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ASSESSING THE LENGTH OF GROWING SEASON IN THE SUDAN SAVANNA ECOLOGICAL ZONE OF NIGERIA AS A CHALLENGE TO FOOD SECURITY FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT

Since the inception of the present Government in May 2015, it has been battling with socio-economic problems ranging from economic recession, fall of crude oil prices in the international markets and insecurity challenge, among others. To achieve sustainable development goals, Government focused on agriculture as the best option for tackling such problems. It is against this background that this paper aimed at assessing the length of growing season in the Sudan Savanna Ecological Zone of Nigeria using daily rainfall data recorded at nearby stations from 1981 to 2010. It assessed the level and mean length of growing season in Kano, Katsina, Maiduguri, Potiskum, Gusau and Sokoto, all of which are located within this ecological zone. Data analysis involved the use of descriptive statistics to compute cumulative pentade rainfall and ogive of cumulative pentade rainfall. Using pentade and Julian day calendars, an annual ogive of cumulative pentade rainfall was drawn using Microsoft Excel for each study location and length of growing season determined from 1981 to 2010. Results obtained indicate that mean length of growing season for the study area was approximately 125 days, a duration that is slightly longer than four months. To achieve sustainable development in agriculture, the study recommends that agricultural policies in the study area should take into consideration the rather short mean length of growing season in the study area while exploring effective and feasible water conservation techniques to complement rainwater.

Key words: assessment, growing season length, Sudan savanna, Nigeria

INTRODUCTION

Length of growing season is 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, for each year, by subtracting the date at which the rains start from the date that the rains end (Madeoye, 1986; Zargina, 1987). Oladipo and Kyari (1993) in their study of growing season rainfall of Northern Nigeria indicated that the onset, cessation and length of growing season showed latitudinal progress but with some disruptions due to geographic effect in the central area (Jos). Adefolalu (1993) stated that the length of the growing season is obtained by subtracting the onset pentade from the cessation pentade and multiplying by five. Aliyu (2009) observed a downward trend in the duration (length) of the growing season in some locations in northern Nigeria from 1978 to 2007, with a significant variability in most of the stations north of latitude 9°N in Nigeria. Odekunle (2004) also observed that rainfall during the crop-growing season determines crops germination, establishment and full development. He further defined growing season as period between onset and cessation of the rains.

The length of the growing season (days) for a particular year is considered as the difference between the Julian day number of the determined cessation date and determined onset for that year. Studies conducted in semi-arid parts of West Africa indicated that there is a significant relationship between the start of rains and the length of growing season (Shevakuma, 1988). Thus, earlier onset most often leads to longer length of growing season and late onset shorter length of growing season. This is an indication that the length of growing season is more dependent on rainfall onset than on its cessation (Omotosho, 1992). The length of growing season often determines which crops could grow in an area, as some crops require long growing seasons, while others mature rapidly. Among researchers that have emphasized linkages of the growing season with reliable onset of rains are Dagg (1965), Bello (1996), Olaniran (1984), Ati *et al*. (2002), and Sawa and Ibrahim (2011).

The unreliable knowledge of length of growing season in the Sudan Savanna Ecological Zone of Nigeria often causes a great threat to agricultural productivity. Most a time crops are grown without considering temporal and spatial variations of length of growing season; this practice often leads to poor yields. The aim of this paper was, therefore,

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to assess the length of growing season in Kano, Katsina, Maiduguri, Potiskum, Sokoto and Gusau. The aim was achieved by the following objectives (i) to determine the level of length of growing season from 1981 to 2010 in each study location, and (ii) to assess the mean length of growing season in each study location and the study area in general.

MATERIALS AND METHODS

Study Area

The study area was Sudan Savannah Ecological Zone of Nigeria. It lies between Latitudes 10° and 12° N and Longitudes 4° and 15° 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, Sokoto, Kebbi, and Borno.

Study Locations

Six locations were chosen for this study. They included Kano, Katsina, Maiduguri, Potiskum, Sokoto and Gusau in the Sudan savanna climatic zone. The locations were chosen based on availability of meteorological stations within the zone. These meteorological stations are synoptic stations that have long period of daily rainfall records. They are consistent in location since their establishment; have no significant missing rainfall records and geographically well distributed within the area.

Types of Data Needed

In this type of empirical study, daily rainfall records are required. The analysis covers the growing season – 1st May to 31st October, for this is the period when all the stations in this climatic zone receive about 95% of their total annual rainfall (Anyadike, 1992).

Sources of Data

Daily rainfall data for each of the six locations sourced from the Nigerian Meteorological Agency (NIMET) Oshodi, Lagos. Oshodi was the headquarters of this agency that kept meteorological data for all meteorological stations across Nigeria. The records of rainfall used are shown in Table 1.

Derivation of the Level and Mean Length of Growing Season

Daily rainfall data for the period 1981-2010 for the six locations were sourced from NIMET, Oshodi, Lagos. These data were used to derive the level and mean length of growing season based on onset and cessation dates of rains. A method used by Adefolalu (1993) which was based on relative definition was adopted to derive the level and mean length of growing season in the study area. Using this method, the onset and cessation dates of rains were determined by dividing each year into pentades, making 72 pentades. Using pentade calendar (Table 2), cumulative pentades rainfall was then calculated for each year in the study period 1981-2010. Cumulative pentade rainfall was plotted against the number of pentades giving an ogive for each year in the study area. The points on the pentade axis corresponding to the first and last points of the maximum inflexion on the rainfall ogive correspond to the onset and cessation pentades, respectively. The last date in the onset pentade gives the exact onset date and the first date in the cessation pentade gives the cessation date of the rainy season. The gap between onset and cessation pentades gives the length of growing season.

The derived onset and cessation dates were then converted to Julian days using Julian day calendar and used to obtain the length of growing season of each year in the study period. The Julian day calendar has regular year of 365 days divided by 12 months. A leap year which occurs once every four years adds one day to February. A leap year thus has 366 days including 29 February as an intercalary day. The Julian year is, therefore, on average of 365.25 day long. This method was used in the derivation of length of growing season in the study area. The method utilizes daily rainfall data that makes it more accurate and precise method for determining the length of growing season. The typology of this method at Kano and Katsina in 1981 is presented in Figs. 2 and 3. The data presented in Fig. 2 reveal that the onset pentade falls on pentade 29 and the onset date of rainfall corresponds to 21-May 1981 (Table 2).

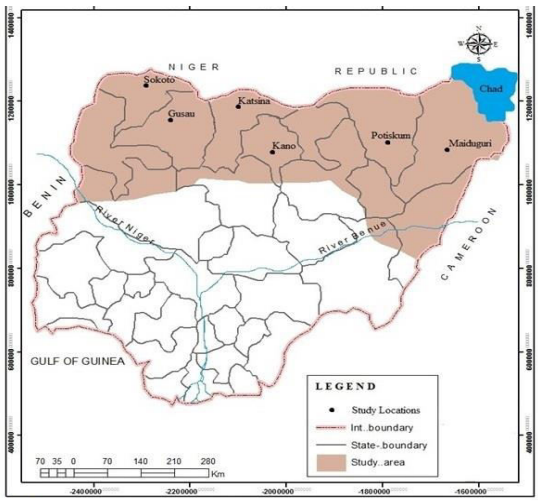

Fig. 1: Study area showing the location of study sites. Source: Les Edition (2006)

Table 1: Rainfall in the study area

Location	Rainfall
Gusau	30 years (1981 to2010)
Kano	30 years (1981 to2010)
Katsina	30 years (1981 to2010)
Maiduguri	30 years (1981 to2010)
Potiskum	30 years (1981 to2010)
Sokoto	30 years (1981 to 2010)

Source: NIMET (2013)

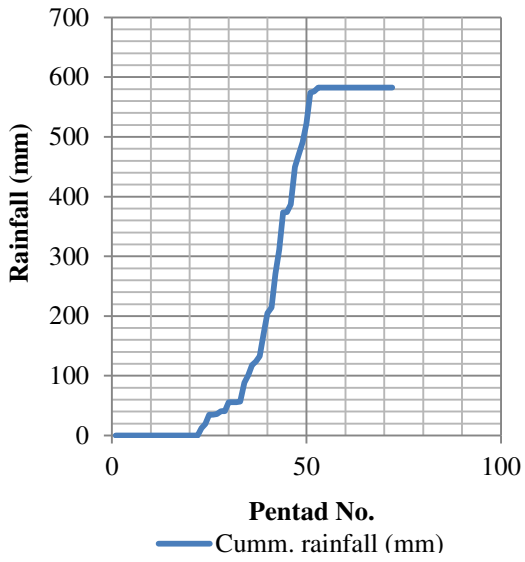

Fig. 2: Ogive of cumulative pentade rainfall at Kano (1981) for determination the level and mean length of growing season

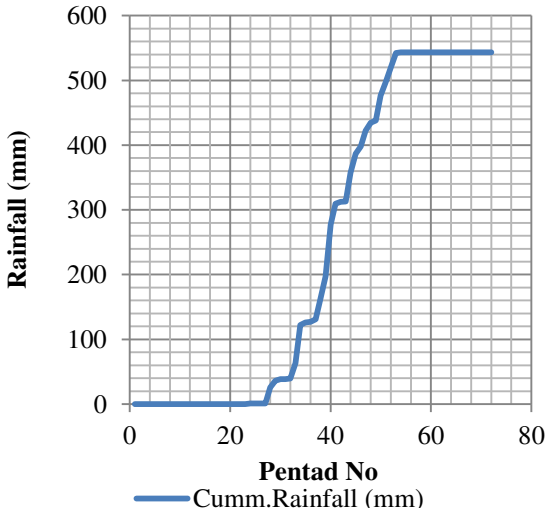

Fig. 3: Ogive of cumulative pentade rainfall at Katsina (1981) for determination of the level and mean of length of growing season

The cessation pentade falls on pentade 53 and the cessation date of rainfall corresponds to 25-September 1981 (Table 2). Using Julian day and pentade calendar, the length of growing season at Kano in 1981 was 156 days (Table 3). Data shown in Fig. 3 indicate that the onset pentade falls on pentade 30 and the onset date of rainfall corresponds to 26-May in 1981 (Table 2). The cessation pentade falls on pentade 53 and the cessation date of rainfall corresponds to 25-September in 1981 (Table 2). Using Julian day and pentade calendar, the length of growing at Katsina in 1981 was 136 days (Table 4). The other onset and cessation dates and length of growing season for the study period in each location were obtained in similar manner using Julian day and pentade calendars.

RESULTS AND DISCUSSION

The Level and Mean Length of Growing Season

Results on the level and mean length of growing season in days for the study locations in the study period from 1981 to 2010 are presented in Tables 3, 4, 5, 6, 7 and 8. It could be observed that both the levels and mean lengths of growing season vary among the study locations.

In Table 3 (Kano station), the mean length of growing season was 133 days. At Katsina (Table 4), the mean length of growing season was 121 days. In Maiduguri, station (Table 5) the mean length of growing season was 120 days. In Table 6 (Potiskum station), the mean length of growing was 121 days. At Sokoto (Table 7), the mean length of growing season was 120 days. At Gusau (Table 8), the mean length of growing season was 133 days. In 1981 the level of length growing season was 156 days at Kano, 136 days at Katsina, 117 days at Maiduguri, 161 days at Potiskum, 130 days at Sokoto and 135 days at Gusau, respectively. Computing the mean length of growing season of the study locations indicates that the mean length of growing season for Sudan Savanna Ecological Zone of Nigeria is approximately 125 days. Data presented in Table 3 reveal variation in the level of length of growing season at Kano in the period of study from 1981 to 2010. The longest length of growing season of 181 days was recorded in 2010 and the shortest of 85 days in 1994. The mean length of growing season for the location was 133 days.

It could be observed from the data presented in Table 4 that the longest length of growing season recorded was in 2009 with 151 days. The shortest length of growing season was in 1993 with 90 days. The mean length of growing season for the study location was 121 days. Data presented in Table 5 indicate that the longest length of growing season was in 2005 with 151 days. The shortest one was in 1986 with 85 days and was the driest year in the period of study. The mean length of growing season for the location was 120 days. It could be observed from the data presented in Table 6 that the longest length of growing season in this location in the study period was 161 days in 1981. The shortest length of growing season occurred in 1993 and 1983 with 70 days and 76 days, respectively. These are the driest years in the period of study. Data presented in Table 7 reveal that the longest length of growing season at Sokoto was in 1997 with 166 days. The shortest length of growing season was in 1996, 1986 and 1992 with 90, 95, and 95 days, respectively. Data presented in Table 8 indicate that the level of length of growing season varied among the years in the study period. For instance, the level of length of growing season was 135 days in 1981, 141 days in 1982, and 151 days in 1991. The longest length of growing in this location was in 2010 with 182 days and the shortest in 1999 with 59 days. The linear distribution of mean length of growing season for the study locations is presented in Fig. 4.

Table 2: Pentade calendar

JANUARY		FEBRUARY		MARCH		APRIL	
Pentade No.	Dates	Pentade No.	Dates	Pentade No.	Dates	Pentade No.	Dates
1	$1^{st} - 5^{th}$	7	$1^{st} - 5^{th}$	13	$1^{st} - 5^{th}$	19	$1^{st} - 5^{th}$
2	$6^{th} - 10^{th}$	8	$6^{th} - 10^{th}$	14	$6^{th} - 10^{th}$	20	$6^{th} - 10^{th}$
3	$11^{th} - 15^{th}$	9	$11^{th} - 15^{th}$	15	$11^{th} - 15^{th}$	21	$11^{th} - 15^{th}$
4	$16^{th} - 20^{th}$	10	$16^{th} - 20^{th}$	16	$16^{th} - 20^{th}$	22	$16^{th} - 20^{th}$
5	$21^{st} - 25^{th}$	11	$21^{st} - 25^{th}$	17	$21^{st} - 25^{th}$	23	$21^{st} - 25^{th}$
6	$26^{th} - 31^{st}$	12	$26^{th} - 28^{th}$	18	$26^{th} - 31^{st}$	24	$26^{th} - 30^{th}$
MAY		JUNE		JULY		AUGUST	
Pentade No.	Dates	Pentade No.	Dates	Pentade No.	Dates	Pentade No.	Dates
25	$1^{st} - 5^{th}$	31	$1^{st} - 5^{th}$	37	$1^{st} - 5^{th}$	43	$1^{st} - 5^{th}$
26	$6^{th} - 10^{th}$	32	$6^{th} - 10^{th}$	38	$6^{th} - 10^{th}$	44	$6^{th} - 10^{th}$
27	$11^{th} - 15^{th}$	33	$11^{th} - 15^{th}$	39	$11^{th} - 15^{th}$	45	$11^{th} - 15^{th}$
28	$16^{th} - 20^{th}$	34	$16^{th} - 20^{th}$	40	$16^{th} - 20^{th}$	46	$16^{th} - 20^{th}$
29	$21^{st} - 25^{th}$	35	$21^{st} - 25^{th}$	41	$21^{st} - 25^{th}$	47	$21^{st} - 25^{th}$
30	$26^{th} - 31^{st}$	36	$26^{th} - 30^{th}$	42	$26^{th} - 31^{st}$	48	$26^{th} - 31^{st}$
SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
Pentade No.	Dates	Pentade No.	Dates	Pentade No.	Dates	Pentade No.	Dates
49	$1^{st} - 5^{th}$	55	$1^{st} - 5^{th}$	61	$1^{st} - 5^{th}$	67	$1^{st} - 5^{th}$
50	$6^{th} - 10^{th}$	56	$6^{th} - 10^{th}$	62	$6^{th} - 10^{th}$	68	$6^{th} - 10^{th}$
51	$11^{th} - 15^{th}$	57	$11^{th} - 15^{th}$	63	$11^{th} - 15^{th}$	69	$11^{th} - 15^{th}$
52	$16^{th} - 20^{th}$	58	$16^{th} - 20^{th}$	64	$16^{th} - 20^{th}$	70	$16^{th} - 20^{th}$
53	$21^{st} - 25^{th}$	59	$21^{st} - 25^{th}$	65	$21^{st} - 25^{th}$	71	$21^{st} - 25^{th}$
54	$26^{th} - 30^{th}$	60	$26^{th} - 31^{st}$	66	$26^{th} - 30^{th}$	72	$26^{th} - 31^{st}$

Table 3: The level and mean length of growing season at Kano from 1981 to 2010

Years	Length of growing season (days)
1981	156
1982	141
1983	116
1984	161
1985	146
1986	110
1987	125
1988	115
1989	110
1990	90
1991	131
1992	131
1993	116
1994	85
1995	131
1996	146
1997	151
1998	156
1999	136
2000	136
2001	115
2002	131
2003	116
2004	136
2005	161
2006	141
2007	161
2008	130
2009	115
2010	181
Mean	133

Source: Data Analysis, 2013

Table 4: The level and mean length of growing season at Katsina from 1981to 2010

Years	Length of growing season (days)
1981	136
1982	130
1983	101
1984	125
1985	136
1986	91
1987	120
1988	120
1989	125
1990	110
1991	146
1992	125
1993	90
1994	110
1995	105
1996	125
1997	130
1998	125
1999	105
2000	130
2001	115
2002	115
2003	141
2004	136
2005	110
2006	110
2007	130
2008	120
2009	151
2010	105
Mean	121

Source: Data Analysis, 2013

The results in Tables 3 to 8 have implications on the basic agrometeorological information needed before planting for necessary pre-sowing activities, such as land preparation, fertilizer and crop species selection in the study locations. Species of drought-tolerant crops should be planted in this ecological zone. This is because each location showed a short mean length of growing season of ca. four months during the period under study. This observation is less by one month compared with that of Anyadike (1992) who reported that all stations in the Sudan climatic zone received ca. 95% of their total annual rainfall in the growing season within 5 months from 1st May to 31st October. This shows that length of growing season differs from total annual rainfall. In Odekunle's (2004) concept, rainfall in the length of growing season determines crop germination, establishment and full development. Therefore, effective and feasible water conservation techniques in the study locations should be explored (Obalum *et al.,* 2011), as such 'saved' water could complement rainfall in crop production in the area.

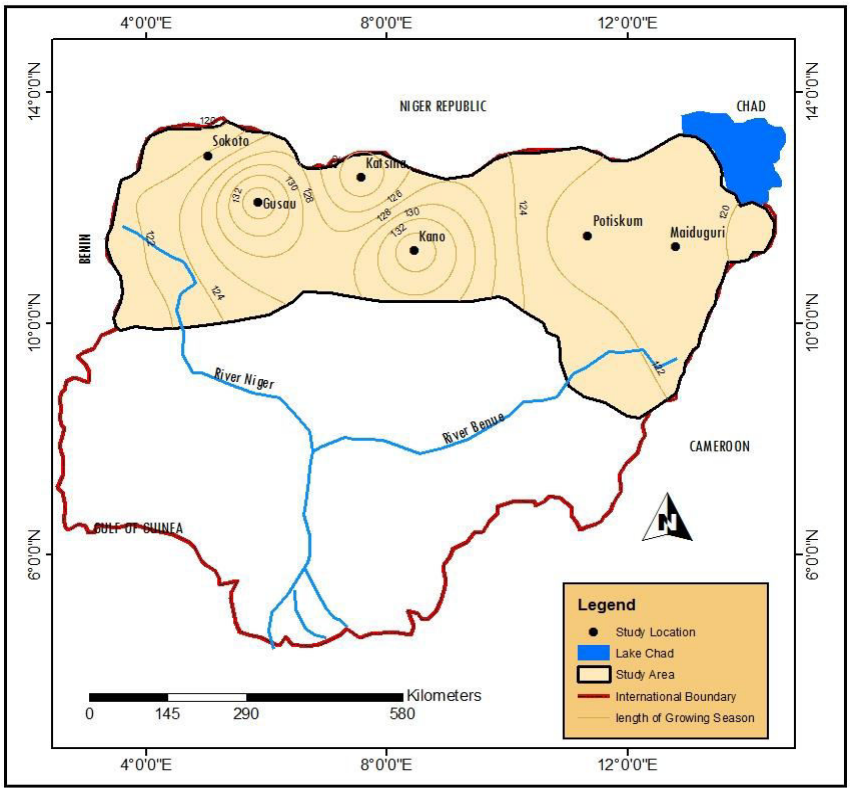

Fig. 4: Linear distribution of mean length of growing season for the study locations

Table 6: the level and mean length of growing season (LGS) at Potiskum from 1981 to 2010

Years	LGS (Days)
1981	161
1982	115
1983	76
1984	105
1985	125
1986	120
1987	125
1988	105
1989	161
1990	105
1991	146
1992	95
1993	70
1994	120
1995	110
1996	151
1997	146
1998	115
1999	115
2000	95
2001	110
2002	115
2003	141
2004	125
2005	135
2006	141
2007	90
2008	156
2009	135
2010	125
Mean	121

Source: Data Analysis, 2013

Table 7: the level and mean length of growing season (LGS) at Sokoto from 1981 to 2010

Years	LGS (Days)
1981	130
1982	115
1983	100
1984	100
1985	100
1986	95
1987	151
1988	110
1989	115
1990	95
1991	135
1992	95
1993	126
1994	105
1995	105
1996	90
1997	166
1998	126
1999	105
2000	146
2001	125
2002	120
2003	146
2004	141
2005	126
2006	120
2007	135
2008	110
2009	110
2010	157
Mean	120

Source: Data Analysis, 2013

Table 8: The level and mean length of growing season (LGS) at Gusau from 1981 to 2010

Years	LGS (Days)
1981	135
1982	141
1983	105
1984	151
1985	135
1986	110
1987	95
1988	130
1989	120
1990	125
1991	151
1992	157
1993	130
1994	151
1995	157
1996	146
1997	115
1998	120
1999	59
2000	157
2001	151
2002	135
2003	141
2004	141
2005	115
2006	120
2007	141
2008	110
2009	177
2010	182
Mean	133

Source: Data Analysis, 2013

The research findings also indicate that the wettest year in the study period was in 2010 at Kano (Table 3), 2009 at Katsina (Table 4), 2005 at Maiduguri (Table 5), 1981 at Potiskum (Table 6), 1997 at Sokoto (Table 7) and 2010 at Gusau (Table 8). These indicate that with exception of Potiskum there was high frequency of wettest year during the last decade of the study period compared with others in the study area. These results were in line with finding of Abaje *et al*. (2013) who also worked in the study area and reported that the area has been experiencing wetter conditions in recent years.

The data in Fig. 4 indicate both increases and decreases in the mean length of growing season from the extreme north to the southern part of the study area. For instance, the mean length of growing season was 120 days at Maiduguri and increased to 121 days at Potiskum. At Sokoto, it was 121 days and increased to 133 days at Gusau. This observation indicates an increase in mean length of growing season from north to south in the study areas. It also indicates spatial variation in the mean length of growing season among the locations. These findings agree with Aliyu (2009) who observed a downward trend in the duration (length) of the growing season in some locations in northern Nigeria from 1978 to 2007, with a significant variability in most of the stations north of latitude 9^0N in Nigeria.

CONCLUSIONS

Sudan Savanna Ecological Zone of Nigeria is a zone characterized by scanty rainfall compared with others ecological zones in the country. The spatio-temporal distribution of rainfall decreases from south to north, so as with the length of growing season. The major finding of this study revealed a rather short mean length of growing season of about four months, which corresponded with scanty rainfall experienced in the zone.

The consequences of this observation are shorter grasses, scattered vegetation and low crop yields in the zone. For sustainable agricultural development in this zone, the study recommends that agricultural policies in the area should take into consideration the rather short length of growing season, by providing early-maturing crop varieties. Also, efforts should be made to harvest and conserve rainwater and water from other sources to support crop production in these areas. Farmers should utilize this finding for proper timing of clearing, tilling, planting, weeding and fertilization as well as harvest to meet the target market. Dams should also be constructed to serve for supplemental irrigation across the locations involved in this study to augment water supply in case of long dry-spells during rainfed agriculture.

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