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Inter-Annual Rainfall Variability on Yam Yield in Lafia, Nasarawa State, Nigeria.

[1]Agidi,V.A, [2]Hassan, S.M and [3]Baleri, T.G
1. *Department of Geography and Environmental Science, University of Abuja, P.M.B 117 Abuja, Nigeria*
2. *Department of Geography and Environmental Science, University of Abuja, P.M.B 117 Abuja, Nigeria.*
3. *Department of Geography College of Education Gindiri, Mangu , Plateau State*

[1]Victor.agidi@gmail.com [2] Shuaibhasan123@gmail.com [3]balergodfrey@gmail.com

Abstract
This study examines the relationship between inter-annual rainfall and yam yield in Lafia, Nasarawa State. Yam yield data for eleven (11) years was collected from Nasarawa Agricultural Development Programme (NADP) while rainfall data was collected from Nigeria Meteorological Agency (NIMET) substation in Lafia. Data collected were subjected to various statistical analysis which include Coefficient of variation, time series analysis, kurtosis, skewness and regression analysis. The coefficient of variation of rainfall for the years under study was 14.30% which implied low inter-annual rainfall variability. Time series analysis was carried on rainfall distribution for the growing months of the years under study; only the months of April and August showed a negative trend line while the months of May, June, July, September and October all showed a positive trend. Downward trend in the month of April could affect yield of yam because that is the month of active germination of yam, while the negative trend in August could also led to low yield because of active tuberization and leaves takes place in that month. Regression analysis showed that there is no significant influence of inter-annual rainfall variability on yam yield in the study area.
Key-words; *Inter annual rainfall, variability, crop yields, yam yield, time series.*

Introduction

The issue of climate change has become more threatening, not only to the sustainable development of socio-economic and agricultural activities of any nation, but to the totality of human existence (Adejuwon, 2004). According to Action Aid (2008), agriculture in developing world is particularly vulnerable to climate change. Crop yield could fall by up to 30% by 2050 in Central and Southern Asia as a result of climate change (Mastrandea *et al.,* 2008). The Inter-Governmental Panel on Climate Change IPCC (2001), report showed that in some African countries yield from rain-fed agriculture could be reduced by up to 50% by the year 2020. Rainfall is undoubtedly the most important climatic variable especially in the tropics and it has a far reaching influence on agricultural production (Adejuwon, 2005). Climate variability has been the most important determinant of crop yields in Nigeria as well as in other parts of West Africa (Awosika *et al.*, 1994). Inter-annual variability in rainfall has been the key climatic element that determines the success of agriculture in Guinea Savanna ecological zone of Nigeria (Ayanlade *et al.*, 2009). (Rainfall) is the main determinant of the type of crops to be grown in an area; the period of cultivation and the farming practice (Abaje *et al.* 2010). Rain-fed farming dominates agricultural production in sub-Saharan Africa, covering around 97 percent of the total cropland and exposes agricultural production to high seasonal rainfall variability (Alvaro *et, al,* 2009). Rainfall is thus crucial to farming activities in Africa and in Nigeria in particular. Therefore any variation in the pattern of rainfall may have significant effect on the livelihood of farmers. This study aimed at determines the influence of rainfall variability on yam yield in Lafia, Nasarawa State over a period a period of 11 years (2000-2010).

Nigeria plays a leading role in the production of yam globally, thus, serving as a source of staple food in the country (Food and Agriculture Organization (FAO), 2005) and also an export commodity. It becomes imperative to study its sustainable production is vital. The unending

variability of rainfall pattern, which is manifested in decreasing length of rainy season, delay of rainfall onset and early cessation of rains (Adejuwon, 2005), might have possible effects on crop yield. It becomes important to have an in-depth knowledge of the impact of rainfall variability on crop production which will help in agriculture decision making.
Several studies on the impacts of climate variability on crops yield have been carried out in different parts of the world; Awosika *et al.* (1994), Anuforum (2004), Adejuwon (2005), Ayalande *et al.* (2009). Some of these studies have shown significant impacts of climate variability on agricultural activities, especially during the last 40-year period. Very little is known about rainfall variability and its impacts on crop yield in Lafia Local Government Area of Nasarawa State. It is therefore, critical to assess the relationship between rainfall variability and yam yield in Lafia LGA.

Material and Methods
Study Area
Lafia Local Government Area is located in Nasarawa State, in the central part of Nigeria. It is located at approximately latitude 8^0 24^I N, $9^0$1'E and 8^0 13^IE, $9^0$8'N. It has a total landmass of about 2797.53 km^2 Lafia L.G.A shares boundary with Plateau State in the north east, Obi and Doma L.G.A in the South, Nasarawa Eggon in the West and Wamba LGA in the North in (Figure 1 and 2). Lafia L.G.A has a tropical sub-humid climate, with two distinct seasons which are wet season and dry season. The wet season lasts for seven months which is between April and October, while the dry season is between November and March (NIMET, 2005). Rainfall is moderately high in Lafia, ranging from 1200mm to 1600mm (Binbol, 2005). Average maximum and minimum daily temperatures are 35°C and 21°C in rainy season and 37°C and 16°C in dry season respectively (NIMET, 2005).

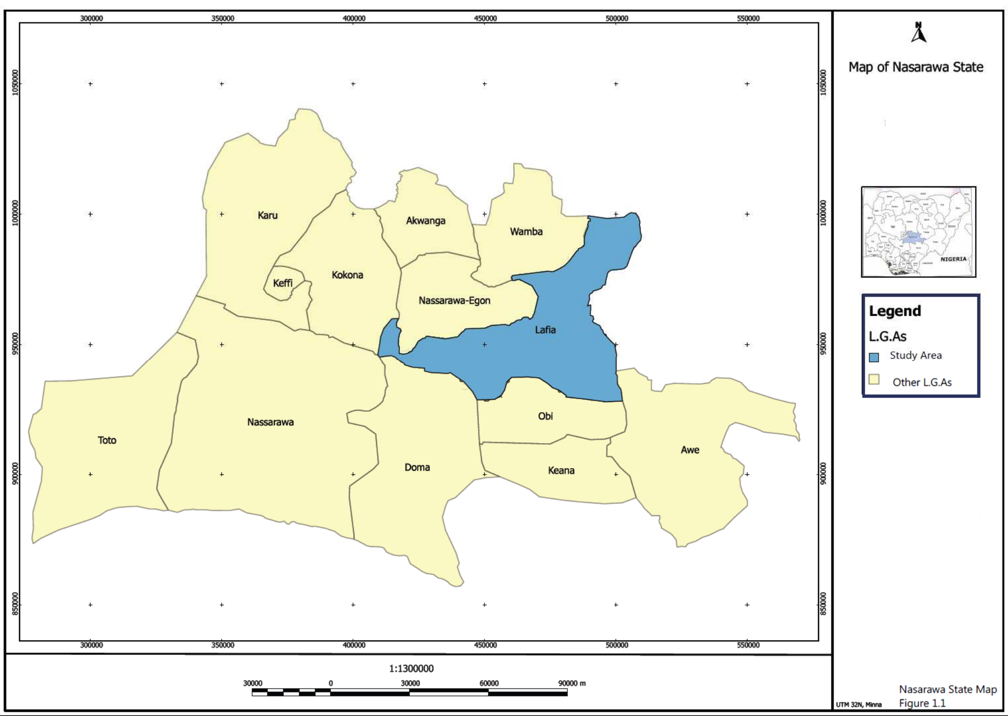

Fig. 1: Map of Nasarawa State showing the study area.
Source: (Min. of Lands & Survey, Lafia)

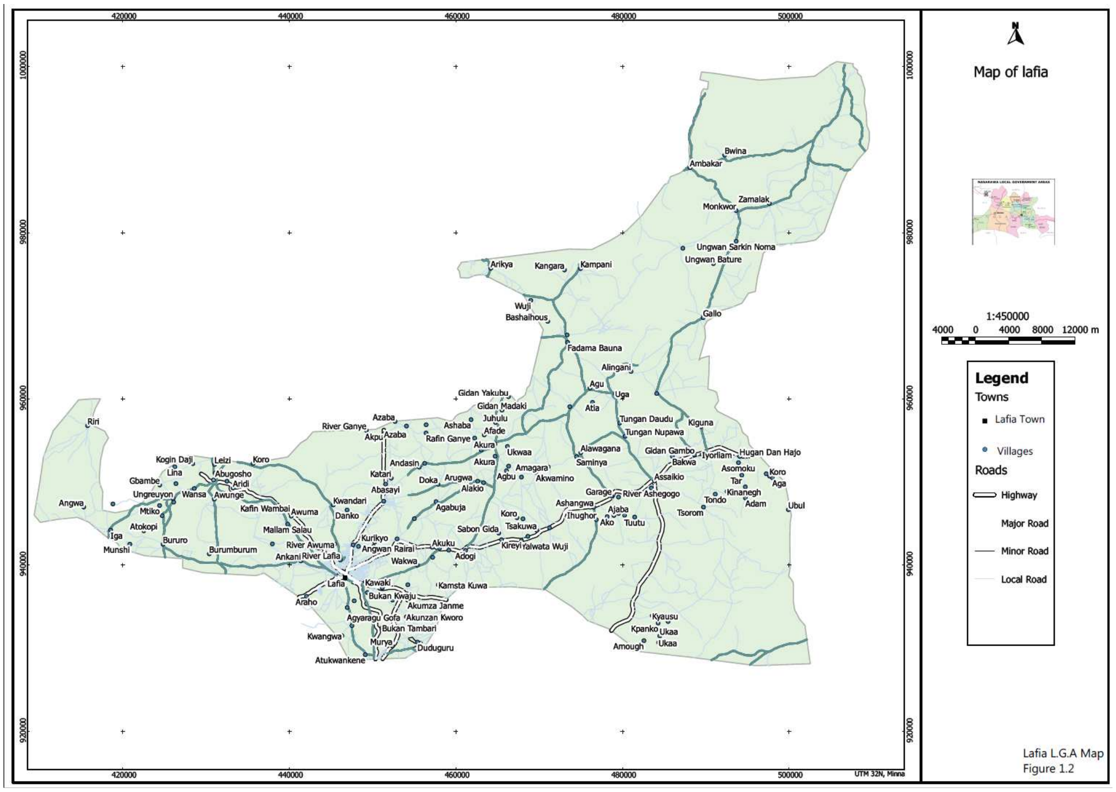

Fig. 2: Map of Lafia L.G.A
Source: (Min. of Lands & Survey, Lafia)

Data Collection:
Twenty seven thousand six hundred and twenty-seven (27,627) registered farmers in Lafia presented their yam at harvest for measured in metric tons in kilogram. Nasarawa Agricultural Development Programmed measure yam by weight, every 1000 kilogram is equivalent to 1 tons and was recorded in metric tons per hectare. Daily rainfall was collected by Nigeria meteorological Agency (NIMET) using rain gauge.

Results and Discussion
Analysis of rainfall for growing season
The mean(X) standard deviation (*SD*), coefficients of variation (CV), standardized coefficients of skewness (Z_1) and Kurtosis (Z_2) of rainfall in the study area are presented in Table 1, showed normality at the 95% significant level indicating normal.

Coefficient of variation for annual rainfall.
Coefficient of variation was used to calculate inter annual rainfall variability for the years under study. The results showed a coefficient of variation of 14.30%, indicating low inter-annual variation. It also suggests that the distribution of rainfall across the years is normal. The distribution of rainfall in the study area is normal, since the annual mean is 1257.5mm. Adejuwon (2004) observed that rainfall distribution in Nigeria is generally normal if the mean is greater than 750mm.

Table 1: Growing Season (April-October) Rainfall Trend Statistics 2000-2010

Month	Mean	Variance (V)	Standard deviation (SD)	Coefficient of variation (CV)	Kurtosis (Z_2)	Skewness (Z_1)
April	6.53	278.2	7.256	0.74814	-0.13	0.402
May	61.03	3213.3	6.686	0.35202	.92	1.035
June	88.4	0504	02.49	0.54401	0.847	0.569
July	35.68	613.4	4.923	0.3179	0.218	0.2
August	75.37	148.9	6.115	0.20378	1.617	0.15
September	00.05	837.6	9.553	0.34768	1.214	0.01
October	27.41	326.8	9.541	0.6243	0.348	0.967

Note: Mean= $(\bar{x})$; Variance=V; Standard deviation=SD; Coefficient of variation=CV; Skewness= Z_1; Kurtosis=Z_2 : Statistically Significant at 95% Confidence Level.

Rainfall Distribution

Rainfall distribution in Lafia from 2000-2010 has shown evidence of fluctuations (Fig. 3). The first three years shows a steady increase from 916.7mm -1281.1mm then a sharp decline to 1170.8mm. So there exist rise and fall in the trend as 2007 and 2009 had the highest rainfall above 1500 mm. The trend line shows that rainfall distribution in the study area is on the increase.

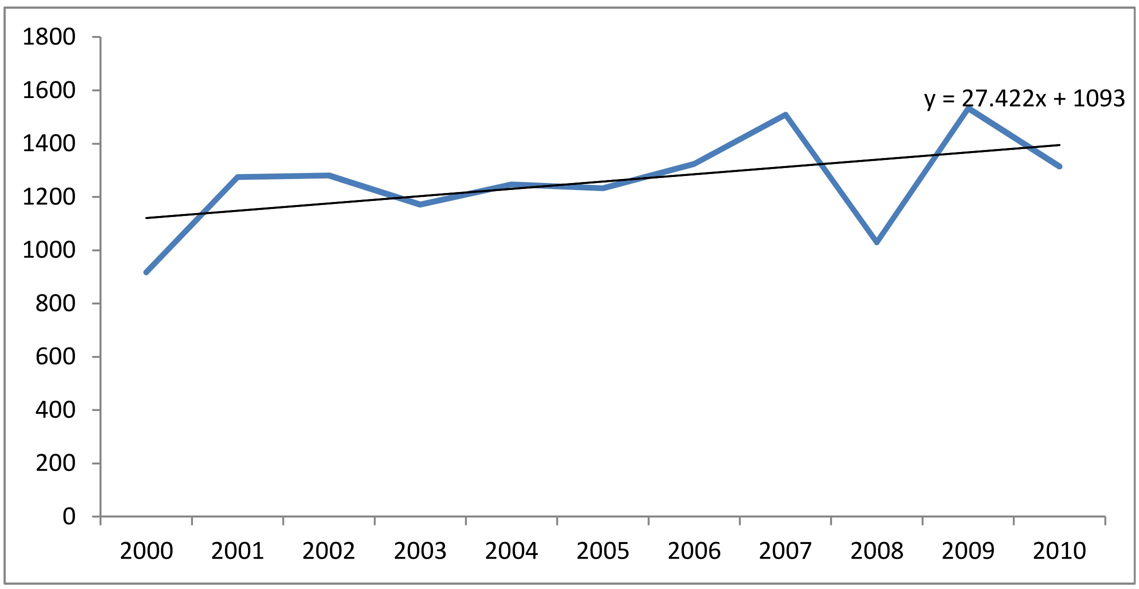

Fig 3. Annual rainfall distribution in Lafia from year 2000-2010.

Time Series of rainfall for the growing season months

To be able to get the time series of the rainfall variability, a monthly chart of the growing season, April-October, was done in order to get its trend.

Inter-annual trend of rainfall for the month of April is shown in Fig. 4. The rainfall distribution for the months of April indicates a downward trend. The years 2001, 2003, 2007, 2009 and 2010 had rainfall above the mean standard deviation for eleven years while the years 2000, 2002, 2004, 2005, 2006 and 2008 fail far below the mean standard deviation.

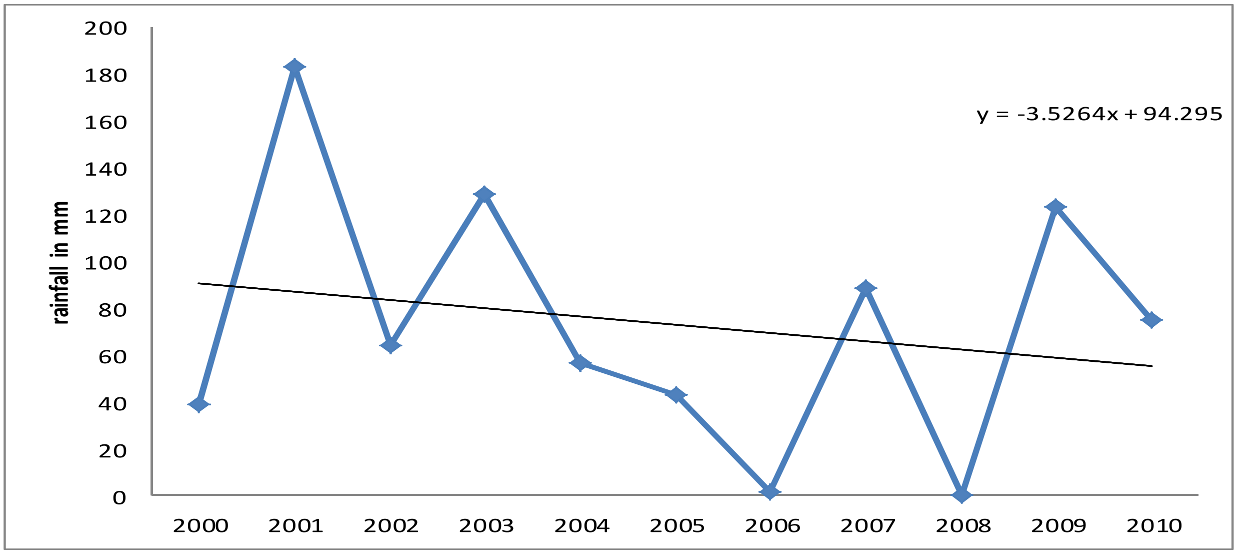

Fig. 4 April Rainfall Distribution for the years 2000-2010

The result here indicated that the decline in the amount of rainfall in the month of April for the years under study will have negative consequences in the yield of yam. Once yam breaks from dormancy in a few weeks after planting constant water is needed for about four months to support its development. Climate change and variability particularly increasing anomaly in the onset, cessation and duration of the rain, and incidences of dry spells during the early growth stage of yam may lead to low yield of yam. The trend of rainfall distribution for the months of May as shown in Fig. 5 shows an upward trend. The years 2000, 2004 and 2009 are far above the mean standard deviation while the years 2002, 2003 and 2010 are below the mean standard deviation.

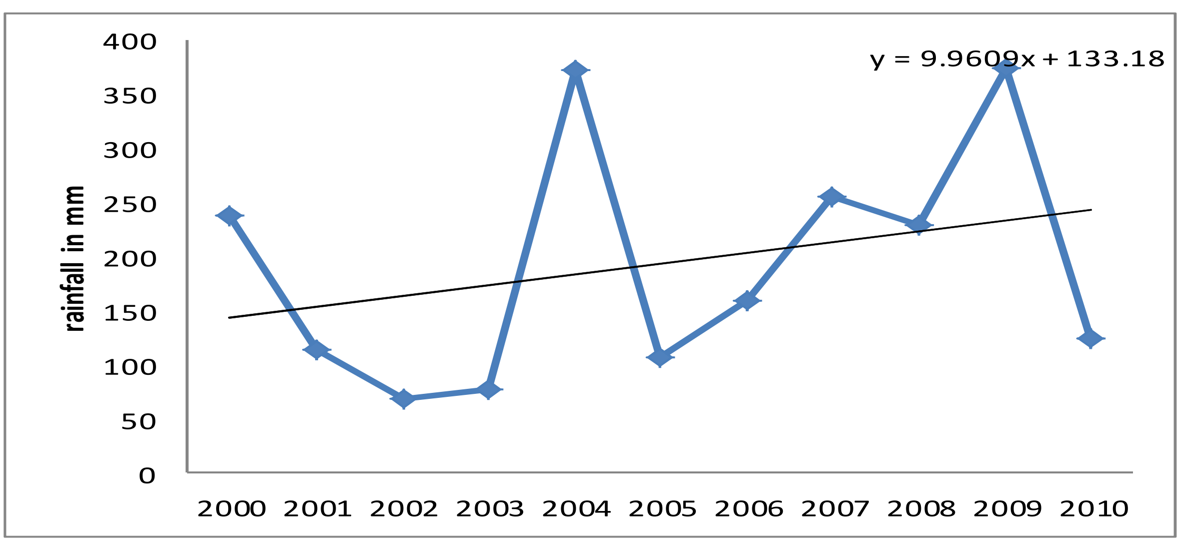

Fig. 5: May Rainfall trend for the years 2000-2010

Increase in the rainfall distribution in the month of May is good for the development of yam. Active process of yam germination and development of root and vine, take place in the first three months of planting. Therefore, increase in rainfall in the month of May supports high yield of yam. Fig. 6 shows a positive or an upward trend for the eleven years under review. The years 2000, 2004, 2009 are far above the mean standard deviation while the year 2002 and 2003 are below the mean standard deviation.

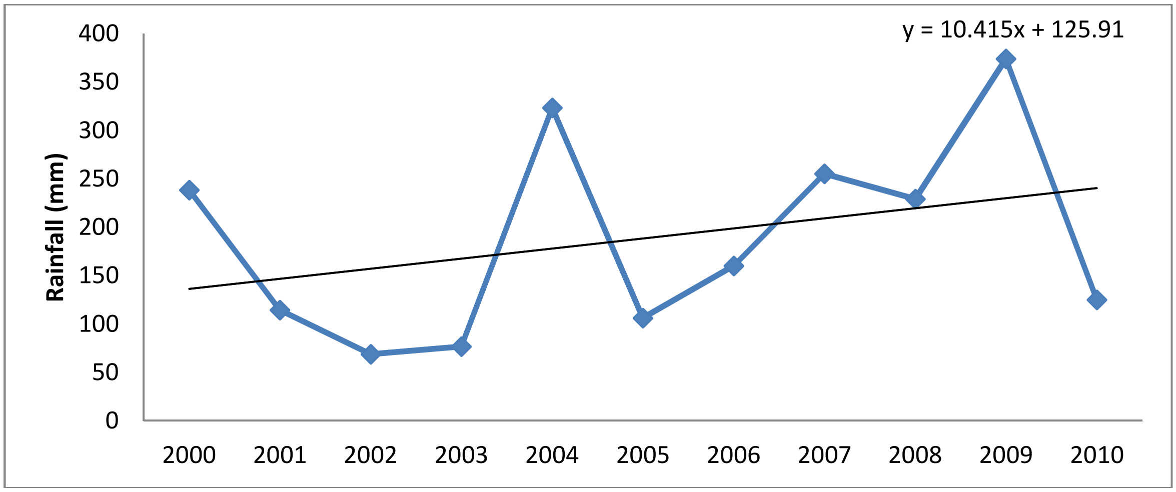

Fig. 6: June Rainfall trend for the years 2000-2010.

Although the trend for the month of June shows an upward trend, the few years that fall below the mean standard deviation will have a poor yield of yam. That may likely be as a result of inadequate moisture at the critical stage of active germination; prolong dry spells after planting, during sprouting and emergence period but unbroken succession of wet days at the critical stage of bulking.

Fig. 7 shows the trend of rainfall distribution for the months of July. The months of July show a positive upward trend. The years 2002, 2006 and 2010 were above the mean standard deviation while the year 2000, 2003 and 200 are far below the mean standard deviation.

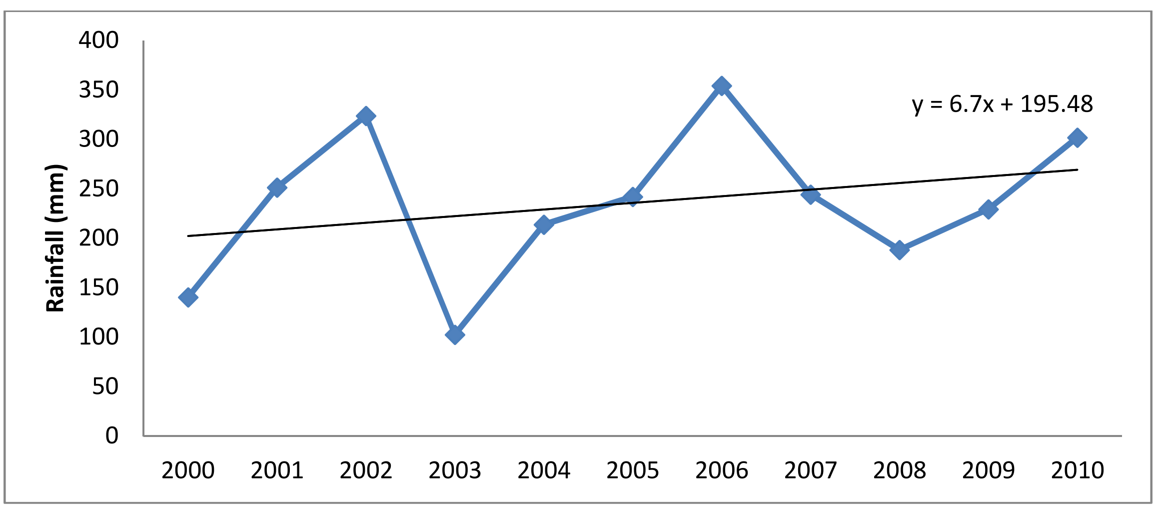

Fig. 7: July Rainfall trend for the years 2000-2010.

The month of July is an active month in yam development when much moisture is needed at this stage to support the development of vine and leaf. Therefore, with the increase in the rainfall proper development of yam will take place. Fig. 8 shows the trend of rainfall distribution for the months of August in the years under review.

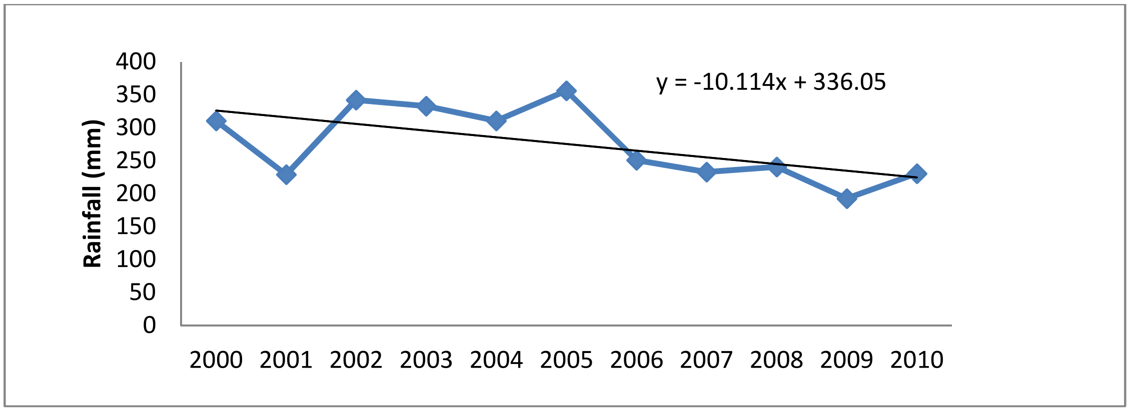

Fig. 8: August Rainfall trend for the years 2000-2010.

The rainfall distribution of the month of August shows a downward trend. The rainfall for years 2002 to 2005 was above the mean standard deviation for eleven years while the years 2001, 2006 to 2010 were all below the mean standard deviation. The downward trend of rainfall in the month of August will have a negative impact on the yield of yam. According to Olanrewaju (2005), yam tubers develop with greater strength between the month of August and September. This implies the development of yam will be affected at this stage and ultimately the yield due to inadequate rains. This means year 2006-2010 rainfall has less influence on yam yield during this month.
Fig. 9 shows the trend of rainfall distribution for the months of September in the years under review.The month of September shows an upward trend for the eleven years under review. The years 2001, 2002, 2003, 2006, 2007 and 2010 is far above the mean standard, while the years 2000, 2004, 2005, 2008 and 2009 are below the mean standard deviation.

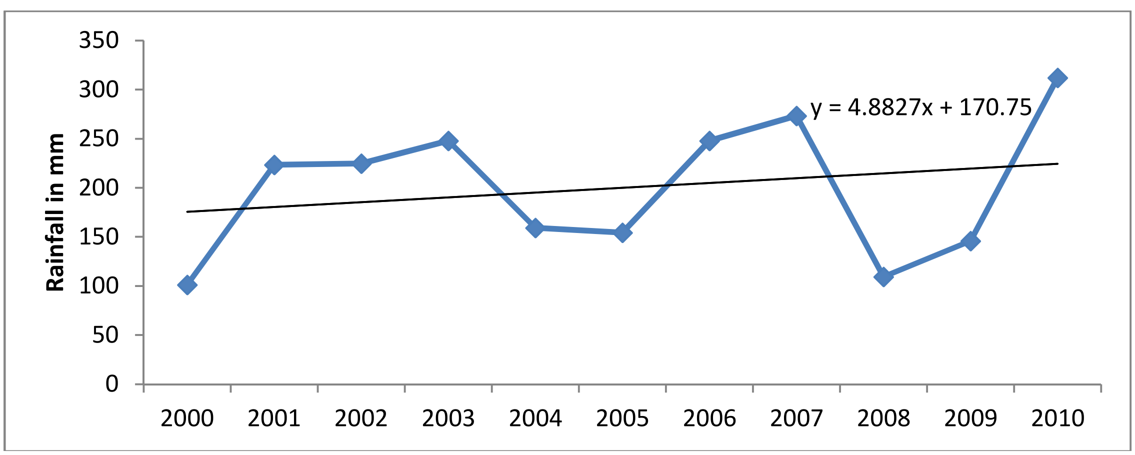

Fig. 9: September Rainfall trend for the years 2000-2010.

September initiates the period of tuberization when active process of material accumulation decline, therefore, the need of water decline in September. The upper trend of rainfall in the month of September will affect the yield of yam negatively. Craufurd *et al.* (2001), observed that any abiotic or boitic stress during the phase of tuberization can drastically affect the growth and development of yam and reduces ultimately the tuber yield.
Fig. 10 shows the trend of rainfall distribution for the months of October in the years under review.

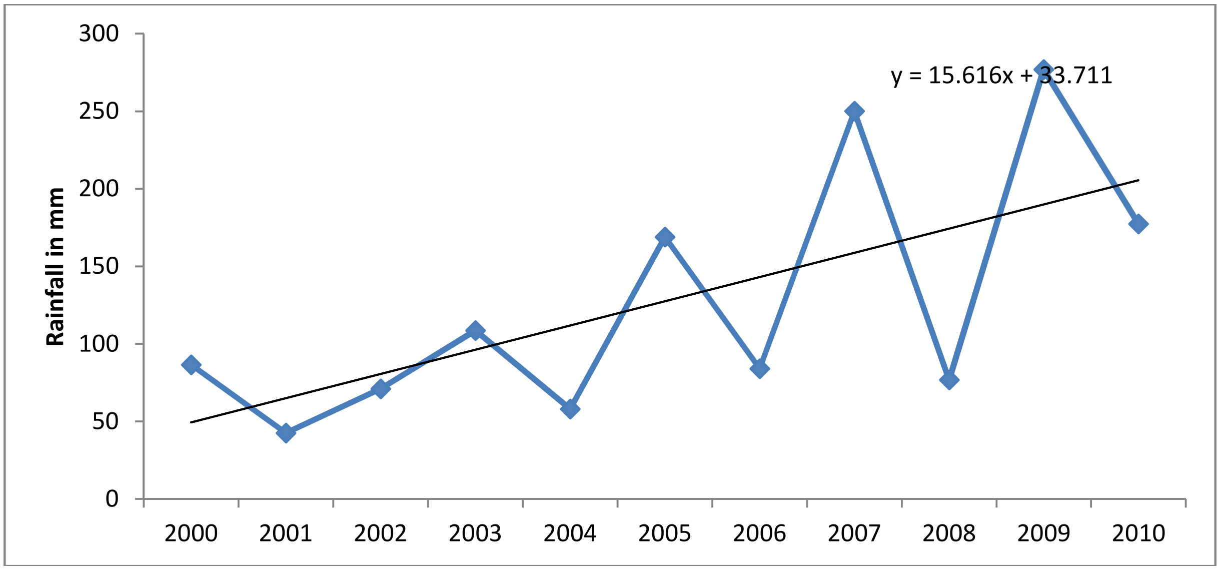

Figure 10 October Rainfall trend for the years 2000-2010.

The month of October shows an upward trend for eleven years under review. The year 2007 and 2009 are above the mean standard deviation, while the years 2004 and 2008 are below the mean standard deviation. Increase in rainfall for the month of October will not be of any effect to the yield of yam. This is the period in which yam enters dormancy, at this point little or no rain is needed for yam development. Dormancy is the term used generally to encompass the process that constitutes a programmed inability for growth in various types of plants, often in spite of suitable environmental conditions (Lang, 1996). This implies that with or without rainfall at this stage the yield will not be affected.

Time series on yam yield.
Yam yield trend for the year 2000-2010 was determined as shown in Fig. 11.

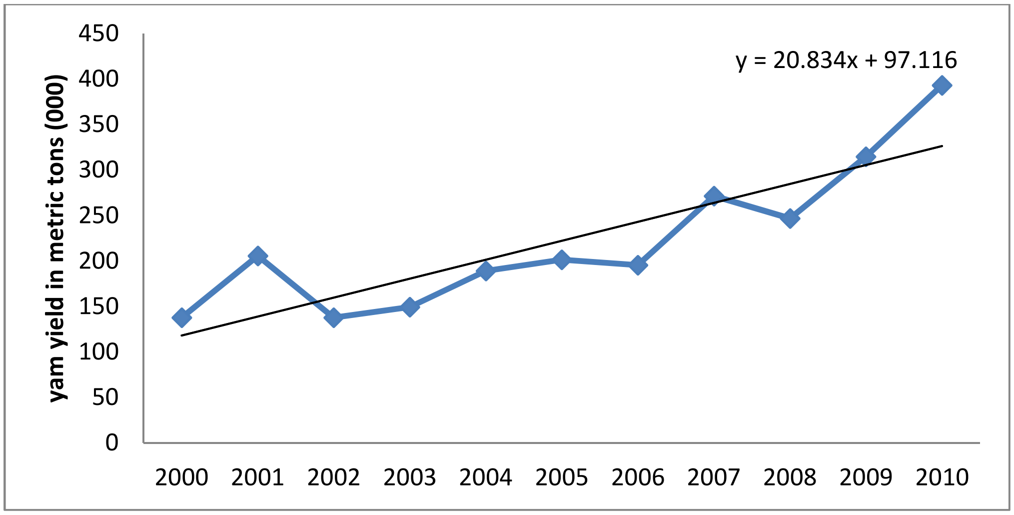

Figure 11. Annual Yam yield trend in Lafia from year 2000-2010
Source: NADP Annual report (2011).

Yam yield in Lafia from 2000-2010 was characterized by increase and decrease. The first 5 year is the obvious in that act, while the last 5 years show a more stable increase with the exception of 2006 and 2008 which shows a decline in the trend. If we are to compare Figure 3 and figure 11, it becomes clear that rainfall has just a little impact on yam yield in some years. Because some years with high rainfall i.e. (2007) witness low yield; this may be attributed to other factors other than rainfall. This supports the findings of Olanrewaju (2005), that for yam to reach its optimum yield the amount of rainfall is not as important as the distribution. Okuewu (2002) also noted that rainfall must be well distributed throughout the year for yam to perform optimally.

Regression of Yam Yield on Rainfall

Simple linear regression analysis was carried out on the yam yield. It shows there is positive regression of yam yield. In other words, there has been a positive increase in the yield of yam over the years under study. With the increase in yam yield despite the seemingly decline in rainfall, therefore, reveals that other factors are playing role in the yield of yam. This concurs with the observation of Oyekwelu *et al. (*2006) that other variables such as farm management practice, soil composition, clearing and preparing fields, harvest method and management of harvest residue have been reported to influence crop yield.

The analysis of inter-annual rainfall on yam yield was done to establish the causal relationship between them. Regression analysis was carried out for crop yield on rainfall for the years under study, the result revealed that the calculated value of t (3668.2), greater than the table value at 5% (2.262), we therefore, reject the null hypothesis at 5%; this goes to show that there is a significant influence of inter annual rainfall variability on the yield of yam in the study area.

The results obtained from this study concur with the findings of Ayanlade *et al.* (2009) which reveal that variation in rainfall affects yam yield adversely in guinea savannah region of Nigeria. The result is also in agreement with the findings of Abaje *et al.* (2010) which observed that millet, sorghum and maize production is likely to be affected negatively by rainfall variability while production of tuber crops such as cassava, yams and sweet potatoes may not be negatively impacted. It should be noted that the impact of rainfall is in two dimension; positive or negative impacts. Positive impact implies that annual rainfall gives rise to high yield while negative impacts

imply that variation of rainfall leads to decrease in yield.
The fluctuation in yam yield in Lafia is attributed to rainfall variability. With better knowledge of climate phenomenon and how it affects yield, farmer will be able to adjust to its vagaries.

Conclusion

Findings show normality for rainfall data for all the months (April-October growing season). The annual yam yield mean statistics results of standardized coefficients of Skewness (Z_1) and Kurtosis (Z_2) show that all the years were accepted as indicative of normality. The months of April and August show a downward trend which connotes decrease in rainfall while the months of May, June, September and October show an upward trend which indicates increase in rainfall.

The annual yam yield production of the study area shows an upward trend, which implies yam yield is on the increase over the years under review. Rainfall variability is found to have significant impact on yam yield in Lafia L.G.A between the years 2000 and 2010. Regression analysis on rainfall and yam yield shows the latter to be affected by the former. Although some years with high annual rainfall had low yield, this goes to show that the amount of rainfall at a time matter less but the frequency and distribution.

The need for proper and constant sensitization of farmers to the understanding of rainfall variability is imperative, as that may help improve yield through farmers understanding of true onset for their crop growing season.

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