Rainfall Amount and Number of Raindays in Kaduna, Northern Nigeria–Implication on Crop Production

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***Abstract*—**Rainfall amount and number of raindays are quantitative parameters that reflect the types of water demand activities to be carried out in a particular location, may it be agriculture, industrial or other issues. These parameters are determined from the daily observations of aqueous deposit from the atmosphere. Generally, rainfall amount and number of raindays determines length of rainy season, which equally determines the length of growing season and types of crop to be planted in a particular environment. This study analyzed the pattern of rainfall in Kaduna, Northern part of Nigeria from 1991 to 2005 using rainfall data collected from the Nigerian Meteorological Agency, Oshodi, Lagos, Nigeria. The findings from the analysis of this study indicated that there was no rainfall in the months of November to February. There were little rainfall in the month of March but the actual onset of rainy season started in the month of April while the cessation of rainfall was in the month of October. Thus, the wet period covers seven months beginning from April to October. The highest value of average monthly rainfall of 271mm was observed in the month of July while the least value of about 10mm occurred in the month of March. The mean annual rainfall of the study area ranges from 880mm to 1380mm. Further analysis indicated that highest numbers of raindays were recorded in the month of July ranged from 15 – 25 days while the least number of raindays were observed in the month of March ranged from 1 – 2-day. The implication of the results of this study on crop production is that only those crops that can reach maturity within seven month from the date of planting is most appropriate for cultivation in this study area. Those crops that will be planted should be those that its water requirement will fall between 880mm to 1380mm. This study will assist in meeting the food challenges of the ever increasing world population.

***Keywords*—**Rainfall amount, raindays, crop production, Kaduna, Nigeria.

I. Introduction

AGRICULTURE is one of the most weather sensitive of all human economic activities. In 2002, Ayoade stated that weather remains a key variable in agricultural production in spite of advancement in science and technology. Weather and climate affect agriculture and determine the adequacy of food supplies. Climate determines whether or not rainfed agriculture will be feasible and the type of crops that can be successfully cultivated in a given area.

Moisture plays a vital role in crop growth and development. It is the medium by which chemicals and nutrients are carried from the soil to various parts of crops. Moisture is also the main constituent of plant tissue and a reagent in photosynthesis. The state of soil moisture is controlled by rainfall, evaporation rate and soil characteristics. The supply of soil moisture may vary from wilting point when no water is available for crop use to field capacity when the soil is fully saturated with moisture but it is still well drained. When soil moisture is excessive all the soil pores are completely filled with water and a water logged condition prevails. In such a situation, free movement of air within the soil is impeded and compounds toxic to the roots of crops may be formed. At the other extreme is the condition of drought in which the amount of water required for evapotranspiration exceeds the amount available in the soil. Unless this water deficit is made good by rainfall or irrigation, crops will wilt and eventually die. Thus, too much or too little water is not good for agriculture.

The role of moisture in agricultural production is even more vital in the tropics where growing season is determined by the availability of rainfall to meet crop water requirements. The above statement had been supported by many researchers, among them are Omotosho et al. (2013) which stated that West African agriculture is almost completely rain-fed and water availability is also totally rainfall dependent. They further stated that agricultural practices and production and water resources availability and management, to a large extent, together determine food security in West African region.

Climate variability is now accepted as a serious environmental issue because it is a threat to sustainable development and food security. It has been affecting the monsoon flow which determines the start, frequency and intensity of thunderstorms and squall lines that deliver at least 80 percent of the annual rainfall in Nigeria and, indeed, the entire West Africa (Omotosho 1985). This region has been affected almost persistently by deficient rainfall and devastating droughts since the early seventies, causing

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hunger, starvation and crippled economies. As shown in Omotosho (1990), the variability of the monsoon, in turn, affects the rainy season onset and length, rainfall amount and number of rain days, all of which are crucial for crop production and yield.

It is known fact that there is a large variation in the agro-climatic and vegetation zones in Nigeria which has resulted to a wide range of farming systems, involving planting of different variety of crop types. These practices depend on the climate of each eco-zone – annual rainfall and its other factors, air and soil temperatures and soil types. The study of Jagtap, 1993 showed there was a decrease in rainfall trend over Nigeria with specific isohyetal values (e.g. 300mm, 1000mm and 1200mm) shifting southward from the 1960s to the 1990s. This indicates consistence in the reduction of rainfall available for agricultural practices, particularly over the northern parts of Nigeria. This has made some researchers to conclude that decreasing rainfall is pre-cursors to desert encroachment, increased temperatures and evaporation (Nicholson, 1994; Omotosho et al. 2013).

Thus, variations in the onset, cessation and amount of rainfall, number of raindays, the length of the rainy season on which the growing season is dependent, and extreme temperatures, can together or separately have severe adverse effects on the yield of both cash and food (arable) crops. This would have serious implications for food security, particularly in the semi-arid zone of Nigeria. In particular, the onset of the rains, rainy season length and number of raindays are very critical elements in the northern parts of the country, as their variability is almost of the same order of magnitude as the mean values (Yayock and Owonubi 1986). An early onset most often leads to a longer length of the growing season and vice-versa (Sivakumar 1997). Since it has been acknowledge that climate variability is a serious environmental issue threatened sustainable development and food security, therefore, there is need to know the type of crops that can be planted in the study area based on the rainfall requirements of commercial and food crops in Nigeria (Table 1).

TABLE 1
RAINFALL REQUIREMENTS FOR SELECTED COMMERCIAL AND FOOD CROPS IN NIGERIA

Crop	Mean annual rainfall
Yam	Not less than 1250 mm
Kolanut	Not less than 1250 mm
Groundnuts	500 – 1000 mm
Beniseed	1250 – 1500 mm
Soyabeans	1520 – 1500 mm
Oil Palm	1500 – 3000 mm
Cocoa	1250 – 2000 mm
Rubber	2000 – 2500 mm
Cotton	625 – 1250 mm

Source: Ayoade, 2002

II. MATERIALS AND METHODS

A. Location and description of study area

The study area is Kaduna town, the capital of Kaduna State which is situated on longitudes 07° 21' E and latitudes 10° 30' N which is the north of the equator in the Northern Nigeria (Figs. 1 and 2). The study area experiences a tropical continental climate with two distinct seasonal climates, dry and rainy seasons. The wet season (May to October) and dry season (November to April). Mean annual rainfall ranged from 1,016mm to 1,524mm (Omotosho et al. 2013). The climatic pattern of Kaduna which is in Northern Guinea Savanna vegetation zone of Nigeria is suitable for the cultivation of subsistence and cash crops round the year, although dry season farming often needs to be complemented by irrigation. Kaduna State's topography is favourable for small, medium and large-scale farming and for tourism.

The climate of Kaduna is also affected by intertropical discontinuity as a result of seasonal winds that blow from the north (North African anticyclone) and the one from the south (St. Helena anticyclone) during dry months. During the wet season, the climate is affected by Azores anticyclone from the north and St. Helena anticyclone from the south. The dry season is also characterized by Harmattan dust haze and hot and dry northerly winds that blow from the Sahara Desert over West Africa.

Fig. 1: Map of Nigeria showing vegetation zones and study area Kaduna, coloured in white

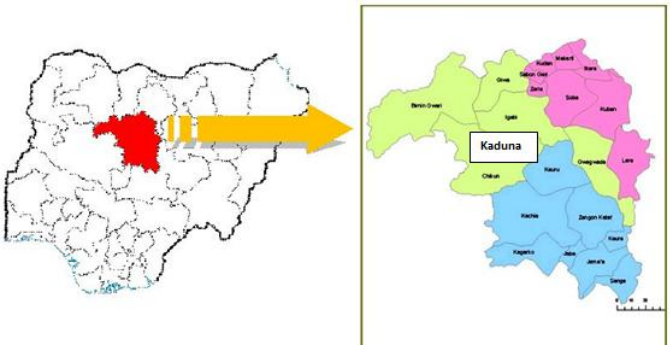

Fig. 2: Map of Nigeria showing Kaduna state in red colour and study area Kaduna town in white

B. Data

The climatic data used for this study consist of daily rainfall for 15 consecutive years (1991–2005). The data were collected from the synoptic weather station located in Kaduna on longitudes 07° 21' E and latitudes 10° 30' N with elevation of about 612 m. This station was established and maintained by the Nigerian Meteorological Agency, Lagos. The Nigerian Meteorological Agency is the official organization charged with the responsibilities of collecting, collating, and documenting weather data, among other things in Nigeria.

C. Methods of analysis

The observed values of daily rainfall was analyzed and categorized into different classes based on personal discretion using lower and upper limit of daily rainfall as indicated in Table 2. This gives detail analysis about the percentage of rainfall in each group within the study period. Also, rainfall frequency diagram was produced to assess the frequency of occurrence of each group of rainfall within the study period. Furthermore, quantitative analysis was employed to compute the annual and monthly trends of rainfall.

TABLE II
CLASSES OF RAINFALL BASED ON PERSONAL DISCRETION USING LOWER AND UPPER LIMIT OF DAILY RAINFALL

Group	Classes of rainfall (mm)
1	0
2	0.1 – 10
3	10.1 – 20
4	20.1 – 50
5	50.1 – 90
6	90.1 – 130

III. RESULTS

The results of this study shows that annual rainfall within the study period ranged between 1011 mm and 1379 mm in the year 2005 and 2004 (Fig. 3) when number of raindays was 95 and 100 days. The trend of number of raindays in Figure 3 show that the least number of raindays is 83 days with annual amount of rainfall of 1044 mm in the year 2001 while the highest number of raindays is 114 days which recorded 1066 mm annual rainfall in the year 1994.

The rainfall values are predominantly high in the study area during the months of July to September, the monthly values of rainfall within the study period ranging from 2.2 mm to 495.4 mm as shown in Figures 4 (a – o). The lowest and highest values of monthly rainfall within the study period over Kaduna was recorded in April 1996 when number of raindays was 1-day and August 1991 when number of raindays was 24 days as indicated in Figures 4f and 4a. The least number of raindays on monthly basis was 1-day in the months of March 1992, 1995, 1999 and 2003; and April 1996 and 2000 as well as November 1992. On the other hand, highest number of raindays on monthly basis was 26 days which was recorded in September 1994.

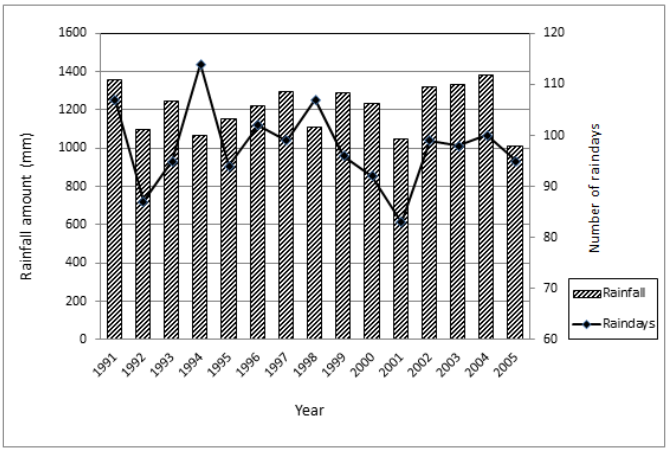

Fig. 3: Annual values of rainfall and number of raindays in Kaduna, Nigeria (1991 – 2005)

The frequency diagram of rainfall in Figure 5 shows that the percentage of raindays in a class of 0.1 mm to 10 mm is 57.21% which is the highest percentage followed by the class of greater than 10 mm to 20 mm which is 22.23%. The class of greater than 20 mm to 50 mm accounted for 18.06% and the class of 50.1 mm to 90 mm is 2.31%, while the class of 90.1 mm to 130 mm accounted for 0.13% which is the least percentage. The total number of raindays within the study period is 1470 days (26.85%).

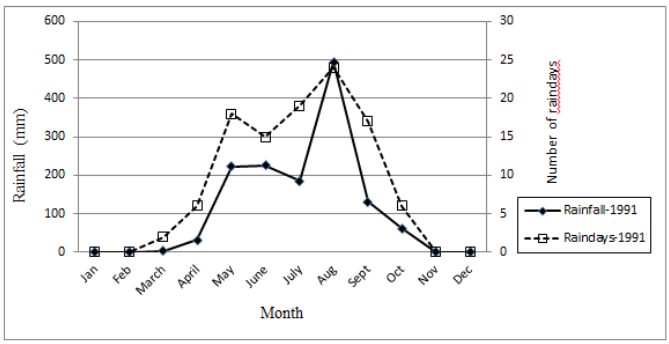

Fig. 4a: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 1991

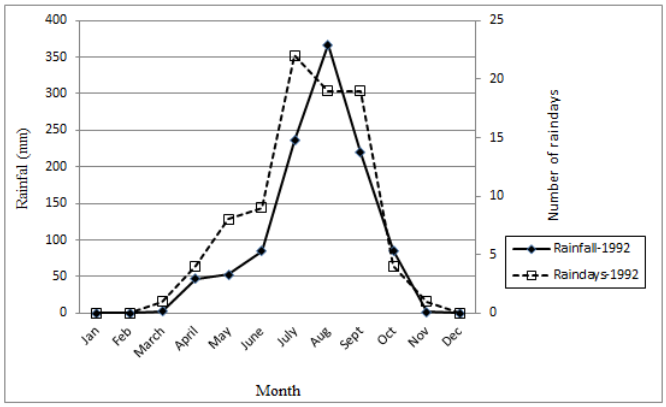

Fig. 4b: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 1992

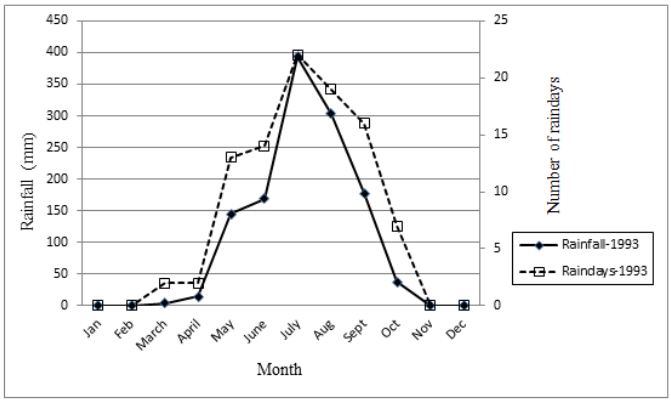

Fig. 4c: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 1993

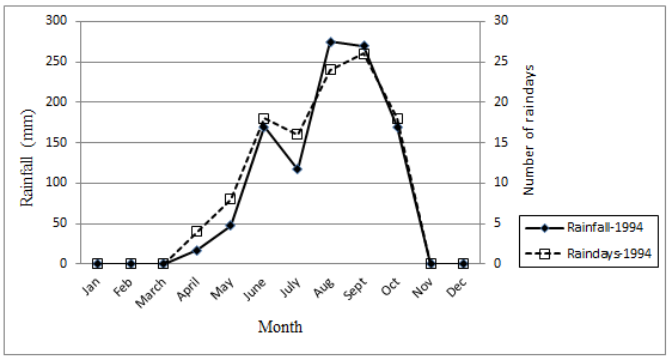

Fig. 4d: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 1994

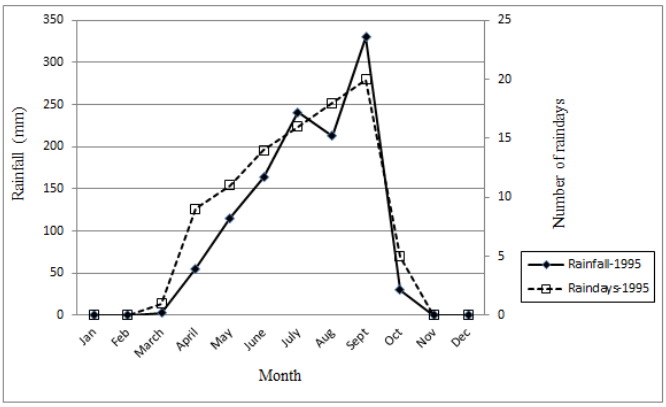

Fig. 4e: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 1995

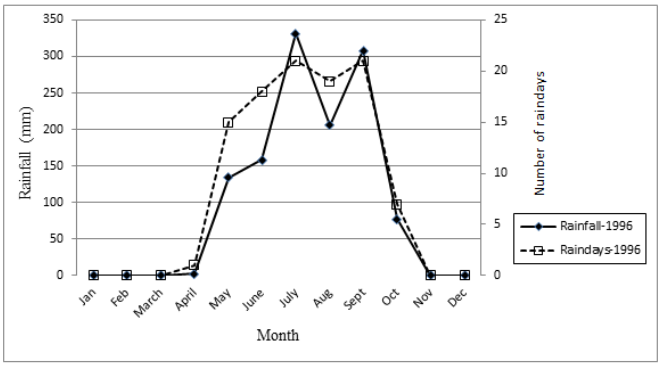

Fig. 4f: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 1996

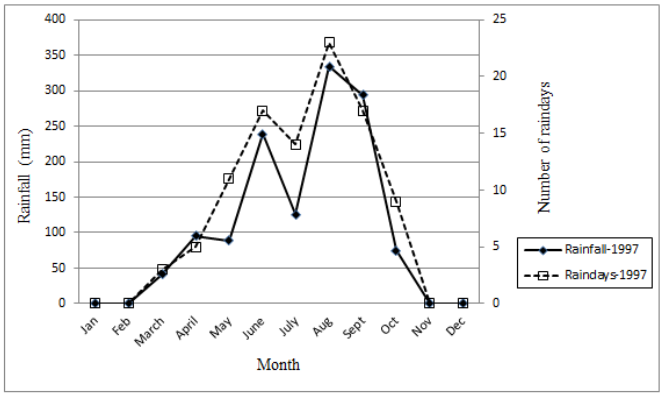

Fig. 4g: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 1997

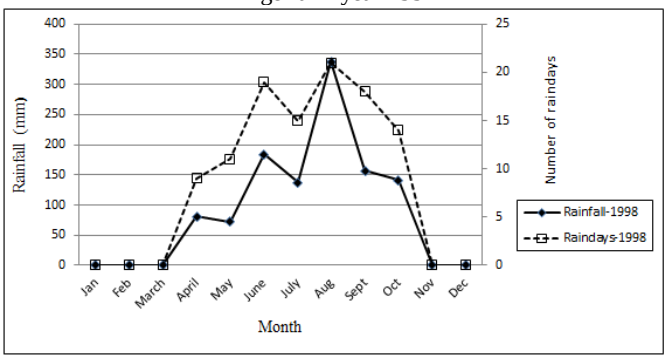

Fig. 4h: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 1998

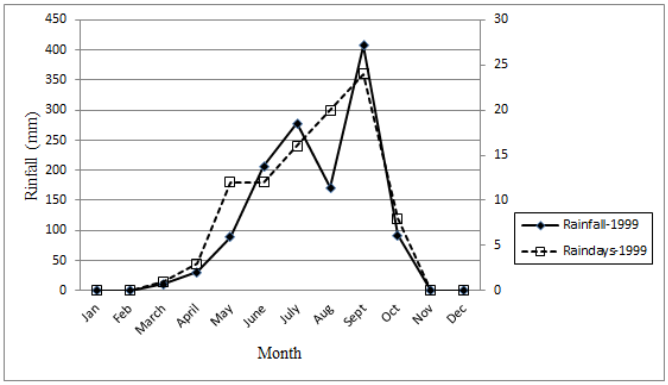

Fig. 4i: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 1999

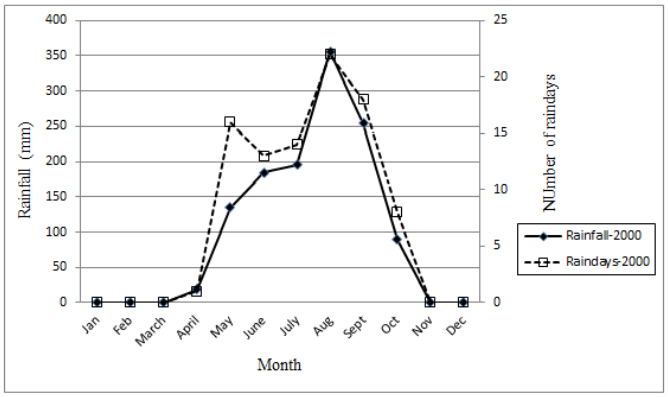

Fig. 4j: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 2000

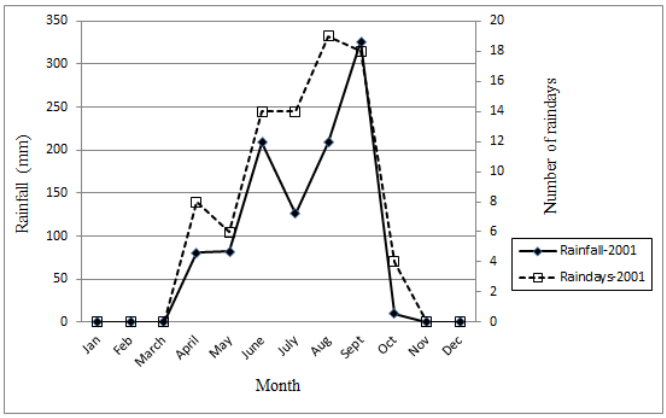

Fig. 4k: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 2001

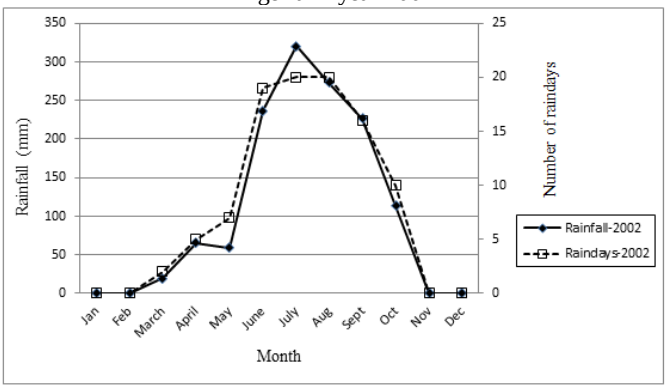

Fig. 4l: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 2002

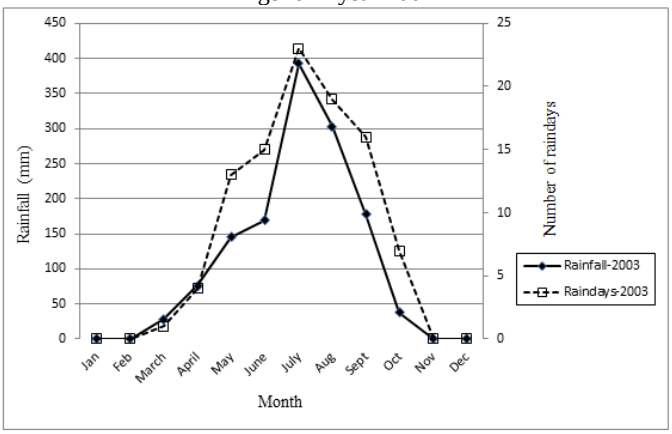

Fig. 4m: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 2003

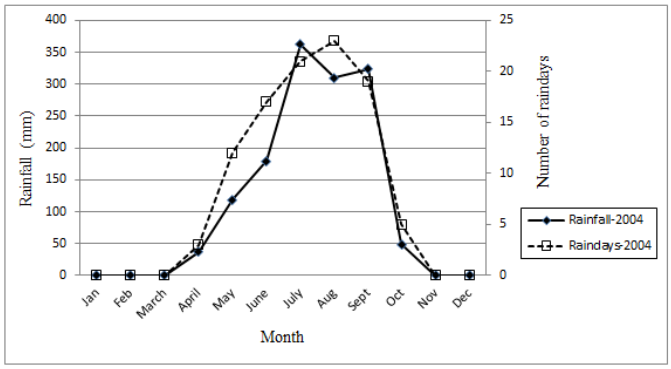

Fig. 4n: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 2004

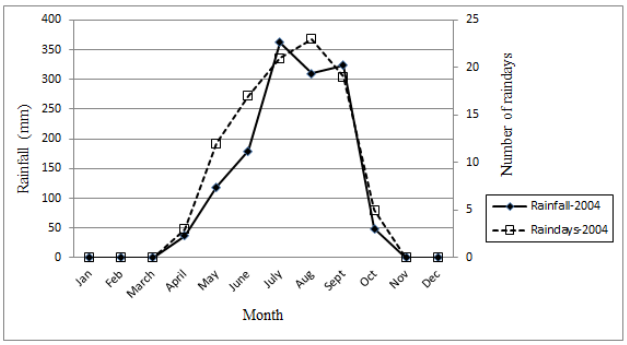

Fig. 4o: Trends of rainfall and number of raindays in Kaduna, Nigeria in year 2005

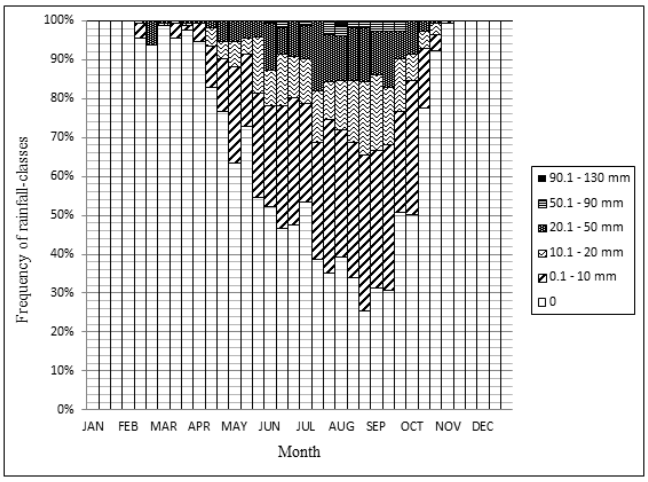

Fig. 5: Frequency of rainfall-classes in Kaduna, Nigeria for the period 1991 to 2005

IV. Discussion

The present study revealed that the onset of rain occurred in the month of April while the cessation of rain occurred in the month of October. The rain begin to stable in the month of May which indicates that the acceptable duration of rainy season covers the months of May to October which could be regarded as the length of growing season in the study area. The most important characteristics of rainfall to farmers are the amount and distribution of rainfall during length of growing season, reliability of rainfall after planting and rainfall variability. The amount and distribution of rainfall during the length of growing season or wet season (May – October) is most important to farmers because most small-scale farmers that constitute the bulk of farming population practice rain-fed farming because they cannot afford huge financial investments that irrigation system required.

The month of April to October is the period when all of the rain-fed agricultural activities take place in Kaduna, Northern Guinea Savanna vegetation zone of Nigeria. Apart from other rainfall characteristics, the total amount of rain during this period is important in determining the types of crops that are cultivated in the study area. This is because the amount and distribution of rainfall in turn determines the availability of water for crop production (Tesfaye et al. 2004, Omotosho et al. 2013). Inadequate rainfall during the length of growing

season may hamper the cultivation of yams which is the most important root crops in Kaduna.

The number of raindays serves as a marker that can be used to verify the distribution of rainfall. During the length of growing season of crops, farmers expect a balance between the distribution of rain days and moderation in rainfall amounts per rain day throughout the season. A fall in the number of rain days associated with an increase rainfall per rain day signifies an increase in the intensity of rainfall. This increase in rainfall intensity as indicated in the years 1992 and 2001 in the study area could have a number of negative effects on agriculture both in the short and long-term. It increases the rate of erosion and loss of particulate nutrients from arable soils, thereby reducing soil fertility and productivity (Fraser et al. 1999). An increase in the intensity of rainfall may be a potential serious risk of an increased flood frequency and severity for most regions of the world (Gordon et al. 1992, Fowler et al. 1995). High daily rainfall may be potentially destructive to agriculture in sensitive areas that are prone to flood. This situation could compound the problem of food shortages and led to unprecedented food price increases. Generally, the study shows that increase in the number of raindays does not depict high amount of rainfall.

The onset of rains season is a very important event to farmers in Sub-Sahara Africa. The onset of rains marks the beginning of three main activities – planting, weeding and harvesting (Omotosho, 1990) which determine the socio-economic life and survival of the farming household. The importance of farming in the lives of these households also means that other activities are based on the accomplishment of these three activities (Omotosho et al. 2000). Planting that depends and is influenced directly by the onset of the rainy season, is the first activity which other two activities are based. Significant shifts in the onset of rains will therefore affect both agriculture and many other non-agricultural activities of small-scale farmers. Several researchers have reported how variability of the onset and cessation of the rainy season in tropical region pose a serious challenge in the process of determining when the rainy season/ planting season begins (Oladipo et al. 1993, Omotosho et al. 2000). Despite the fact that farmers contend that the onset of rains is becoming more uncertain with a tendency towards delayed onset, the data used for this study shows that there is no serious delay or shift in the onset of rains in the study area.

In general, the study have establish that yams, groundnuts, soyabeans, beans and cotton could be cultivated in the study area without a problem of rainfall if adequate agricultural management practices are put in place. This outcome of this study is in agreement with the report of Ayoade, 2002 on the rainfall requirements of selected commercial and food crops in Nigeria. Moreover, it is acceptable norm from the agronomic point of view that a given amount of rainfall can be regarded as reliable if it is received at least 8 years out of 10 in the long run i.e. 80% probability which the data used for this study have satisfied

V. Conclusion

Based on the findings of this study, there are fluctuations in the amount of annual rainfall and number of raindays which could be linked to climate change. Although, these fluctuations have not cause any serious delay or shift in the onset of rains and cessation of the study area. In view of this, rainfall duration and number of raindays are still very favourable for the agricultural activities the study area is known for.

The agrometeorological studies of this type are invaluable for farmers. Such studies are prerequisites to analyze both the annual dates of onset and cessations of the rains (April and October) and crops to be planted. This study suggests that the emergent risks that could arise from climate variability make it imperative to develop an integrated long-term climate policy that is adaptive to the evolving climate challenges. The policy should essentially facilitate the establishment of a dense network of weather stations for monitoring climatic parameters..

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