

ORIGINAL ARTICLE

Effect of Rainfall Variability on Maize Yield in Gassol LGA, Taraba State, Nigeria

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ABSTRACT

Rainfall characteristics and variability have profound influence on crop yield in most parts of Nigeria and Sub Saharan Africa. Knowledge of rainfall characteristics and variability and relationship with crop yield are important in policy interventions to stabilise farmer's incomes and food supply in the LGA and Taraba State at large. This study examines the impact of rainfall variability on maize yields in Gassol LGA. Specifically, the study examines the trend of rainfall variability and maize crop production and the relationship between rainfall variability and maize yield in the study area. Archival data of rainfall and crop yield were obtained from relevant Government Ministry and Agency. The data were analysed using trend analysis, regression and correlation analysis with the aid of Statistical Package for Social Science (SPSS) and Minitab. The result of the findings show that rainfall is increasing, while onset is delayed and cessation is early in the study area. The study finding shows that onsets of rainfalls are becoming more uncertain and unpredictable with dry spells after planting in the study area. The result shows that there is a low relationship between maize yield and rainfall variability in the study area. Rainfall variability amounts only to 23% of the total variance influencing maize yield per hectare in the past 30 years in the study area. A reliable estimation of the onset and cessation dates of the rain could help maximise rainwater use by farmers in the study area.

KEYWORDS gassol, maize, rainfall, variability, Taraba State

INTRODUCTION

Rainfall availability is one of the most critical factors affecting crop productivity in rainfed agriculture. Rainfall variability from season to season greatly affects soil water availability to crops, and thus posed serious crop production risks especially in the savanna lands of Nigeria. Three main characteristics of rainfall that are important here are its amount, frequency and intensity, the values of which vary from place to place, day to day, month to month and also year to year. The knowledge of these rainfall characteristics is essential for planning its full utilisation in crop production (Omoyo, 2015). Generally extreme climatic events and the mean values of climate variables such as rainfall influence crop yields under rainfed conditions in most parts of the world.

Agriculture is one of the key socio-economic activities substantially affected by climate variability and change globally (Adamgbe and Ujoh, 2013). Climate change and climate variability are projected to contribute to increased drought episodes, food insecurity, irreversible decline in herd sizes and deepening poverty (Bergamaschi et al., 2001, 2004). The constraints posed by climate change on agriculture range from pronounced seasonality of rainfall to severe and recurrent droughts (Omoyo et al., 2015). The burden of climate change will be enormous on those already poor

and food insecure particularly in Sub Saharan Africa (Bergamaschi et al., 2001, 2004).

Therefore evaluating the impact of rainfall variability on maize yield can provide viable options for enhancing adaptive capacity of small holder farmers in the study area. Studies carried out in other parts of the world shows that crop productivity is highly dependent on climate and weather under rain-fed agriculture (Bergamaschi et al., 2001, 2004; IITA, 2004 and Hulme et al., 2001). In Nigeria, inter-annual rainfall variability has been shown to be a major cause of stress to farming and crop production (Adejuwon, 2005).

The interaction between increase in temperature and precipitation as a result of climate change is likely to result in the loss of arable land due to decreased soil moisture, increased aridity, increased salinity, and ground water depletion (Kandji, 2006). Overall, crop yields in Africa are projected to fall by 10–20% by 2050 because of warming and drying, but there are places where yield losses may be much more severe, as well as areas where crop yields may increase (FAO, 2001).

Maize is the most important and widely consumed food crop in most Sub Saharana Africa and Taraba State in particular. It is the staple food crop for most of the local people in the state. The relationship between maize yield and climate variables has been

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demonstrated by Bergamaschi et al. (2001) and Berlato et al. (2005). The findings revealed that maize plants tend to experience extreme sensitivity to water deficit, during a very short critical period, from flowering to the beginning of the grain-filling phase (Podesta et al., 1999 and Parry et al., 2007). Maize crops tend to have the highest water requirement during the critical period, when the maximum leaf area index combines with the highest evaporative demand (Slingo et al., 2005). Thus, maize crop is very sensitive to water deficit during its critical period (flowering to beginning of grain filling) for two reasons: high water requirement, in terms of evapotranspiration; and high physiological sensitivity when determining its main yield components such as the number of ears per plant and number of kernels per ear (Omoyo et al., 2015).

Previous studies in the state have concentrated on the incidence of climate change and impact on farmers in Taraba State. Attention has not been paid to the impact of individual climatic element such as rainfall on crop yield of any type. There is need to determine how changing climate parameters such as rainfall plays critical role in yields of maize in Gassol LGA of Taraba State. This will help to guide agricultural planning and enhance adaptive capacity of small holder farmers in the study area. The study is important because it can be used to target research into causal relationship between crop yield and climate variability and eventually policy interventions to stabilize farmer's incomes and food supply in the LGA and State at large. It is against this background that this study focuses on the impact of rainfall variability on maize yields in Gassol LGA. Specifically, the study examines the trend of rainfall variability and maize crop production and the relationship between rainfall variability and maize yield in the study area.

MATERIALS AND METHODS

Description of Study Area

Gassol LGA is located within the central zone of Taraba State. It was created in December 14, 1996 by the military administration of late General Sani Abatcha. It is bounded to the north by Karim Lamido LGA, to the south by Bali LGA, to the west by Wukari and Donga LGAs and to the east by Ardo Kola LGA (Fig. 1). Gassol LGA is located between latitude 7°32'N to 8°40'N and longitude 10°25'E to 11°45'E. It has land mass of 5982 km² and population of 244,749 (125,293 males and 119,456 females) according to the 2006 national census. It consists of two large administrative Chiefdoms, namely Gassol and Mutum-Biyu chiefdoms. There are six approved district areas in each of the chiefdom. The major ethnic groups in the area are Wurkum, Wurbo, Jukun, Fulani, Jenjo, Mumuye, Munga and Bandawa. About three-quarter of the population are crop farmers, while others are cattle rearers and fishermen. Maize is the most important crop cultivated in the area. Others include groundnut, yam, cassava, millet and guinea corn. Gassol LGA has a tropical continental climate with

well-marked wet and dry seasons. The wet season starts in April and ends in October, while the dry season commences in November and ends in March. The vegetation is made up of the wooded savanna which consists of different trees scattered all over the region and dense growth of grasses. The soil consists of sandy loam soil which developed from the underlying rock outcrops and clay loam soil developed from flooding along the river valleys. The land is very fertile and produces large quantities of maize and yams, which has led to the influx of migrants from neighboring LGAs and States. Cultural festivities in Gassol LGA include the Zouoh and Malbiyu of the Wurkum people which comes up in April and September to mark the beginning of the cropping season and the harvest season respectively.

Data Collection

The data required for this study include monthly and annual rainfall totals and rain days per annum for Gassol LGA for a period of 30 years. The monthly rainfall data from the Meteorological station at Gassol town of Gassol LGA (latitude 8°31'N) was obtained from the Upper Benue River Basin Development Authority headquarter at Yola. The rainfall data was used in calculating the mean monthly rainfall, annual rainfall, the onset, cessation and length of rainy season. Maize yield data was obtained from Taraba State Agricultural Development Programme for the period 1985–2014. The choice of 30 years was based on availability and consistency of data from the authorities.

Method of Data Analysis

Although, there are many methods of calculating the onset and cessation of rains, the Walter's method (Walter, 1967), which utilises monthly rainfall data, was adopted in this study. The choice of Walters's method is because it is relatively easier to accomplish, more economical and original as it requires no derivation of other indices for the computation but utilizes only the rainfall records which are measured directly (Umar, 2011). The method used to determine the actual date of the onset of rains is as follows:

$$\frac{\text{Days in the month (51 - accumulated rainfall of previous months)}}{\text{Total rainfall for the month}}$$

where the month under reference is that in which the accumulated total rainfall is in excess of 51 mm³, for the cessation date of rains, the formula is applied in the reverse order from December.

The decadal and inter annual variability in the time series of annual temperature and rainfall were analyzed using the trend analysis. Minitab statistical package was used for the analysis. The decadal and inter annual variability in the time series of annual rainfall, length of rainy season, onset and cessation was determined using coefficient of variation (CV), while the trends in the

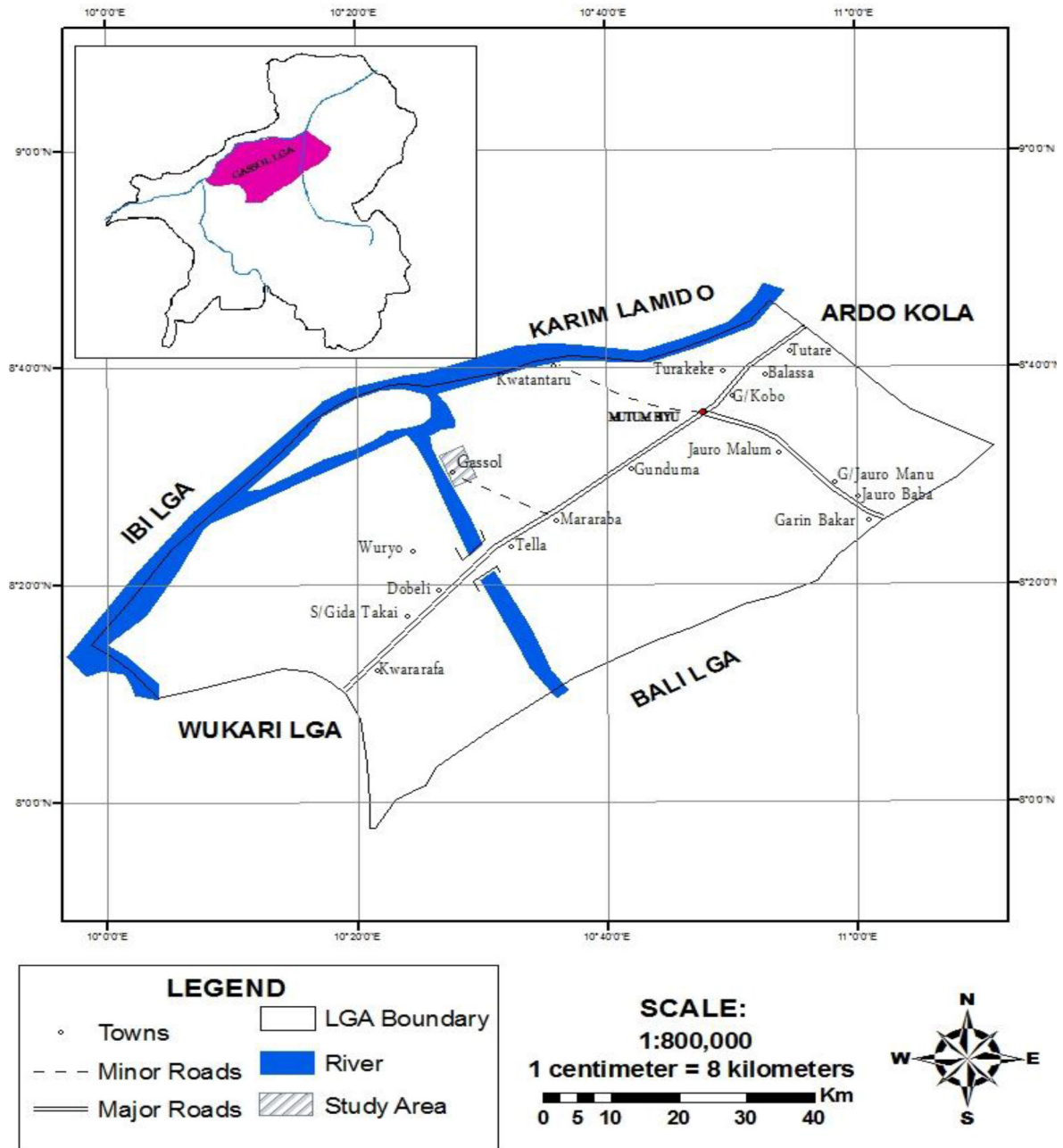


Fig. 1 Map of gassol LGA.

time series of these parameters (annual rainfall, length of rainy season, onset and cessation) were determined using simple regression and correlation analysis. The

coefficient of variation is given as: $CV = \frac{\sigma}{\bar{x}} \times 100\%$

where \bar{x} the mean of the entire series and σ is the standard deviation from the mean of the series.

In order to determine the trend in the time series of the annual rainfall, length of rainy season, onset and cessation in all the stations considered for the period 1978/80–2010/12, the simple regression analysis was used where by the values in the time series were regressed on time. The equation of the line of best fit was then computed using the Minitab statistical software. The equation is as follows:

$$Y = a - b\bar{x} + c$$

where a = intercept of the regression, b = regression of the coefficient and c = error term or residuals of the regression.

To determine whether the trend line in the time series analysed is upward or downward, the simple correlation coefficient (r) was used and defined as follows:

$$r = \frac{\sum xy - \bar{x}\bar{y}}{\sigma_x - \sigma_y}$$

where r is correlation coefficient, N is total number of observations in the series, Y is the observation in the series,

x is the time in years, σ_x is the standard deviation of x and σ_y is the standard deviation of y . Where the value of (r) is positive, it indicates upward trend in the time series analysed and where the value of (r) is negative, it indicates downward trend in the time series analysed. The data were presented using tables, frequencies, figures and percentages.

The Pearson product moment correlation using SPSS software was used in testing the relationship between rainfall variability and maize yield in Gassol LGAs

Hypotheses

H_0 : There is no significant relationship between maize yield and rainfall variability in the study area, its alternative: H_1 : there is significant relationship between maize yield and rainfall variability in the study area.

RESULT OF THE FINDINGS

Description of the Trend of the Climatic Elements

The rainfall data collected were processed and subjected to trend analysis. The summary of the trends of the rainfall characteristics studied are presented in Tables 1 and 2, while the graph of the trend analysis are shown in Figs. 2–9.

Table 1: Summary of the trend of rainfall characteristics studied.

S/No	Climatic Elements	Gassol
1	Annual rainfall	Increasing
2	Onset date of rains	Late
3	Cessation date of rains	Early
4	Length of rainy season (LRS)	Decreasing
5	July monthly rainfall	Increasing
6	August monthly rainfall	Increasing
7	September monthly rainfall	Increasing

Source: Computer analysis.

Annual Rainfall

Annual rainfall data show increasing trend in the study area. The trends of annual rainfall in Gassol station showed an upward trend (Fig. 2). Previous studies on climate change in Taraba State by Adebayo (2012) and Oruonye (2014 a, b) shows that the rainfall decreases from south to north of the state. Annual rainfall decreases as latitude increases. Rainfall averages in the study area for the period 1985 to 2014 is 958mm³ (Gassol, Lat. 8°31'N) (Table 2).

Length of Rainy Season (LRS)

Length of rainy season (LRS) is the difference between the cessation date and onset date. Length of rainy season in the study area shows decreasing trend (Fig. 3). The implication of such a trend, mean a reduction in annual rainfall amount,

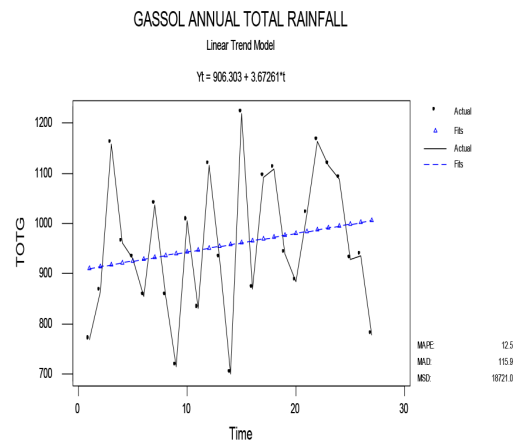


Fig. 2 Trend of annual total rainfall in gassol.

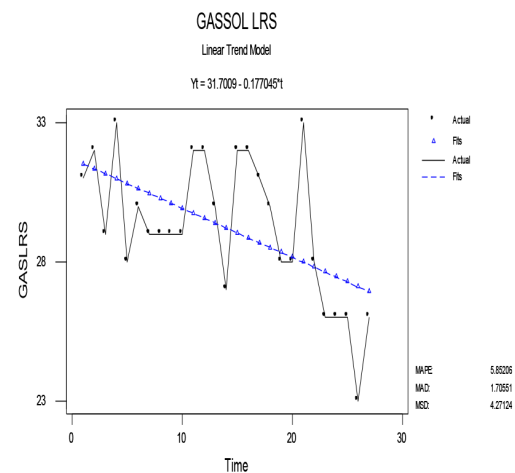


Fig. 3 Trend of LRS in gassol.

Table 2: Summary analysis of climatic data.

Variable	Gassol (8°31')
Annual rainfall	
Mean (mm)	957.7
Coefficient of variation (%)	15
Onset date of rain	
Mean (date)	10th May
Coefficient of variation (%)	6
Cessation date of rain	
Mean (date)	6 th Oct.
Coefficient of variation (%)	4
Length of rainy season (LRS)	
Mean (days)	145 days
Coefficient of variation (%)	9

Source: Computer analysis.

and hence reduced crop yield, especially if the trend persisted for a long period of time, which can lead to a tendency towards a drier condition. The mean length of rainy season (LRS) shows that the study area has 145 days (Table 2).

Onset and Cessation

The onset refers to the time a place receives an accumulated amount of rainfall sufficient for the growing of crops. It is not the first day the rain falls (Adebayo and Oruonye, 2013). Walter (1967) define onset of rains in Nigeria in terms of time of receiving an accumulated amount of rainfall in excess of 51mm³. Rainfall cessation means the termination of the effective rainy season. It does not imply the last day rain fell, but when rainfall can no more be assured (Adebayo and Oruonye, 2013). The end of the rains is the date after which no more than 51 mm³ of rain is expected (Umar, 2010). The result from the study shows that the study area has late onset of rain (Table 1 and Fig. 4). It is important to stress that from Table 1, the onset and cessation of the rains in the study area tend to concentrate around the months of April/May and October/September, respectively. Onset date of rain exhibits an upward trend (Fig. 4). This indicates that the rain is starting late and hence the beginning of growing season is being delayed in the study area. This was reported in previous studies in the state by Adebayo 2012 and Oruonye (2014 a,b). Cessation date of rain exhibits a downward trend in the study area (Fig. 5). This clearly shows that the rains now end earlier in the study area. The specific date of occurrence of either the onset or cessation of the rains is an important consideration in determining the beginning and end of the growing season in an area (Umar, 2010). Efficient crop production in the tropics is equated with the onset of rain and cessation of rainy season and its variability. This is because, onset, cessation and length of the rainy season form important components of moisture resources status for determining the potential of various crops (Olanrewaju, 2006).

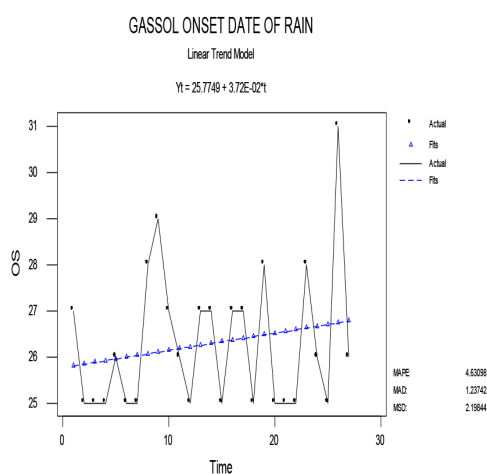


Fig. 4 Trend of onset dates of rain in gassol.

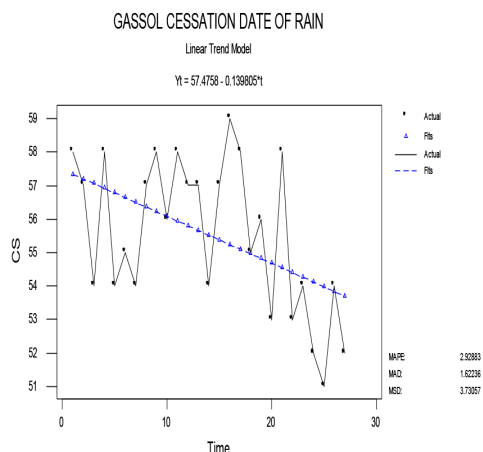


Fig. 5 Trend of cessation dates of rain in gassol.

In regions characterised by seasonal rainfall which is associated with dry spells of varying magnitudes as is the case with the study area, a reliable determination of the onset of the rains is not only pertinent to the determination of the time to plant or transplant with minimum risks of crop failure but also critical to good crop yield such as maize (Umar, 2010). On the other hand, a fairly accurate determination of the cessation of the rains might not only facilitate the determination of a dependable duration of the rains at a given location but is also beneficial to the selection of crop varieties that will mature by the end of the growing season.

From the findings of the study, July and August monthly rainfall show increasing trend in the study area. The monthly rainfall of September shows decreasing trend in the study area. In Gassol, the study area, monthly rainfall in July and August is increasing while that of September is decreasing. This finding is corroborated by the result of an earlier study by Adebayo (2012) and (Oruonye, 2014 a,b). Increase in rainfall in August and September is usually accompanied with floods (Oruonye, 2014 a,b). Adebayo (2012) observed that the floods are being aggravated in many parts of Taraba and Adamawa states by the release of excess water from Lagdo dam in the Republic of Cameroon.

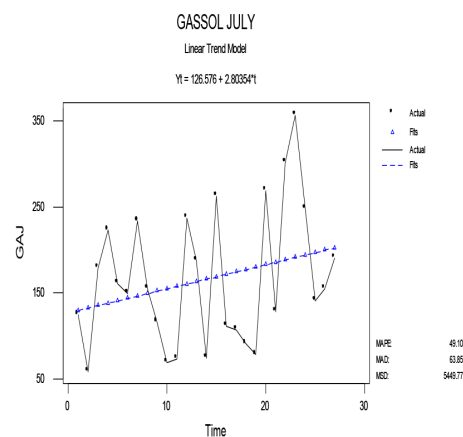


Fig. 6 July rainfall in gassol.

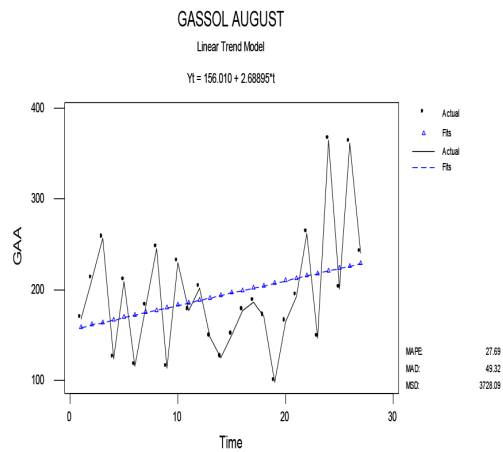


Fig. 7 August rainfall in gassol.

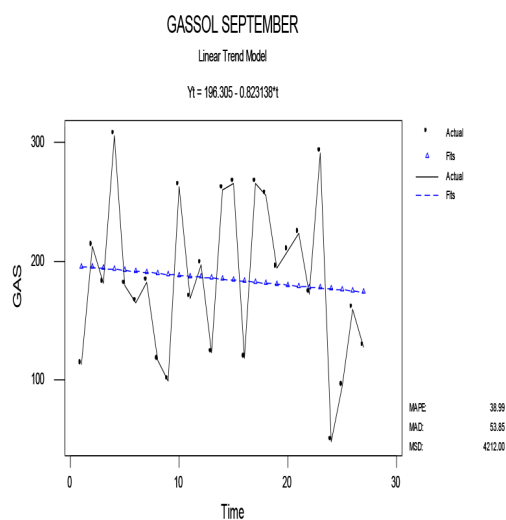


Fig. 8 September rainfall in gassol.

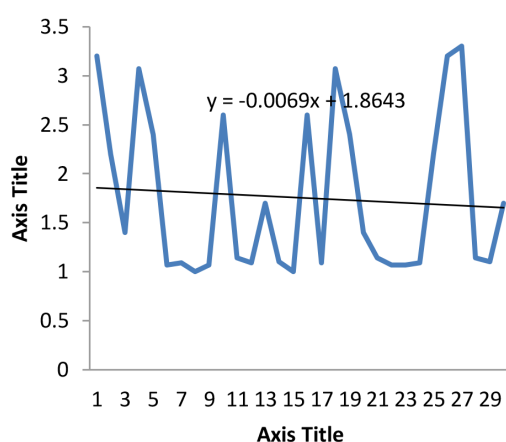


Fig. 9 Trend of maize production in the study area.

Maize Yield

The result of the analysis shows that the highest maize yield of 3.3 ton/ha was recorded in 2011 and the lowest

yield of 1.0 ton/ha was recorded in 1992 and 1999. The results of the findings show that the mean annual maize yield is 1.76 tons/ha. Thus, with a range of 2.3, mean of 1.72, standard deviation of 0.81, maize yield was more likely heterogeneous under the period of study. Studies in other parts of Africa have shown that the less the rainfall variability, the less maize yield anomalies thus the more reliable the rain is for maize production (Nyandiko et al., 2015). The results appear to support the view of (IITA, 2004) that higher variations in rainfall above the mean eventually leads to fluctuations in maize yields and thus food insecurity. As recently demonstrated by Bergamaschi et al. (2004), maize yields in Africa at lower altitudes is likely to fall by 20–50% because of drying and warming as a result of climate change.

DISCUSSION OF RESULTS

Generally, rainfall onset, cessation, distribution and amount have considerable effect on maize yields and food security particularly under rain-fed conditions. The annual rainfalls, length of rainy season, onset and cessation dates are important crop growing season parameters. This makes growing season variability an important indicator of climate change. Hence, better knowledge of the characteristics of the rainfall regimes is required to make assessment of agricultural potential more realistic. Annual rainfall in the study area poses serious constraint on maize production in the study area.

The onset of the rainy season determines the commencement of the growing season and date of planting for the farmer. A delay in the onset of the rainy season, particularly in the wet and dry environment like the study area will delay the date of planting and will result in maize crops extending their growing into the winter season, where the prevailing lower temperatures will negatively affect maize crop yield. On the other hand, an early cessation of the rainy season will result in the cutting short of the growing season of crops and consequently result in maize crops failing to reach their physiological maturity stage. The length of rainy season which also determines the length of the growing season is defined as the period in days from the date of the onset to the date of cessation of the rainy season.

Dry spells cause poor germination, increase the need for replanting and leading to wilting and drying out of maize crops. Onsets of rainfalls are becoming more uncertain and unpredictable with dry spells after planting in the study area. It used to rain for few days (i.e. 5 days), then dry for a couple of days. The dry spell could not be calculated for the study area because of difficulty of getting the daily records for the past 30 years. Since maize farming in the study area usually follows the start of the rains, if a long dry spell occurs, the maize seedlings die (false start) and the farmers are compelled to replant (Oruonye, 2014 a,b). Therefore, a reliable estimation of the onset and cessation dates of the rain could help maximise rainwater use by farmers in the study area (Oruonye, 2014 a,b).

Table 3: Result of correlation analysis.

		VAR00001	VAR00002
VAR0000	Pearson Correlation	1	-.012
1	Sig. (1-tailed)		.476
	N	30	30
VAR0000	Pearson Correlation	-.012	1
2	Sig. (1-tailed)	.476	
	N	30	30

The result of the Pearson product moment correlation is presented in Table 3. The result shows that the coefficient of correlation 'r' is 0.476. This shows there is a low relationship between maize yield and rainfall variability in the study area. This implies that there are other factors apart from rainfall variability that influences maize crop yield in the study area. The coefficient of determination 'r²' is 0.23 which is computed to be 23%. This means that rainfall variability amount only to 23% of the total variance influencing maize yield per hectare in the past 30 years in the study area. The remaining 77% of the variations in the yield of maize could be attributed to other factors. These factors could be soil characteristics, farming methods, weeds, level of flooding, seed varieties, pest and diseases, human labour, soil fertility, fertilizer use and harvesting methods among others.

The test of significance shows that the result is not statistically significant at 5% ($P < 0.05$). Thus we accept the null hypothesis of no significant relationship between maize yield and rainfall variability in the study area and reject the alternative.

CONCLUSION

This study has examined the trend of rainfall variability and maize crop production and the relationship between rainfall variability and maize yield in the study area. Archival data of rainfall and crop yield obtained from relevant Government Ministry and agency were used in the study to analyzed trend of rainfall characteristics and maize yield in the study area. The study findings show that onsets of rainfalls are becoming more uncertain and unpredictable with dry spells after planting in the study area. The mean maize yield in the study area for the period under investigation is 1.76 tons/ha. The result shows that there is a low relationship between maize yield and rainfall variability in the study area. Rainfall variability amounts only to 23% of the total variance influencing maize yield per hectare in the past 30 years in the study area. Since maize farming in the study area usually follows the start of the rains, if a long dry spell occurs, the maize seedlings die (false start) and the farmers are compelled to replant. Therefore, a reliable estimation of

the onset and cessation dates of the rain could help maximise rainwater use by farmers in the study area. Based on the findings of this study, there is need for the government to pay more attention to the improvement of extension services and communication of weather and climate information to the farmers. Irrigation can be encouraged in the area to reduce the high dependence on rainfed agriculture.

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