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A Note on Dry Season Rainstorm Characteristics (1952 – 1982) over Ibadan, Nigeria

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Abstract

This study is an attempt to investigate the variabilities in the dry season rainstorm characteristics in Ibadan. Daily rainstorms data, particularly rainstorm events, duration and rainfall amount recorded in Ibadan during dry season between 1952 and 1982 were collected. Data collected were aggregated on monthly, annual and seasonal bases. Data were analyzed using descriptive statistics, paired sample t-test, and correlation analysis, at $p \leq 0.05$. The results among others showed that 295 rainstorms were recorded during dry season, with an average duration of 1 hour and close to 95% lasted less than two hours. The rains that accompanied the dry season rainstorms in Ibadan varied a great deal. Rainfall decreases from 125.8 mm (1976) to 12.8 mm (1982). About 9.7% of rainstorms gave less than 30 mm of rainfall; 74.2% yielded rainfall amounts of between 31.0 and 90.0 mm. Over 12% of the rainfalls were between 91.0 mm and 120 mm. Only about 3.2% of the rainfall was greater than 120 mm during dry season rainstorm events. There was significant difference between mean duration and rainfall amount ($p=0.000$). There was a relationship between rainstorm characteristics. In fact, the correlation coefficient produced between the rainstorm events, duration and rainfall amount showed that, duration (-.041) and rainfall amount (-.557) relatedinversely with the incidence of rainstorms. The correlation statistics further revealed that there was significant correlation between the duration and rainfall amount (.027).The results could serve as the backbone for urban, agricultural and disaster planning, all of which help to sustain man's livelihood.

Keywords: Daily Rainfall, Dry Season, Rainstorm Characteristics, Rainstorm duration, Rainfall Amount, Ibadan.

1. BACKGROUND

Rainstorm is the dominant form of precipitation in the tropics. Rainstorm is a highly localised and largely stationary weather system affecting a limited area of about 20-50 km², depending on the size of the cumulus tower. It is short lived with a lifetime of 1-2 hours (Friesen, 2002).The prevalence of rainstorm on any part of the tropical region varies both spatially and temporally. This is largely due to the fact that the earth is spherical and is constantly in motion. The parameters that determine the extent of precipitation are determined by the general circulation of the atmosphere, topography, etc. In the tropics, between latitudes 35^0N and 35^0S of the equator, there are alternating wet and dry seasons. Rainstorm is prevalent during the wet season (Friesen, 2002).

In Nigeria, wet and dry seasons are experienced with a dry season from mid-November to early-March, and wet season from early-March to mid-November. However, even within the country there are variations in the distribution of rainfall. The duration of the wet season reduces from the South to the North and from the West to the East. This is all largely due to the increase in distance from the coastline, and the position of the Inter-tropical Convergence Zone (ITCZ).The ITCZ is the zone at which the dry Northeast trade winds from over the Sahara meet with the moist Southwest monsoon trade winds from over the Atlantic. The latter is responsible for the wet conditions that induce rainfall. When the ITCZ is located in the South by January, dry conditions are mostly prevalent over the country, while when it is located in the North by July, mostly wet conditions prevail over the country (Adejokun 1978; Adedokun, 1985). While it does not retreat equator-ward beyond 4^0N latitude during the 'Harmattan 'dry season (Adefolalu, 1983). Five weather zones are associated with the ITD (Figure 1).Zone A to the north of the ITD is rainless as well as Zone B to the immediate south because they do not contain rain-producing clouds. Rainfall in the ITD occurs in Zone C and D where conditions favour the development of clouds of great vertical extent. Thunderstorms and squall lines are associated with Zones C weather and monsoon rains with Zone D weather.

Consequently, rainfall is spatially discontinuous when Zone C weather prevails. On the other hand, the monsoon system gives continuous rains which may last 12 hours or more (Olaniran, 1995). Overall, rainfall occurs at a distance of about 500 km south of the surface location of the ITD, 4–6 weeks behind it in its annual cycle. When the fifth weather type associated with the ITD i.e. Zone E, prevails over an area, light rainfall usually results because Zone E weather is dominated by layered stratiform clouds. The position of the ITD fluctuates seasonally and the different ITD zones affect different areas of the country at various times (Figure 1). Between January/February and August, the ITD migrates northward and there is a corresponding shift northward of the area of rainfall activity, and from the end of August when the ITD begins its north – south retreat, the zones of rainfall activity similarly shift southward. In July – August, when the ITD is at its most northerly position, Zone E weather migrates a short distance inland causing a period of reduced rainfall in the coaster area, a phenomenon known as the 'little dry season' or the 'July/August break'(Ojo, 1977).

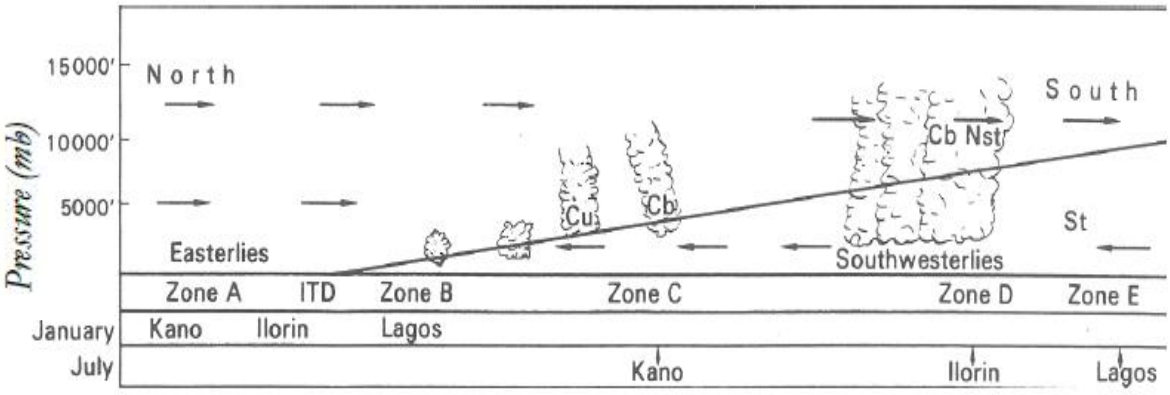

Figure 1: The I.T.D and the Weather Zones in an Idealized Atmospheric Cross-Section fromSouth to North over Nigeria
Source: (Ojo, 1977)

During this period the southwesterlies become deflected into westerlies which bring little or no rain. This causes rainfall to increase eastward over southern Nigeria during the July – August period (Olaniran, 1988a, b, Adediran, 2020). This explains why the onset of the rains over the country is more gradual than the retreat. Hence, the migration of the ITD, and its influence on the distribution of the dry continental air and the moist maritime air is fundamental to the understanding of West African climates.

The account of the rainfall – producing systems presented above for Nigeria, depicts rainfall activity over the country as a function of the migration pattern of the ITD (Ayoade, 1970; Kowal and Knabe, 1972; Olaniran, 1995; 1988 a; 1988 b; Sekoni, 1992 and Adediran, 2017; 2020). Accordingly, droughts in Nigeria, and indeed over West Africa, are associated with a restricted northward advance of the ITD. On the other hand, wet years result from a considerable northward advance of the ITD. Different from this simplistic picture, the ITD itself is erratic in its south–north retreat. It moves in a series of surges, retreats and stagnations. Data presented by Walter (1967) showed that along longitude 3^0E in that year the ITD advanced up to 11^0N latitude in January but retreated southward to 6^0N latitude in normally experienced, although in occasional years there may be brief spells of the steady monsoonal rain of zone E. In other words, practically all the rainfall in the southern parts of the country is due to the isolated rainstorms, disturbance lines and monsoon rain. The former are experienced in the south only at the beginning and at the end of the February i.e. the following month, a retreat of 500 km. Oguntoyinbo and Richards
(1977) also reported a similar situation for southern Nigeria during 1972/73. Such irregular movements of the ITD have implications for the location of the area of rainfall activity over the country. Often, they cause a false start of the rainy season i.e. early onset of rainfall at a location which is subsequently followed by a prolonged dry spell. The position of the ITD in Nigeria is very important, not because there is any particular weather activity at this boundary, but because it serves as a reference line for the normal weather system and structure associated with the two-dimensional boundary between the Harmattan and the Monsoon (Clarckson,1957). Figure 1 shows a cross section of the atmosphere along the longitude of Ibadan in August when the ITD is usually at its northernmost position. It is clear from the diagram that the weather types of zones B, C, and D are only experienced in the southern parts of the country. In the latitude of Ibadan, only three of the five weather types are rainy season whereas the latter are experienced in the south at the peak of the rainy season.

In general, several authors have worked on rainfall pattern such as rainfall intensity, duration and amount, and their implications on human welfare (Walter, 1967; Ayoade,1970; Jackson, 1977;

Walsh and Lawler, 1981; Oguntoyinbo, 1982; Oguntoyinbo and Akintola, 1983, Ayoade and Akintola, 1986; Sumner, 1988; Sekoni, 1992; Adefolalu, 2001; Indrani, 2009; Kundzewicz, 2012; Ayoade, 2012; Audu et al., 2013; Keggenhoff et al., 2014; Zhihe et al., 2015; Ivana et al., 2016 and Adediran, 2017; 2020). However, none of these studies considered the variabilities of dry season rainstorm. Rainstorm is a natural factor in the rainforest zone of tropical West Africa with its distinct dry season from November to February. Rainstorms during the dry season can have substantial impacts on the local hydrology and human activities reaching from the rotting of harvests to improved grazing conditions. Hence, the need for a detailed understanding of the dynamics of dry season rainstorm characteristics – number of rainstorms, rainstorm duration and rainfall amount, formed the basis for this study. An in-depth understanding of the tendencies and variabilities of these characteristics of rainstorms could serve as the backbone for urban, agricultural and even disaster planning, all of which help to sustain and improve man's livelihood for success in any of his endeavours. This paper is aimed at investigating the variabilities of dry season rainstorm characteristics over Ibadan, between 1952 and 1982.

1.2 MATERIALS AND METHODS

1.2.1 The Study Area

Ibadan (7° 15 and 7° 30 N, 3° 50 and 4° 00 E)(Figure 2) has a tropical grassland of Savanna climate (Koppen's Aw) with distinct wet and dry seasons. The onset of the wet season is estimated at 15 March within a two week variation period and 15 November as the tentative end of the wet season with the same level of variation (Oguntoyinbo and Akintola, 1983; Ayode, 2012, Adediran, 2017; 2019; 2020). The area also experiences the double maxima rainfall regime with the characteristic break in August known as the "little dry season" (Ayoade and Akintola,1986; Ayoade, 2012; Adediran, 2017; 2019;2020). The mean annual rainfall over the study area is about 1500 mm. The mean monthly temperature is about 27°C. Hottest months coincide roughly with the movement of overhead sun. The first hottest months occur between March-April, while the second is between November-December (Ayoade and Akintola, 1986).The climate can also be described as dry humid using Thornthwaite's moisture index. The dry seasons are associated with the prevalence the dry continental northeasterly Harmattan from the Sahara desert (Garnier, 1967; Ayoade, 1974; Sekoni,1992 and Adediran, 2017; 2019; 2020). The fluctuating boundary zone between these two air masses has been called various names of which the Inter-tropical Discontinuity (ITD) appears to be the least ambiguous. As in other parts of Nigeria, the sequence of weather types experienced in Ibadan during a given year is determined largely by its location relative to the fluctuating surface position of the ITD (Garnier, 1967; Ayoade, 1974; Sekoni, 1992 and Adediran, 2017; 2019; 2020).

For a better understanding of seasonal variation, the twelve months of the year were grouped into three distinct classes based on the seasons we experience in Nigeria Ayoade and Akintola, (1986). These three groups are as follows: the dry season months, comprising January, February, November and December when the dry season is at its peak; the early and late rainy season

months, comprising March, April, September and October which represent the onset and ending of the rainy season, and the rainy season months, comprising May, June, July and August when the rainy season is fully established. The onset of the dry season is about the start of November to February each year. More than 10% of annual rainfall is received during dry season (Ayoade and Akintola, 1986).

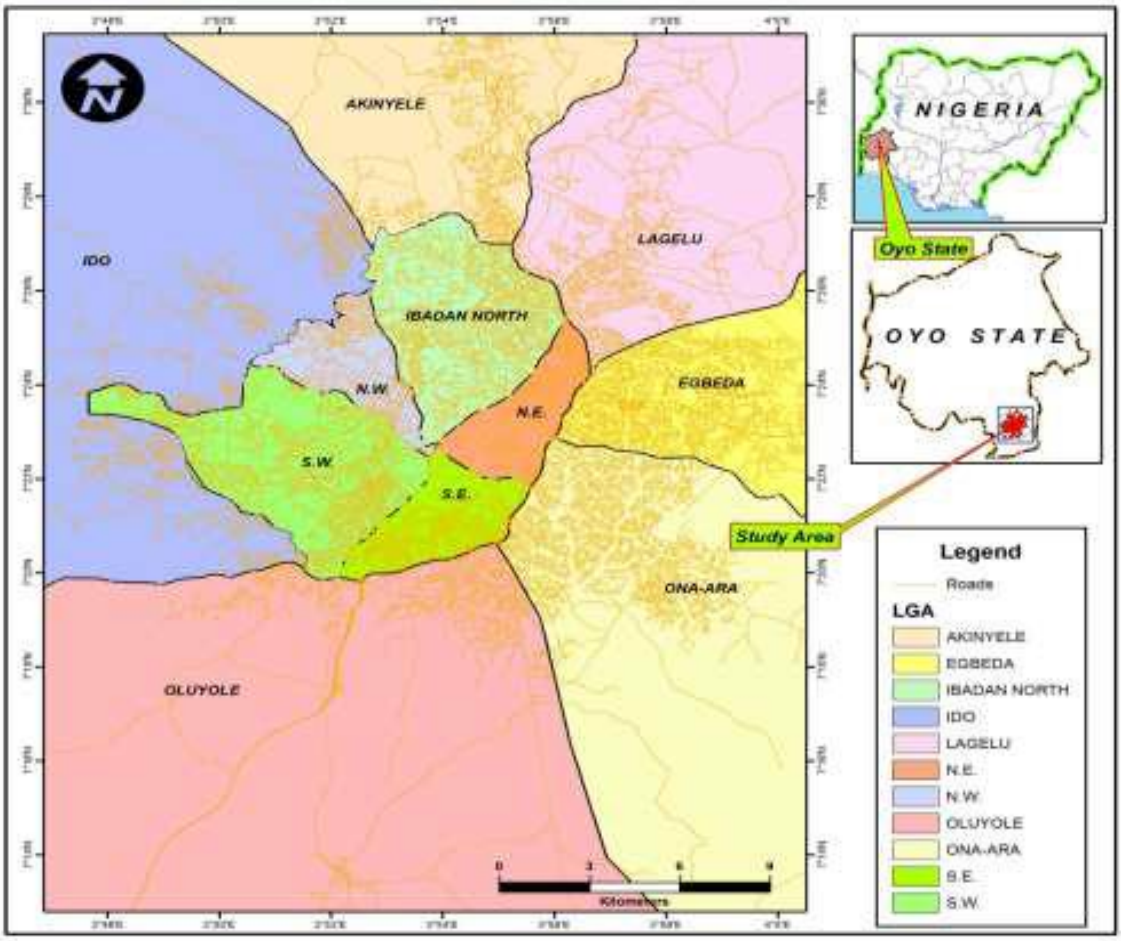

Figure 2: The Study Area
Source: Shuttle Radar Topographical Mapping (2013)

1.3 DATA BASE AND ANALYSIS

The data used for this study was extracted from daily autographic rainfall charts kept by the Department of Geography, University of Ibadan, Ibadan. Daily rainfall data were processed for one autographic rain gauge stations over a 31 year period (1952 to 1982). The duration and rainfall amount are expressed in minutes (min) and millimetre (mm), respectively (Ayoade, 2008and Adediran, 2017; 2019; 2020). The data collected for the period of the study were screened, aggregated, and analysed using descriptive and inferential statistics such as frequency (%), mean, standard deviation, paired samples t-test statistics, correlation analysis, at $p \leq 0.05$. The monthly mean and total annual rainfall values were computed for the period under study

from daily data. Statistical analysis such as summation and averaging were carried out on the data. The annual rainfall amount was computed for the location using equations 1.

$$A_R = \sum_{i=1}^{12} Ri \quad \ldots\ldots 1$$

where; R is the monthly rainfall amount at the location, A_R is the annual rainfall amount at that location.

The mean monthly duration and rainfall amount for the period of thirty-one years were computed for the location using equation 2.

$$\bar{R} = \frac{\sum_{j=1}^{31} Rj}{31} \quad \ldots\ldots 2$$

where; $\bar{R}$ represents the mean monthly duration/rainfall amount for the location over the 31 years period,while j is the period of thirty-one years.

1.4 RESULTS AND DISCUSSION OF FINDINGS

1.4.1 Results

1.4.1.1 Temporal Pattern of Dry Season Rainstorm events, Duration and Rainfall Amount over Ibadan (1952 – 1982)

The total frequency of rainstorm events recorded during this period was 295showed an average duration of 70 minutes. Also, 161 minutes was the maximum duration of rainstorm events in this data, while 31 minutes was the minimum. The standard deviation for duration of rainstorm events was 29.7.Close to 95% of rainstorm events lasted less than two hours. The remaining 5% of rainstorm events lasted more than two hours. Also, the average amount of rainfall events was found to be 7.4 mm. Besides, 19.9 mm was the maximum amount of rainfall events in this data, while 2.5 mm was the minimum. The standard deviation was 4.4.). About 9.7% of rainstorms gave less than 30 mm of rainfall; 74.2% yielded rainfall amounts of between 31.0 and 90.0 mm. Over 12% of the rainfall were between 91.0 mm and 120 mm. Only about 3.2% of the rainfall were greater than 120 mm during dry season rainstorm events.

1.4.1.2 Annual Frequency, Mean Duration and Mean Rainfall Amount of the Dry Season Rainstorms (1952-1982)

As shown in Table 1, the total frequency of occurrence of rainstorms recorded during the period under study was 295. The mean durations of rainstorms varied between 31 minutes and 161 minutes which was recorded in 1952 and 1957, respectively. Also, the mean amount of rainfalls varied between 2.5 mm and 19.9 mm which was recorded in 1954 and 1979, respectively. In the data set, there were notable variations in the annual frequency of occurrence of rainstorms, mean duration and mean amount of rainfall. Figure 3 shows the trend of increase and decrease in rainfall over the period of time being studied.

Table 1: Annual Frequency, Mean Duration and Mean Rainfall Amount of Dry Season Rainstorms (1952 – 1982)

Year	Annual Frequency	Annual Percentage (%)	Mean Duration (mins)	Mean Rainfall Amount (mm)
1952	14	4.8	31	4.9
1953	13	4.4	116	2.6
1954	12	4.1	80	2.5
1955	9	3.0	52	3.6
1956	14	4.8	33	5.3
1957	12	4.1	161	7.8
1958	10	3.4	48	3.3
1959	7	2.4	55	4.2
1960	13	4.4	50	3.5
1961	8	2.7	76	4.9
1962	11	3.7	47	7.3
1963	13	4.4	77	4.6
1964	10	3.4	54	5.2
1965	14	4.8	68	6.4
1966	12	4.1	71	5.5
1967	9	3.0	60	8.8
1968	8	2.7	90	5.2
1969	7	2.4	60	4.1
1970	14	4.8	52	3.2
1971	6	2.0	35	8.5
1972	10	3.4	48	6.8
1973	5	1.7	85	11.1
1974	7	2.4	87	9.2
1975	8	2.7	44	9.1
1976	9	3.0	123	13.9
1977	11	3.7	70	10.7
1978	3	1.0	91	18.7
1979	5	1.7	119	19.9
1980	13	4.4	88	8.2
1981	6	2.0	74	14.7
1982	2	0.6	37	6.4
Total	295	100		

Source: Department of Geography Rainfall Station, University of Ibadan

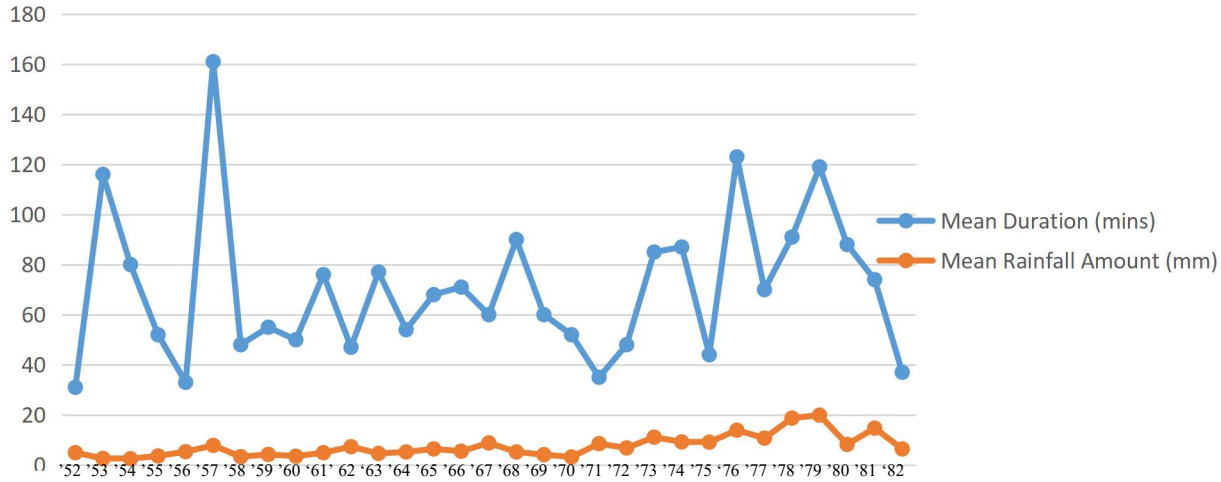

Figure 3: Trend of Mean Duration (mins) and Rainfall Amount (mm) (1952 -1982)
Source: Author's Analysis, 2024

1.4.1.3Dry Season Variabilities of Rainstorm Events, Duration and Rainfall Amount

There were notable variations in the frequency of occurrence of rainstorms, mean duration and mean rainfall amount of the dry season months under the period of study. As shown in Table 2, the highest frequency of occurrence of rainstorms was found to be month of February with a value of 137, followed by November with a value of 87. The lowest frequency of dry season rainstorms was put at 27 which occurred in January (Table 2).

In the data set, the highest mean duration of rainstorms was recorded in February with a value of 185 minutes. This was followed by the month of November with a value of 120 minutes. The lowest mean duration of rainstorms during the dry season months was found in December with a value of 60 minutes (Table 2). The highest average amount of rainfall events was found to be 21.3 mm in November. Besides, 20.8 mm was observed in December in this data, while 15.7 mm was recorded for the month of February, followed by the month of January with a value of 10.5 mm.

Table 2: Dry Season Variabilities of Rainstorm Events, Duration and Rainfall Amount

Season	Month	Frequency	Mean Duration (mins)	Mean Rainfall Amount (mm)
Dry	January	27	116	10.5
	February	137	185	15.7
	November	87	120	21.2
	December	44	60	20.8

Source: Author's Analysis, 2024

1.4.1.4 Comparison between the Mean Duration of Rainstorms (mins) and Mean Amounts of rainfall (mm)

The analysis of paired sample t-test two-independent sample comparison of mean rainstorms duration and mean rainfall amounts was done using paired sample t-test method.

The summary of the result is shown in Table3. The results of the analysis of the differences between the mean rainstorms duration and mean rainfall amounts revealed that there was significant difference in the mean duration of rainstorms and mean amounts of rainfall (p=0.000). This implies that the mean duration of rainstorms and mean amounts of rainfall varied significantly during the dry season over the period under investigation.

Table 3: Paired Sample Tests between Mean Duration of Rainstorms (mins) and Mean Amounts of rainfall (mm)

		Mean	Std Deviation	Std Error Mean	95% Confidence Interval of the Difference		1	df	Sig. (2-tailed)
					Lower	Upper			
Paired 1	Duration-Amount	62.96452	28.31121	5.08494	52.57988	73.34915	12.383	30	.000

Source: Author's Analysis, 2024

1.4.1.5 Correlation coefficient produced between the Rainstorm Events, Mean Durationof Rainstorms (mins) and Mean Amounts of rainfall (mm)

As shown in Table 4, the correlation coefficient of rainstorm events, mean duration of rainstorms and amounts of rainfall revealed that duration of rainstorms (-.041) and amounts of rainfall (-.557) related inversely with the occurrence of rainstorms. The correlation statistics further revealed that there is significant correlation between the duration of rainstorms and amounts of rainfall (p=.027) during the dry season over the period under investigation. The implication of this result is that the more the occurrence of rainstorm events, the less would be the durations and amounts of rainfall during the dry season in the study area. More so, the more the duration of rainstorms, the more the amounts of rainfall during the dry season in the study area.

Table 4: Correlation Coefficient of Duration of Rainstorms and Amounts of Rainfall on Rainstorm Events during Dry Season over the Period under Investigation

	Rainstorm Events	Duration (mins)	Rainfall Amount (mm)
Rainstorm Events	1.00	-0.0.41	-0.557**
Duration (mins)		1.00	0.397*
Rainfall Amount (mm)			1.00

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.06 level (2-tailed).

1.4.2 Discussion of Findings

The study revealed the features of the dry season rainstorm characteristics over the study area. The annual total of the incidence of rainstorms, mean duration of rainstorms and mean amounts of rainfall values varied over the period under investigation. This was evident in the data set where the rainstorm events range between 14 and 2 in 1952 and 1982, respectively. The mean duration of rainstorms and mean amounts of rainfall were equally varied.

More so, there were notable variations in the frequency of occurrence of rainstorms, mean duration and mean rainfall amount of the dry season months. In the data set, the highest mean duration of rainstorms was recorded in February with a value of 185 minutes. This was followed by the month of November with a value of 120 minutes. The highest average amount of rainfall events was found to be 21.3 mm in November. Besides, 20.8 mm was observed in December in this data, while 15.7 mm was recorded for the month of February, followed by the month of January with a value of 10.5 mm. However, in case of mean duration and mean rainfall amount of the dry season months, the duration of rainstorms and amount of rain per rainstorm were high in those months with low mean monthly duration and rainfall notably December and January. This was evident in the trend analysis of mean duration and rainfall amount chart. Similar result can be found in the work of Ayoade and Akintola, 1986.

In addition, the results of the analysis of the differences between the mean rainstorms duration and mean rainfall amounts revealed that there was significant difference in the mean duration of rainstorms and mean amounts of rainfall ($p=0.000$). This implies that the mean duration of rainstorms and mean amounts of rainfall varied significantly during the dry season over the period under investigation. This was also evident in the absolute and relative values obtained in the mean rainstorms duration and mean rainfall amounts.

The correlation coefficient of rainstorm events, mean duration of rainstorms and mean rainfall amounts revealed that duration of rainstorms (-.041) and amounts of rainfall (-.557) related inversely with the occurrence of rainstorms. The implication of this result is that the more the occurrence of rainstorm events, the less would be the durations and amounts of rainfall during the dry season in the study area. There appears to be some relationship between mean duration of rainstorms and the average amount of rainfall per rainstorm. This is, however, confirmed by statistical test. The correlation coefficient obtained was 0.027 which was significant at the critical 5% probability level. This result implies that the higher the duration of rainstorms, the higher would be the amounts of rainfall of dry season rainstorms in the study area.

1.4.3 Conclusion

There was a close relationship between duration of rainstorms and rainfall amount on both monthly and annual time scales. Most dry season rainstorms in Ibadan were rather small in size as they yielded between 125.8 mm and 12.8 mm, and they did not show a dominance of duration

periods. There were as many rainstorms of short duration as there were of medium or long duration during the dry season over the period under investigation in the study area.

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