2008 reverse was the case; Gombe had late cessation than Dadin Kowa. In 2009 and 2010, Dadin Kowa had late cessation.

Conclusion

The rainfall cumulative model was adopted for this study. Result shows that onset dates for Gombe town and Dadin Kowa are 25 and 30 May, with a variability of $\pm$10 and $\pm$15 days, respectively. While cessation dates, is 12 October, for Gombe town and Dadin Kowa with a variability of $\pm$ 10 days. The hydrological growing seasons is 140 days with a variability of $\pm$ 10 days for Gombe town and 137 days with a variability of $\pm$ 15 days for Dadin Kowa. A radar diagram was used to compare onset, cessation and length of growing season in the two locations temporally from 2001 to 2017. Results revealed that onset and length of growing season followed same trend with Gombe town having the dominant late onset while Dadin Kowa had the longest length of rainy season between 2001 and 2017. In terms of cessation from 2001 to 2017, Dadin Kowa on the average had late cessation. Proper determination of onset of rains will help farmers plan their agricultural calendar well and reduces losses due to false onset of the rains.

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Table 1: Mean Pentad Onset and Deviation of rains in Gombe town and Dadin Kowa

Station	Mean Pentade onset number	Mean Pentade onset date	Month	Pentade STD deviation	Onset range in days
Gombe	29	25th	May	2.0	±10
town	30	30th	May	3.0	±15
Dadin Kowa					

Table 2: Mean Cessation Dates and Standard Deviations in Gombe town and Dadin Kowa

Station	Mean Pentade number	Mean Pentade date	Month	Pentade SD	Range in days
Gombe Town	57	12th	October	2.0	10
Dadin Kowa	57	12th	October	2.0	10

Table 3: Mean Length of Growing Season and Standard Deviations in Gombe town and Dadin Kowa

Station	Mean LGS in Days	Standard Deviation in Days	Upper Limit in Days	Lower Limit in Days
Gombe	140	10	150	130
Town	137	15	152	122
Dadin Kowa				

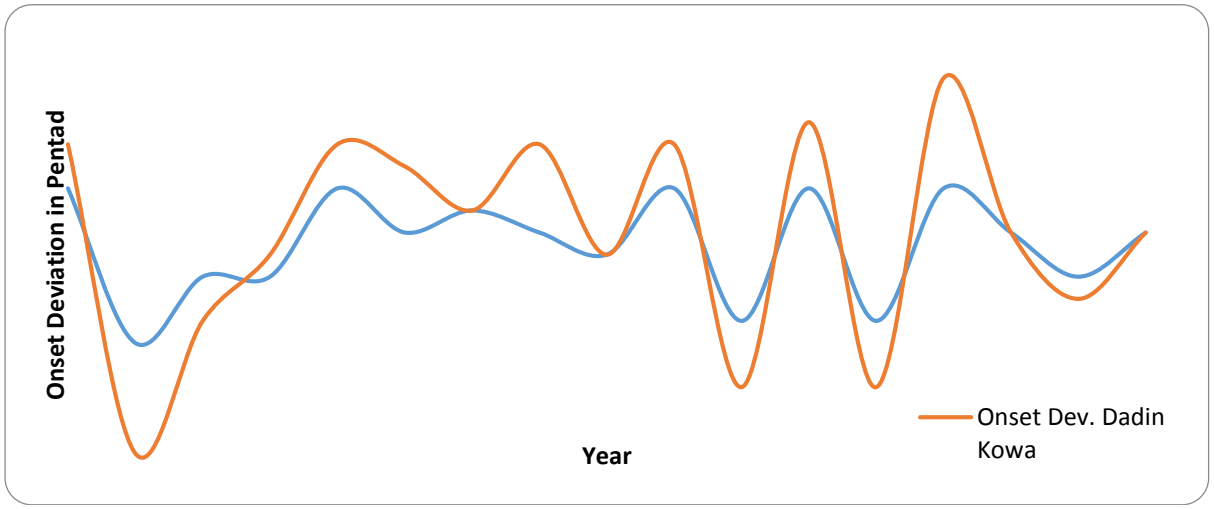

Fig. 1: Onset of Rains Variability in Gombe Town and Dadin Kowa between 2001 and 2017

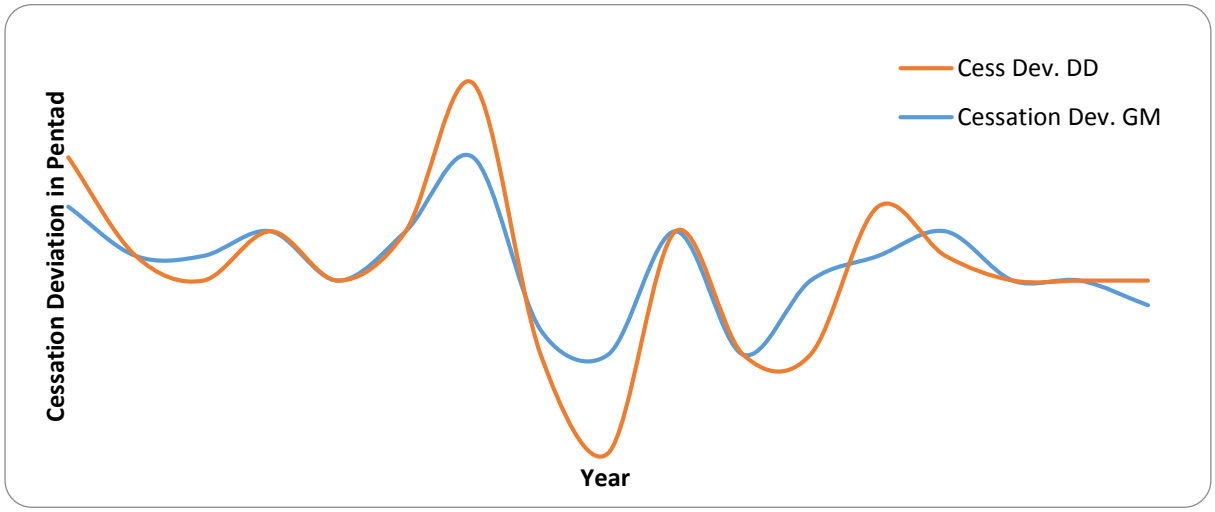

Fig. 2: Cessation of Rains Variability in Gombe Town and Dadin Kowa between 2001 and 2017

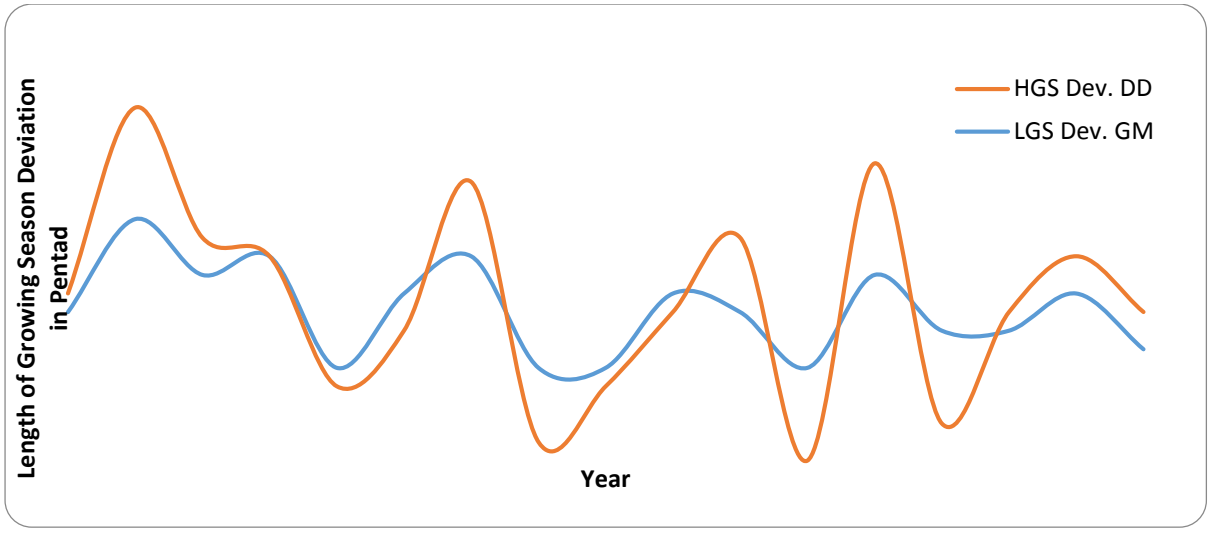

Fig. 3: Length of Growing Season Variability in Gombe Town and Dadin Kowa between 2001 and 2017

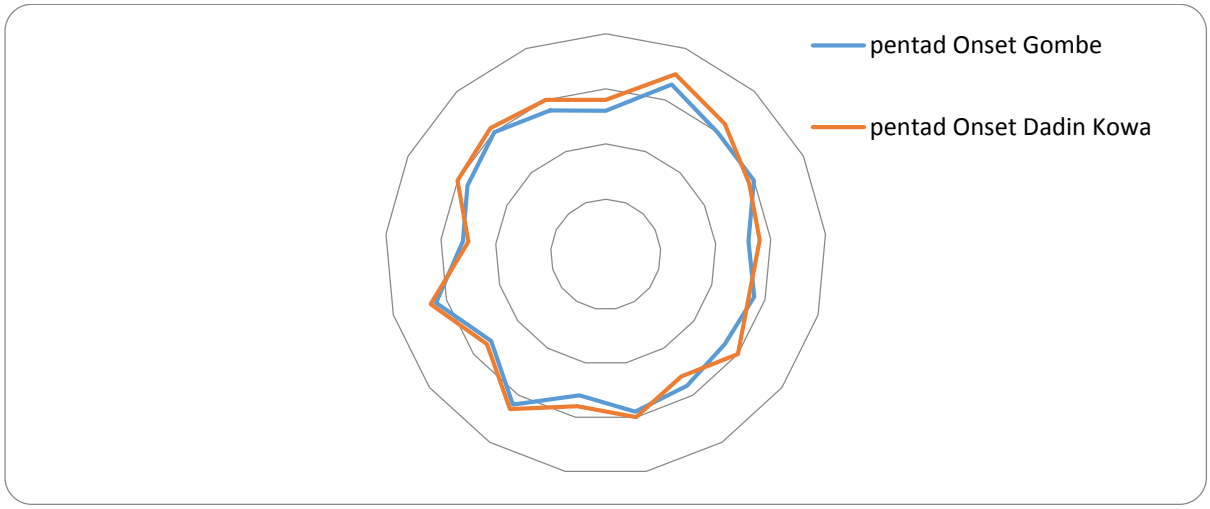

Fig. 4: Comparing Pentads Onset in Gombe and Dadin Kowa between 2001 and 2017

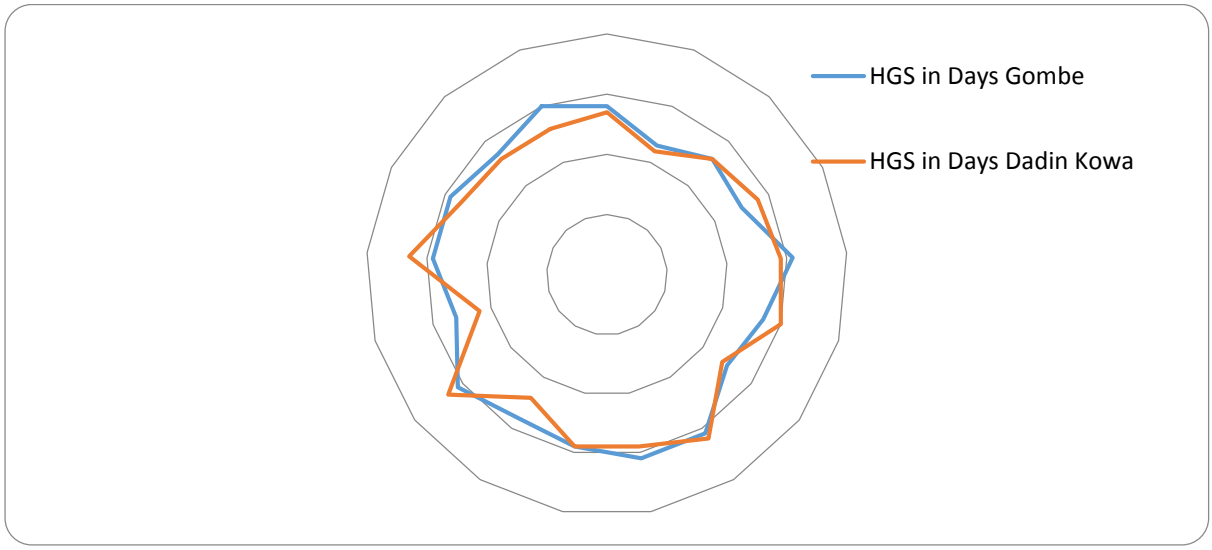

Fig. 5: Comparing Hydrological Growing Seasons in Gombe and Dadin Kowa between 2001 and 2017

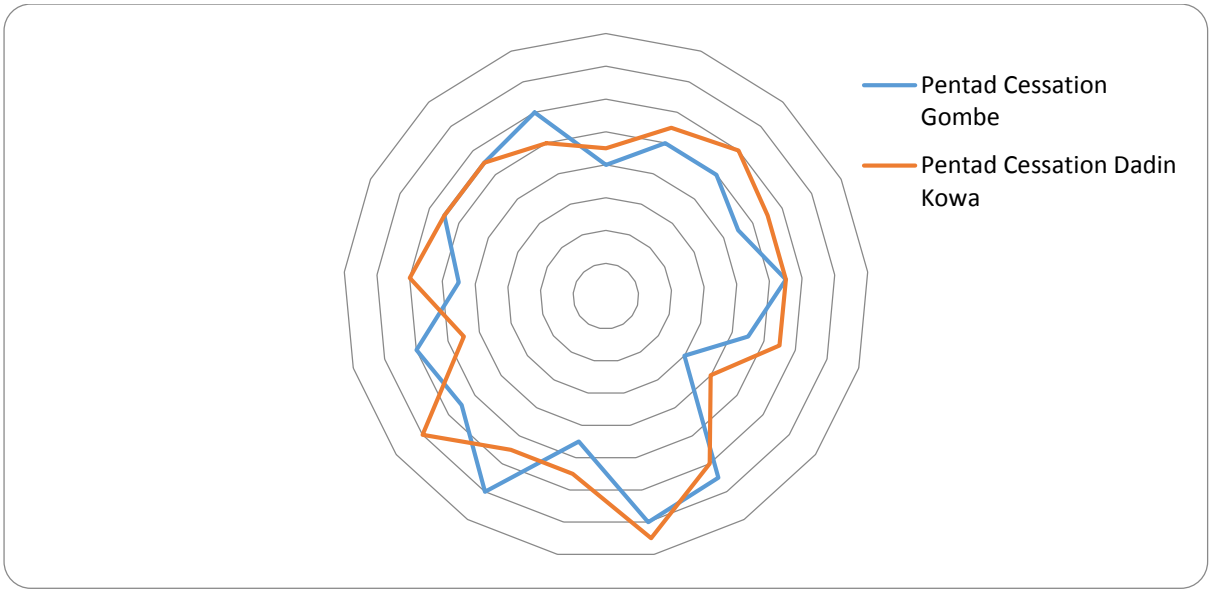

Fig. 6: Comparing Cessation in pentad at Gombe and Dadin Kowa between 2001 and 2017

Appendix I Onsets, Cessation Dates and Hydrological Growing Season in Gombe and Deviations from Mean between 2001 and 2017

Year	Pentad Onset	Onset Dev.	Onset Date	Pentad Cessation	Cessation Dev.	Cessation date	Pentad HGS	HGS Dev.	HGS in Days
2001	26		10th May	54		27th Sept	28		140
2002	33	3	13th June	56	3	7th Oct	23	0	115
2003	30	-4	30th May	56	1	7th Oct	26	5	130
2004	30	-1	30th May	55	1	2nd Oct	25	2	125
2005	26	-1	10th May	57	2	12th Oct	31	3	155
2006	28	3	20th May	55	0	2nd Oct	27	-3	135
2007	27	1	15th May	52	2	17th Sept	25	1	125
2008	28	2	20th May	59	5	22nd Oct	31	3	155
2009	29	1	25th May	60	-2	28th Oct	31	-3	155
2010	26	0	10th May	55	-3	2nd Oct	29	-3	145
2011	32	3	9th June	60	2	28th Oct	28	1	140
2012	26	-3	10th May	57	-3	12th Oct	31	0	155
2013	32	3	9th June	58	0	17th Oct	26	-3	130
2014	26	-3	10th May	55	1	2nd Oct	29	2	145
2015	28	3	20th May	57	2	12th Oct	29	-1	145
2016	30	1	30th May	57	0	12th Oct	27	-1	135
2017	28	-1	20th May	58	0	17th Oct	30	1	150
Mean	**29**	1	**25th May**	**57**	-1	**12th Oct**	**28**	-2	**140**
SD	**2.0**			**2.0**			**2.0**		**10.0**

Source: Field work, 2017

Appendix II Onsets, Cessation Dates and Hydrological Growing Season in Dadin Kowa and Deviation from Mean between 2001 and 2017

Year	Pentad Onset	Onset Dev.	Onset Date	Pentad Cessation	Cessation Dev.	Cessation date	Pentad HGS	HGS Dev.	HGS in Days
2001	28		20th May	55		2nd Oct	27		135
2002	35	2	21st June	57	2	12th Oct	22	1	110
2003	32	-5	9th June	58	0	17th Oct	26	6	130
2004	29	-2	25th May	57	-1	12th Oct	28	2	140
2005	28	1	20th May	57	0	12th Oct	29	0	145
2006	27	2	15th May	57	0	12th Oct	30	-1	150
2007	30	3	30th May	54	0	27th Sept	24	-2	120
2008	26	0	10th May	58	3	17th Oct	32	4	160
2009	30	4	30th May	61	-1	1st Nov	29	-4	145
2010	28	0	20th May	57	-4	12th Oct	29	-1	145
2011	33	2	14th May	57	0	12th Oct	24	-1	120
2012	27	-3	15th May	60	0	28th Oct	33	4	165
2013	33	3	14th June	55	-3	2nd Oct	22	-5	110
2014	25	-3	5th May	58	2	17th Oct	33	6	165
2015	30	5	30th May	57	-1	12th Oct	27	-5	135
2016	31	0	4th June	57	0	12th Oct	26	1	130
2017	30	-1	30th May	56	0	7th Oct	26	2	130
Mean	**30**	0	**30th May**	**57**	1	**12th Oct**	**28**	2	**137**
SD	**3**		**±15**	**2**		**±10**	**±3**		**±15**

Source: Field work, 2017