Available online: www.notulaebiologicae.ro
Print ISSN 2067-3205; Electronic 2067-3264
Not Sci Biol, 2019, 11(2):241-248. DOI: 10.15835/nsb11210314
Original Article

Analysis of Length of Growing Season in Some Agro-ecological Zones Using Non-parametric Trend Test

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Abstract

The ever increasing population and consequently increase in demand for food and the increasing exploitation of the land justifies the need for adequate studies on rainfall as an important factor affecting agricultural production. The date of the onset of rains is an important factor in planning agricultural operations such as land preparation and sowing. The study conducted agro-statistical analysis of rainfall characteristics over three different zones of Nigeria. Daily rainfall data were collected for the period between 1971 and 2005 for 6 stations and were subjected to standard analysis to determine trends and variations in the onset dates, cessation dates, length of rainy season, number of wet days, drought episodes. The results showed that the inter-annual variability of the onset dates is higher than that of cessation dates with a progressive shift in both onset and cessation dates. The length of rainy season varied from 77-291 days in Guinea zone, 77-243 days for Savannah and 73-155 days for the Sahel. Changes in the length of growing season ranged between -9 and -10 for Guinea zone, -21 and 11 days for Savannah zone and -28 and 20 days for the Sahel. Similarly, the numbers of wet days have declined over Nigeria. The information presented in this study are to serve as input for proper land and water resources management for productive agricultural enterprise across the three major agro-ecological zones of Nigeria.

Keywords: analysis; cessation; growing season; length; onset; stations

Introduction

Knowledge of trends and variations of current and historical hydro-climatological variables is pertinent to the future development and sustainable management of water resources of a given region especially within the context of global warming. Water and energy cycles and the increasing demand for water due to population and economic growth (Cannarozzo *et al*., 2006; Oguntunde *et al*., 2006). One of the very important necessities of research into climate change (Houghton *et al*., 1996) is to analyze and detect historical changes in the climatic system. Rainfall is a principle element of the hydrological cycle, so that understanding its behavior maybe profound social and economic significance. The detection of trends and oscillations in precipitation time series yields important information for the understanding of climate. However, the rainfall changes are particularly hard to gauge, because rainfall is not uniform and varies considerably from place to place and time to time, even on small scales. Several studies have been carried out on different temporal scales and in different parts of the globe. Existing analysis of daily series, show for some areas a positive trend in daily precipitation intensity and a tendency toward higher frequencies of heavy and extreme rainfall in the last few decades (Houghton *et al.,* 1996). Many authors analyzed the precipitation pattern in several parts of Europe. For example, Brazdil (1992) described fluctuations of precipitation in Europe using a series of annual areal precipitation sums. Some of the results suggest spatial and temporal non-uniformity in trend exists, which generalize over large areas difficult if not impossible. Significant positive trends have been observed in the USA (Karl *et al*., 1995; Trenberth, 1998; Kunle *et al*., 1999). In Nigeria, with over 70% of the populace engaged in rain-fed agriculture, rainfall is the most important climatic variable. Therefore, the need for continuous rainfall studies cannot be over-emphasized for the purpose of long-term water resources planning and management. Change in climate is a global concern today. Shifts or variations in rainfall in its extent and distributions have direct implication for food supply. For accurate decision-making, information from processed data is required and hence the need to look into all the possible ways of analyzing data generated from the environment.

Received: 18 Oct 2018. Received in revised form: 04 Apr 2019. Accepted: 25 Jun 2019. Published online: 28 Jun 2019.

Materials and Methods

The study area

Nigeria, located in West Africa between latitudes 4-14°N and longitudes 2-15°E, has a total area of about 925,796 km^2. The climate highly varied across its length dominated by the influence of three main wind currents. The ecological zones of the country are broadly grouped into three (Fig. 1), which is Guinea, Savannah and Sahel. The climate varied from semi-arid, through sub humid to humid from the north to the south. Rainfall commences at the beginning of the rainy season around March/April from the coast (in the south), spreads through the middle belt, reaching its peak between July and September, to eventually get to the northern part very much later (Oguntunde *et al*., 2006).

Data source and collection

In order to achieve these objective, Daily rainfall from Enugu, and Ondo states were taken as representative of Guinea Zone, while Daily rainfall from Ilorin and Yola were taken as representative of the savannah zone. The data from Kastina and Sokoto were taken as the representative of the Sahel zone of Nigeria. These six cities were selected based on availability of accurate and reliable data from the Nigerian Meteorological Agency (NIMET).

Data analysis performed on each of the six stations

Onset, cessation and length of growing season

The method propose by the Agrhymet (1996) was used to calculate the onset of rainy season (date) over the city.

Non-parametric trend test

A non-parametric test recommended by the World Meteorological Organization (WMO, 1985) called Mann-Kendall test was used to explore trends in hydro-climatological time series and test for the trends in this study. This test can be applied in cases when the data values *X* of a time series can be assumed to obey the model (Oguntunde *et al*., 2006; Dinpashoh *et al*., 2011):

$$\chi = f(t) + ei \quad (1)$$

Where *f(t)* is a continuous monotonic increasing or decreasing function of time,

Residual ei are assumed to be from the same distribution with zero mean Mann-Kendall test (Salami *et al*., 2002), while the value of statistic S is given as:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}(x_j - x_k) \quad (2)$$

Where n is the length of the time series X_j...... X_n, and Sgn (·) is a sign function, X_j and X_k are values in years j and k, respectively.

The expected value of S equal zero for series without trend and the variance was computed using:

$$\sigma^2(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{q} t_p(t_p-1)(2t_p+5)\right] \quad (3)$$

Where:

q is the number of tied groups,

t_p is the number of data values in pth group.

The test statistic Z is given as:

$$Z = \begin{cases} \frac{S-1}{\sqrt{\sigma^2(S)}} & if \quad S > 0 \\ 0 & if \quad S = 0 \\ \frac{S+1}{\sqrt{\sigma^2(S)}} & if \quad S < 0 \end{cases} \quad (4)$$

The Sen's method is used in cases with linear trend, meaning that;

$f(t)$ in equation (2) is equal to:

$$f(t) = Qt \pm B \quad (5)$$

Where *Q* is the slope and *B* is a constant.

To get the slope estimate *Q* in equation (6) we first calculate the slopes of all data value pairs as:

$$Q_i = \frac{\chi_j - \chi_k}{j - k}$$

where $j > k$.

If there are *n* values x_j in the time series we get as many as $N = n(n-1)/2$ slope estimates Q_i.

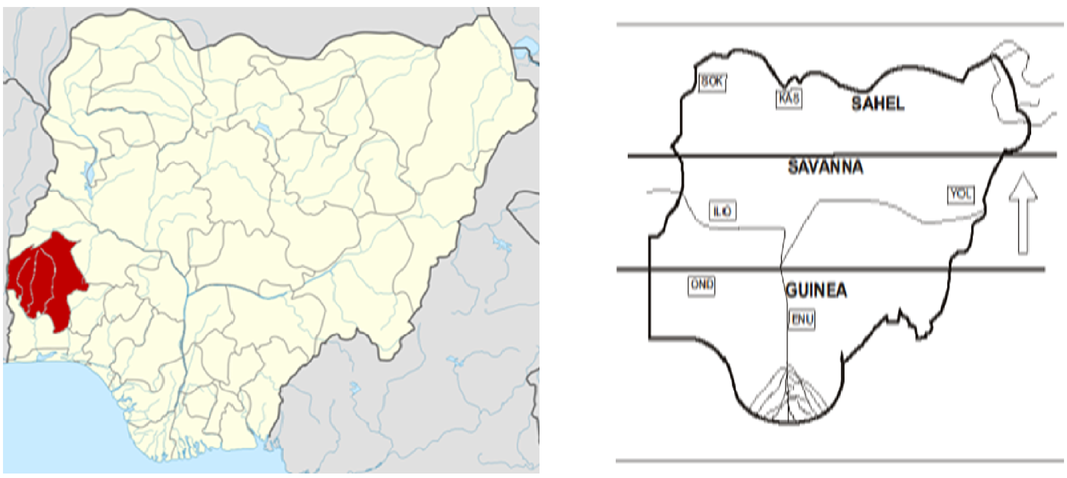

Fig. 1. The ecological zones of Nigeria

The Sen's estimator of slope is the median of these N values of Q_i, thus both trend and slope tests were calculated using MAKESENS 1.0 software.

Results

Summary description of rainfall characteristics for Guinea zone: Enugu and Ondo

The result of onset dates, cessation dates, length of growing season, and number of wet and dry days for Guinea Zone represented by Enugu and Ondo are as presented in Tables 1 and 2. The observation in Table 1 showed that rain generally starts in Enugu by February. The onset of rain at Enugu ranges from 23rd of February (54DOY) to 1st of May (121 DOY) with the earliest cessation date in Enugu was 12th of October (285 DOY) while the latest cessation date was 19th of Nov. (324 DOY). The shortest length of rainy season in Enugu was 77 days while the longest was 215 days as shown in Table 1. The length of rainy season (LGS) in Enugu ranges from 77 days to 215 days and the number of dry days (NDD) in Enugu ranges from 221 days to 290 days while the number of wet days (NWD) ranges from 75 days to 144 days.

For Ondo station, the result of onset dates, cessation dates, length of rainy season and number of wet and dry days in Ondo is as presented in Table 2. The observation showed that rain starts in Ondo by March. The onset of rain in Ondo ranges from 9th of February (68 DOY) to 1st of May (121 DOY) as shown in Table 2, while the earliest cessation date in Ondo was 28th of September (271 DOY) while the latest cessation date was 7th of Dec (341 DOY). Furthermore, the number of dry days (NDD) in Ondo ranges from 257 days to 273 days while the number of wet days (NWD) ranges from 92 days to 108 days.

Summary description of rainfall characteristics for Savanna Zone: Ilorin and Yola

The results of onset dates, cessation dates, length of rainy season and number of wet and dry days for the savanna is as presented in Table 3. Table 3 showed onset of rain in Ilorin station ranges from 14th of March (73 DOY) to 29th of April (120 DOY). The earliest cessation date in Ilorin was 30th of September (273 DOY) while the latest cessation date was 8th of Nov. (313 DOY). Table 3 showed that the shortest length of rainy season at Ilorin was 171 days while the longest was 235 days. Furthermore, the number of dry days (NDD) in Ilorin ranges from 269 days to 298 days while the number of wet days (NWD) ranges from 67 days to 97 days.

For Yola station, the results of onset dates, cessation dates, length of rainy season, and number of wet and dry

Table 1. Onset, cessation, length of growing season (LGS), number of dry days (NDD) and number of wet days (NWD) in Enugu

	Onset		Cessation				
Year	Normal date	Julian date	Normal date	Julian date	LGS	NDD	NWD
1971	21-Mar	80	17-Oct	290	147	256	109
1972	14-Mar	74	27-Oct	301	145	255	110
1973	29-Mar	88	25-Oct	298	145	255	110
1974	2-Apr	92	30-Oct	303	92	229	137
1975	6-Apr	96	17-Nov	321	143	254	111
1976	10-Mar	70	6-Nov	311	87	226	139
1977	13-Apr	103	17-Oct	290	131	248	117
1978	22-Mar	81	5-Nov	309	132	249	117
1979	23-Feb	54	24-Nov	328	81	223	142
1980	21-Apr	112	22-Nov	227	108	237	129
1981	4-Mar	63	31-Oct	304	125	245	120
1982	28-Feb	53	4-Nov	308	144	255	111
1983	1-May	121	12-Oct	285	215	290	75
1984	8-Apr	99	12-Nov	317	155	260	105
1985	12-Mar	71	7-Nov	311	121	243	122
1986	7-Mar	66	4-Nov	308	164	265	101
1987	20-Mar	79	16-Oct	289	165	265	100
1988	5-Mar	65	28-Oct	302	129	247	118
1989	14-Apr	104	31-Oct	304	141	253	112
1990	8-Apr	98	16-Nov	320	120	243	123
1991	14-Mar	73	5-Nov	309	77	221	144
1992	14-Mar	74	6-Nov	311	138	252	114
1993	5-Apr	95	1-Nov	305	129	247	118
1994	2-Apr	92	30-Oct	303	134	250	116
1995	14-Apr	104	6-Nov	310	119	242	123
1996	10-Mar	70	26-Oct	300	135	250	115
1997	11-Mar	70	11-Nov	332	115	240	125
1998	18-Apr	108	30-Oct	303	142	254	112
1999	5-Apr	95	31-Oct	304	119	242	123
2000	24-Mar	86	6-Nov	312	126	249	117
2001	29-Mar	88	16-Oct	289	123	244	121
2002	6-Mar	65	5-Nov	305	112	239	127
2003	11-Apr	101	8-Nov	312	149	257	108
2004	6-Apr	97	19-Nov	324	124	245	121
2005	14-Apr	104	3-Nov	307	133	249	116

Table 2. Onset, cessation, length of growing season (LGS), number of dry days (NDD) and number of wet days (NWD) in Ondo

	Onset		Ceasation				
Year	Normal date	Julian date	Normal date	Julian date	LGS	NDD	NWD
1971	19-Feb	50	7-Dec	341	291	257	108
1972	14-Mar	74	27-Oct	301	227	238	128
1973	14-Mar	73	4-Nov	308	235	247	118
1974	20-Mar	79	3-Nov	307	228	240	125
1975	17-Mar	76	4-Dec	338	262	234	131
1976	26-Feb	57	18-Nov	323	266	235	131
1977	25-Mar	84	26-Oct	299	215	245	120
1978	19-Mar	78	3-Nov	307	229	219	146
1979	14-Mar	73	3-Nov	334	261	208	157
1980	20-Feb	51	3-Dec	338	287	232	134
1981	9-Mar	68	10-Nov	314	246	242	123
1982	24-Feb	55	19-Nov	323	268	251	114
1983	1-May	121	13-Nov	317	196	273	92
1984	1-Mar	61	30-Oct	303	242	242	92
1985	27-Feb	58	31-Oct	304	246	273	92
1986	22-Feb	53	1-Nov	305	252	255	110
1987	7-Mar	66	25-Oct	298	232	244	121
1988	5-Mar	65	2-Nov	307	242	240	126
1989	21-Mar	80	1-Nov	305	225	249	116
1990	1-Apr	91	9-Nov	313	222	250	115
1991	22-Feb	53	30-Oct	303	250	233	132
1992	17-Mar	77	9-Nov	314	237	241	125
1993	14-Feb	45	10-Nov	314	269	233	132
1994	18-Feb	49	17-Nov	321	272	261	104
1995	9-Feb	40	6-Nov	310	270	237	128
1996	10-Feb	41	27-Oct	301	260	233	133
1997	1-Apr	91	31-Oct	304	213	245	120
1998	2-Apr	92	23-Nov	327	235	253	112
1999	2-Mar	61	10-Nov	314	253	242	123
2000	24-Mar	84	6-Nov	311	227	249	117
2001	4-Mar	63	12-Nov	316	253	246	119
2002	9-Mar	68	28-Sep	271	203	261	104
2003	18-Mar	77	14-Nov	318	241	244	121
2004	25-Mar	85	18-Nov	323	238	247	119
2005	12-Mar	71	2-Nov	306	235	249	116

days for the savanna zone were as presented in Table 4. The onset of rain in Yola ranges from 6th of April (96 DOY) to 27th of May (127 DOY) are shown in Table 4. However, the earliest cessation date in Yola was 6th of October (280 DOY) while the latest cessation date was 12th of Nov. (316 DOY). Table 4 also showed that the shortest length of rainy season at Yola was 77 days while the longest was 243 days. Furthermore, the number of dry days (NDD) in Yola ranges from 221 days to 304 days while the number of wet days (NWD) ranges from 64 days to 144 days.

Summary description of rainfall characteristics for Sahel zone: Sokoto and Kastina

The results of onset dates, cessation dates, length of rainy season, and number of wet and dry days for the savanna zone were as presented in Table 5. The observation showed the onset of rain in Sokoto station ranges from 2nd of May (122 DOY) to 24th of June (175 DOY). The earliest cessation date in Sokoto was 9th of September (252 DOY) while the latest cessation date was13th of October (287 DOY). Table 5 showed that the shortest length of rainy season at Sokoto was 73 days while the longest was 155 days. Furthermore, the number of dry days (NDD) in Sokoto ranges from 306 days to 336 days while the number of wet days (NWD) ranges from 30 days to 59 days.

For Kastina station, the results of onset dates, cessation dates, length of rainy season, and number of wet and dry days for the savanna zone were as presented in Table 6. The observation showed the earliest onset date in Katsina was on 21st of April (111 DOY) while the latest was 24th of June (176 DOY). The result further shows that the cessation of rain at Katsina was by September. The earliest cessation date in Katsina was 10th of September (253 DOY) while the latest cessation date was 27th of October (300 DOY). Table 6 showed that the shortest length of rainy season at Katsina was 87 days while the longest was 153 days. Furthermore, the number of dry days (NDD) in Katsina ranges from 314 days to 325 days while the number of wet days (NWD) ranges from 40 days to 51 days.

Discussion

The date of the onset of rain is an important factor in planning agricultural and operations such as land preparation and sowing. From the analysis of the rainfall date for these six stations, it can be deduced that trends in rainfall characteristics varied across the six stations and a significant change in the four northern stations studied in Nigeria. In a related study in the Volta basin of Ghana, Oguntunde *et al*. (2006) reported that higher spatial variability than the temporal annual variations. Similar to the findings of this study, Ajayi (1998) analyzed rainfall data for Onne and Ibadan in Nigeria and concluded that there a reduction in the number of rainy days. Thus, the results obtained from this study partly agrees with the previous findings of Ajayi (1998), Hess *et al.* (1998) Oguntunde *et al.* (2006) and Oguntunde *et al*. (2011).

Table 3. Onset, cessation, length of growing season (LGS), number of dry days (NDD) and number of wet days (NWD) in Ilorin

	Onset		Ceseasion				
Year	Normal date	Julian date	Normal date	Julian date	LGS	302	NWD
1971	29-Mar	88	18-Oct	291	203	275	90
1972	7-Apr	98	14-Oct	288	190	266	100
1973	21-Apr	111	31-OC	304	193	259	106
1974	15-Apr	105	29-Oct	302	197	273	92
1975	23-Mar	82	27-Oct	300	218	266	99
1976	18-Mar	78	8-Nov	313	235	269	97
1977	22-Apr	112	19-Oct	292	180	290	75
1978	4-Apr	94	5-Nov	309	215	275	90
1979	21-Mar	80	4-Nov	308	228	267	98
1980	17-Apr	108	27-Oct	301	193	273	93
1981	18-Apr	108	26-Oct	299	191	277	88
1982	8-Apr	98	31-Oct	304	206	274	91
1983	2-Apr	92	12-Oct	285	193	296	69
1984	17-Mar	77	21-Oct	295	218	270	96
1985	24-Mar	83	16-Oct	289	206	271	94
1986	16-Mar	75	5-Nov	308	233	284	81
1987	14-Mar	73	20-Oct	293	220	268	97
1988	9-Apr	100	11-Oct	285	185	295	71
1989	14-Apr	104	17-Oct	290	186	288	77
1990	13-Apr	103	1-Nov	305	202	269	96
1991	9-Apr	99	21-Oct	294	195	267	98
1992	4-Apr	95	31-Oct	305	210	292	74
1993	26-Apr	116	26-Oct	299	183	266	99
1994	1-Apr	91	29-Oct	302	211	271	94
1995	16-Apr	106	8-Nov	312	206	269	96
1996	29-Apr	120	17-Oct	291	171	286	80
1997	11-Apr	101	29-Oct	302	201	280	85
1998	12-Apr	102	30-Sep	273	171	299	66
1999	14-Apr	104	26-Oct	299	195	259	106
2000	26-Mar	86	11-Oct	285	199	282	84
2001	24-Apr	114	9-Oct	282	168	298	67
2002	14-Apr	104	18-Oct	291	187	275	90
2003	5-Apr	95	30-Sep	273	178	294	71
2004	22-Apr	113	31-Oct	305	192	282	84
2005	14-Apr	104	20-Oct	293	189	285	80

Table 4. Onset, cessation, length of growing season (LGS), number of dry days (NDD) and number of wet days (NWD) in Yola

	Onset		Ceseasion				
Year	Normal date	Julian date	Normal date	Julian date	LGS	NDD	NWD
1971	14-May	134	16-Oct	289	139	252	113
1972	26-May	147	14-Oct	288	134	250	116
1973	16-May	136	9-Oct	282	145	255	110
1974	16-May	136	21-Oct	294	91	228	137
1975	21-Apr	111	24-Oct	297	143	254	111
1976	18-May	139	7-Nov	312	88	227	139
1977	5-May	125	20-Oct	293	131	248	117
1978	6-Apr	96	28-Oct	301	131	248	117
1979	2-May	122	12-Nov	316	81	223	142
1980	25-Apr	116	29-Oct	303	108	237	129
1981	23-Apr	113	23-Oct	296	125	245	120
1982	27-May	137	12-Oct	285	143	254	111
1983	25-May	125	12-Oct	285	215	290	75
1984	22-Apr	113	25-Oct	295	156	261	105
1985	12-May	132	27-Oct	300	121	243	122
1986	18-May	138	18-Oct	291	163	264	101
1987	27-May	147	16-Oct	289	165	265	100
1988	18-May	139	28-Oct	302	130	248	118

1989	1-May	120	11-Oct	285	141	253	112
1990	29-Apr	119	12-Nov	316	119	242	123
1991	1-May	121	29-Oct	302	77	221	144
1992	12-May	133	4-Nov	309	138	252	114
1993	26-Apr	116	21-Oct	294	129	247	118
1994	27-Apr	117	28-Oct	301	133	249	116
1995	2-May	122	31-Oct	304	119	242	123
1996	9-May	130	21-Oct	295	136	251	115
1997	14-Apr	104	28-Oct	301	115	240	125
1998	18-Apr	108	16-Oct	289	141	253	112
1999	6-May	126	29-Oct	302	119	242	123
2000	15-May	136	9-Oct	283	124	245	121
2001	9-May	129	15-Oct	288	223	294	71
2002	10-May	130	23-Oct	296	223	294	71
2003	22-May	142	14-Oct	287	223	294	71
2004	21-Apr	112	6-Oct	280	218	292	74
2005	30-Apr	120	19-Oct	292	243	304	61

Table 5. Onset, cessation, length of growing season (LGS), number of dry days (NDD) and number of wet days (NWD) in Sokoto

	Onset		Ceseasion				
Year	Normal date	Julian date	Normal date	Julian date	LGS	NDD	NWD
1971	15-May	135	19-Sep	262	127	329	36
1972	6-May	127	25-Sep	269	142	327	39
1973	9-Jun	160	9-Sep	252	92	325	40
1974	4-Jun	185	1-Oct	274	89	313	52
1975	15-May	135	15-Sep	258	123	318	47
1976	26-May	147	19-Oct	293	146	313	53
1977	28-May	148	28-Sep	271	123	316	49
1978	3-Jun	154	23-Sep	266	112	321	44
1979	26-May	146	29-Sep	272	126	320	45
1980	23-May	144	26-Sep	270	126	325	41
1981	16-May	136	19-Sep	252	116	324	41
1982	10-Jun	161	23-Sep	266	105	332	33
1983	15-Jun	166	16-Sep	259	93	334	31
1984	12-Jun	164	29-Sep	273	109	336	30
1985	25-May	145	27-Sep	270	125	328	37
1986	24-Jun	175	22-Sep	265	90	335	30
1987	14-Jun	165	8-Oct	281	116	332	33
1988	1-Jun	153	23-Sep	267	114	323	43
1989	14-Jun	165	2-Oct	275	110	313	52
1990	18-May	138	13-Sep	256	118	318	47
1991	13-May	133	3-Oct	276	143	306	59
1992	22-May	143	15-Sep	259	116	324	42
1993	9-Jun	160	28-Sep	271	111	325	40
1994	12-Jun	163	19-Sep	252	89	316	49
1995	15-Jun	196	26-Sep	269	73	316	49
1996	16-May	137	15-Sep	259	122	321	45
1997	2-May	122	17-Sep	260	138	316	49
1998	1-Jun	152	20-Sep	263	111	312	53
1999	16-May	136	25-Sep	268	132	308	57
2000	2-Jun	154	20-Oct	294	140	323	43
2001	26-May	146	13-Sep	256	110	322	43
2002	3-May	124	6-Oct	279	155	314	51
2003	29-May	149	19-Sep	252	103	319	46
2004	14-May	135	19-May	263	128	320	46
2005	30-May	150	24-Sep	267	117	315	50

Table 6. Onset, cessation, length of growing season (LGS), number of dry days (NDD) and number of wet days (NWD) in Katsina

	Onset		Ceseasion				
Year	Normal date	Julian date	Normal date	Julian date	LGS	NDD	NWD
1971	10-May	130	22-Sep	265	135	333	32
1972	28-May	149	30-Sep	274	125	333	33
1973	4-Jun	155	3-Oct	276	121	329	36
1974	5-May	125	2-Oct	275	150	310	55
1975	12-May	132	15-Sep	258	126	314	51
1976	10-Jun	162	23-Oct	297	135	313	53
1977	5-Jun	156	28-Sep	271	115	318	47
1978	31-May	151	27-Oct	300	149	312	53
1979	1-Jun	152	30-Sep	273	121	317	48
1980	3-May	124	3-Oct	277	153	316	50
1981	17-May	137	27-Sep	270	133	314	51
1982	23-May	143	10-Oct	283	140	322	43
1983	14-Jun	165	20-Sep	263	98	327	38
1984	26-May	147	11-Oct	285	138	327	39
1985	16-Jun	167	28-Sep	271	104	330	35
1986	24-Jun	175	29-Sep	272	97	329	36
1987	28-May	148	25-Sep	268	120	327	38
1988	3-Jun	155	22-Sep	266	111	310	56
1989	5-Jun	156	5-Oct	278	122	313	52
1990	15-May	135	10-Sep	253	118	325	40
1991	11-May	133	3-Oct	276	143	327	38
1992	24-Jun	176	19-Sep	263	87	324	42
1993	2-Jun	153	23-Sep	266	113	322	43
1994	28-May	148	22-Oct	295	147	330	35
1995	8-Jun	159	7-Oct	280	121	315	50
1996	22-May	143	30-Sep	274	131	320	46
1997	23-May	148	14-Oct	287	139	329	36
1998	28-May	169	26-Sep	269	100	308	57
1999	18-Jun	169	26-Sep	269	100	322	44
2000	5-Jun	157	9-Oct	283	126	342	23
2001	21-Apr	111	19-Sep	262	151	315	50
2002	4-Jun	155	10-Oct	283	128	319	46
2003	26-May	146	13-Oct	286	140	310	56
2004	17-May	138	30-Sep	274	136	313	52
2005	27-May	147	1-Oct	274	127	318	47

Conclusions

The importance of adequate analysis of climatological data cannot be overemphasized. It helps in making vital decision relevant to agricultural practices. The study analyzed long-term rainfall data to determine the length of growing season in three agricultural zones (Guinea, Savannah, and Shael zones) of Nigeria. The results showed that there were variations in the rainfall changes as well as the onset and cessation dates over the stations. At Ilorin, there was significant reduction in the length of growing season and the number of wet days. Peradventure the shortened length of growing season was consequent upon the reduction in the number of wet days as well as the cessation of rain. Likewise, there was significant reduction in the length of growing season and the number of wet days in Katsina. However, at Ondo and Enugu stations, a slight delay in onset of rain as well as reduction in the number of wet days were observed, which though not statistically significant, but might unanimously be responsible for the reduction in the length of growing season. For agricultural purpose, the date of the onset of rain is more important than the cessation date since the major problem facing farmers is when to start tilling and planting. Since the study deduced that length of growing season is reducing over the years, therefore early maturing crops are needed to remedy the situation. Thus the methodology adopted in this study are useful for making maps needed for decision making at the farm and regional level and with data generated as baseline information can be used for agro-climatic mapping. Thus, the methodology used in this study can be adopted for other ecological zones the in assessment and mapping for crop zonation and land use planning.

Conflicts of interest

The authors declare that there are no conflicts of interest related to this article.

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