# Climate Change in Adamawa State, Nigeria: Evidence from Agro Climatic Parameters

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## Abstract

The aim of this paper is to assess the extent and nature of climate change in the state based on some agro climatic data from different parts of the state. Monthly rainfall data for 36 years from three stations namely Gyawana, Yola and Mubi representing the southern, central and northern senatorial zones of the state respectively were obtained. Monthly maximum and minimum temperature data were also collected for the same period and stations. These data were subjected to various agroclimatological analysis, descriptive and trend analyses. Results of the trend analysis of climatic data from different parts of the state revealed that: mean temperature is increasing, annual rainfall is decreasing, onset date of rain is increasing (delayed onset), cessation date of rains is decreasing (early cessation), while length of rainy season is reducing. Similarly, monthly rainfall in May, July, August and October is decreasing while monthly rainfall in June and September is increasing. The decrease in May, July and August rainfall leads to persistence of dry spells in the state especially in July and August. Increase in rainfall in September in recent years is usually accompanied with floods.

**Keywords:** Climate change, trend analysis, annual rainfall, temperature, onset and cessation dates

## Introduction

Climatic change involves a shift of climatic condition to a new equilibrium position with values of climatic elements changing significantly. The Inter governmental Panel on Climate Change (IPCC) defines climate change as any change in climate over time, whether due to natural variability or as a result of human activity. Climate change may be due to natural process or external forces or to persistent anthropogenic changes in the composition of the atmosphere or land use. Human induced factors account for short-term variations in climate over the last century. Such human-induced changes include: the emissions of green house gases and aerosols, changes in land use and the depletion of the ozone layer through various human activities such as industrialization, urbanization, and agriculture and land clearance amongst others. The outcome of these induced changes is global warming which is the most visible index of global climate change (Adebayo, 2010).

Climate change is a major global environmental problem facing the entire world today. Its impact is felt in all facets of life. Many social, biological and geophysical systems are at risk from climate change. In Adamawa state, Nigeria, recent environmental changes and its associated socio economic consequences suggest the presence of climate change (Adebayo, 2010). However, the extent and nature of climate change in Adamawa state based on the existing climatic data have not been

comprehensively documented. Hence, the aim of this study is to present the evidences of climate change in the state based on long term analysis of some agro climatic variables.

**Materials and Methods**

Adamawa State is located at the North Eastern part of Nigeria. It lies between latitude 7 and $11^0$ N and between Longitude 11 and $14^0$ E. It shares boundary with Taraba State in the south and west, Gombe State in its North-west and Borno state to the North. The State has an international boundary with the Cameroon Republic along its eastern side (Fig. 1). It has a land area of about 38,741 $km^2$ (Adebayo, 1999). The state is divided into 21 local government areas.

Adamawa State has a tropical wet and dry climate. Dry season lasts for a minimum of five months (November-March) while the wet season spans April to October. Mean annual rainfall in the state ranges from 700mm in the North-west, to 1600mm in the extreme southern part of the state (Adebayo, 1999).

The state is naturally divided into two ecological zones; the guinea and Sudan savannah zones. In general, the distribution of vegetation reflects the combined control of rainfall, topography and to a lesser extent, that of soils. Agriculture is the mainstay of about 80% of the inhabitants of the State. The ecological condition of the state permits cultivation of root crops, cereals and rearing of livestock in large numbers.

Monthly rainfall and temperature data for a period of 36 years were collected from Nigerian Meteorological Agency, Yola, Uer Benue River Basin Authority Yola, Savanna Sugar Company, Gyawana, ADP zonal office, Mubi and Adamawa State University, Mubi. The data were subjected to agroclimaological analysis for the computation of onset, cessation and length of rainy season. Several methods have been proposed for computing these indices e.g. Walter (1967), Olaniran (1988), Adefolalu (1993). In this study the Walter (1967) method which utilizes monthly rainfall data was adopted. The method is as follows for the start of rainy season:

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

where the month under reference is that during which the accumulated total of rainfall is in excess of 51 mm. For the cessation date of rains formula is alied in the reverse order from December.

The data were further subjected to both descriptive and inferential statistics. The descriptive statistics involves the use of means, standard deviation coefficient of variation and percentages while trend analysis was used to analyse the climatic elements over the past 36 years.

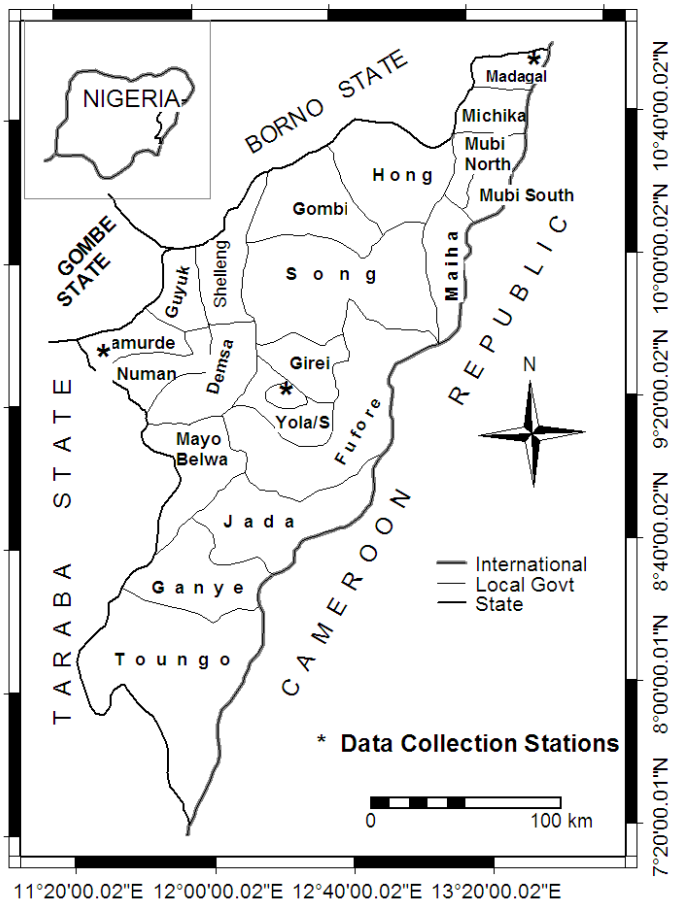


**Fig 1: Map of Adamawa State Showing Data Collection Stations**

## Results and Discussion

### *Statistical Summary of the Major Climate Elements*

In this chapter, attempt was made to examine the climate condition in the state in the last 30-36 years. The major elements examined are mean temperature, annual rainfall, the onset date, cessation date and length of rainy season. In addition the pattern of monthly rainfall from May to October is also discussed. This analysis covers three locations (one from each zone) that have records of climatic data for the desired period. Table 1 shows the summary of the major climate elements considered.

***(a) Mean Temperature:*** The mean temperature values for the three locations are 28.53$^{o}$C for Gwayana, 28.33$^{o}$C for Yola while that of Mubi is 25.43$^{o}$C. This shows that temperature is comparatively lower in Mubi (Northern zone) than other parts of the state. This is due to relief factor. This zone is located on the high lands where elevation ranges between 400 and 1500m above sea level (Adebayo and Dayya, 2004). Temperatures normally decrease with

increasing altitude. The state mean temperature is 28.11.The coefficient of variation shows that Yola has lowest (2.72%) indicating that annual temperature in Yola is less variable over the years.

***(b) Annual Rainfall:*** The mean annual rainfall ranges from 865.2mm in Gyawana to 1113.3mm in Mubi while the state mean is 936.1mm. The coefficient of variation indicates that annual rainfall is more variable in Gyawana than Yola and Mubi.

***(c) Onset, Cessation and Length of rainy season:*** The mean onset date is earlier in Yola ($5^{th}$ may) than in Gyawana ($15^{th}$ May) and Mubi ($10^{th}$ May). The coefficient of variation shows that onset date is more variable in Gyawana. The mean cessation date is virtually the same for all the locations ($6^{th}$ October) except Mubi which is $1^{st}$ October. The coefficient of variation shows that this parameter is less variable over the state. The mean length of rainy season (LRS) for the state is 152 days which is almost the same for Mubi and Gyawana. However, Yola has a slightly higher LRS of 161 days.

***(d) Monthly rainfall (May to October) in Yola:*** The mean monthly rainfall is highest in August (198mm) closely followed by September (192 mm). These are the months of peak rainfall in the state during which flash floods always occur especially in settlements along the river courses. The coefficients of variation indicate that monthly rainfall in May, June and October are highly variable with CV values greater than 40%. July has the least variability (28.32%).

***Trend of the climatic elements***

***(a) Temperature:*** The long term trend of temperature in Gyawana and Yola are shown in Figures 2 and 3. There is no sufficient temperature data for Mubi for this trend analysis. The graphs for the two locations indicate that there is an upward movement in this element over the years. This upward trend in temperature is a reflection of the global warming resulting into general increase in the earth's temperature. The implication of increasing temperature is enormous on man and his environment. These include increase heat related diseases, wilting of crops, and reduction in water resources. Adebayo (2001) also reported a high correlation between maximum temperature and reported cases of measles in Yola. Regression analysis suggests that the cases of measles increases by 15% for every $1^{o}C$ increase in maximum temperature.

**Table 1:** Summary Analysis of Climatic Data

| Variable | Gyawana | Yola | Mubi | State Mean |
|---|---|---|---|---|
| **Temperature** | | | | |
| Mean ($^0$C) | 28.53 | 28.33 | 25.427 | 28.11 |
| Coefficient of Variation (%) | 3.86 | 2.72 | 5.68 | 3.50 |
| **Annual rainfall** | | | | |
| Mean (mm) | 865.2 | 951.3 | 1113.3 | 936.1 |
| Coefficient of Variation (%) | 31.28 | 11.79 | 14.61 | 17.35 |
| **Onset date of rains** | | | | |
| Mean (pentade) | 26.931 | 24.500 | 25.913 | 25.912 |
| Coefficient of Variation (%) | 15.56 | 11.77 | 9.00 | 8.31 |
| **Cessation date of rains** | | | | |
| Mean (pentade) | 55.96 | 55.694 | 54.739 | 55.468 |
| Coefficient of Variation (%) | 3.92 | 3.98 | 7.93 | 2.73 |
| **Length of rains** | | | | |
| Mean (days) | 149.66 | 161.14 | 151.96 | 152.25 |
| Coefficient of Variation (%) | 16.92 | 11.87 | 14.46 | 9.03 |
| **May rainfall** | | | | |
| Mean (mm) | | 122.50 | | |
| Coefficient of Variation (%) | | 42.86 | | |
| **June rainfall** | | | | |
| Mean (mm) | | 140.00 | | |
| Coefficient of Variation (%) | | 40.79 | | |
| **July rainfall** | | | | |
| Mean (mm) | | 192.0 | | |
| Coefficient of Variation (%) | | 28.32 | | |
| **August rainfall** | | | | |
| Mean (mm) | | 197.7 | | |
| Coefficient of Variation (%) | | 37.23 | | |
| **September rainfall** | | | | |
| Mean (mm) | | 180.6 | | |
| Coefficient of Variation (%) | | 38.65 | | |
| **October rainfall** | | | | |
| Mean (mm) | | 59.97 | | |
| Coefficient of Variation (%) | | 70.62 | | |

**Source:** Computed from the raw climatic data (1975-2010)

***(b) Annual rainfall:*** The trends of annual rainfall in the three locations are depicted in figures 4 to 6. There is a general downward trend of annual rainfall all over the state. In general, annual rainfall has been decreasing in Nigeria in recent decades. For instance, Odjugo (2010) reported a downward movement of annual rainfall in Nigeria based on the mean values of the selected stations. Similarly, Umar (2011) reported a downward trend in annual rainfall in over 42% of the rainfall stations studied. The implications of decreasing rainfall include reduction in surface water availability,

drought, crop failure and scarcity of animal fodders.

***(c) Onset, Cessation and Length of rainy season:*** Onset dates of rains exhibit an upward trend in all the three locations ( Figures 7-9). This indicates that rainfall is starting late and hence the beginning of growing season is being delayed all over the state.

Cessation dates of rains (Figures 10-12) displays a downward trend in Gyawana and Yola indicating that rains now end earlier in these locations. However the graph for Mubi shows an upward trend. Generally in the Sudano Sahelian zone of Nigeria, there has been a downward trend of cessation dates of rains in the last three decades (Sawa and Adebayo, 2011).

Length of rainy season is decreasing in all locations as shown in figures 13- 15. This is expected because late onset and early cessation will produce short length of rainy season. This finding has also been corroborated by Sawa and Adebayo (2011) for northern Nigeria.

***(d) Monthly rainfall (May to October) in Yola:*** The graphs of May, July, August and October show downward trend while those of June and September show upward trend (Figures 16-21). The decrease in May, July and August rainfall might be due to persistence of dry spells in the state especially in July and August as reported by Adebayo (1998). Increase in rainfall in September is common in recent years and it is usually accompanied with floods as in the case of Gyawana and Yolde Pate (Yola south LGA) in 2011.

**Conclusion and Recommendations**

The long term trends of temperature in Numan and Yola indicate that there is an upward movement in this element over the years. This upward trend in temperature is a reflection of the global warming resulting into general increase in the earth's temperature. The trends of annual rainfall in the three locations (Gyawana, Yola and Mubi) showed that there is a general downward trend of annual rainfall all over the state. Onset dates of rains exhibit an upward trend in all the three locations. This indicates that rainfall is starting late and hence the beginning of growing season is being delayed all over the state. Cessation dates of rains displays a downward trend in Gyawana and Yola indicating that rains now end earlier in these locations. Length of rainy season is decreasing in all locations.

Monthly rainfall in May, July, August and October is decreasing while monthly rainfall in June and September is increasing. The decrease in May, July and August rainfall leads to persistence of dry spells in the state especially in July and August. Increase in rainfall in September in recent years is usually accompanied with floods.

To reduce the scourge of climate change in the state, it recommended that:

i. Government should establish weather stations in all the 21 LGAs in the state to enhance access to weather information.
ii. Farmers should adjust planting dates to avoid crop failure due to late onset and early cessation of rains.
iii. Government, Non Governmental Organisations (NGOs) and civil society organizations should intensify environmental education and awareness campaign on climate change impacts, mitigation and adaptation.
iv. The state Ministry of Environment should prepare a strategic plan for combating climate change and other environmental problems.

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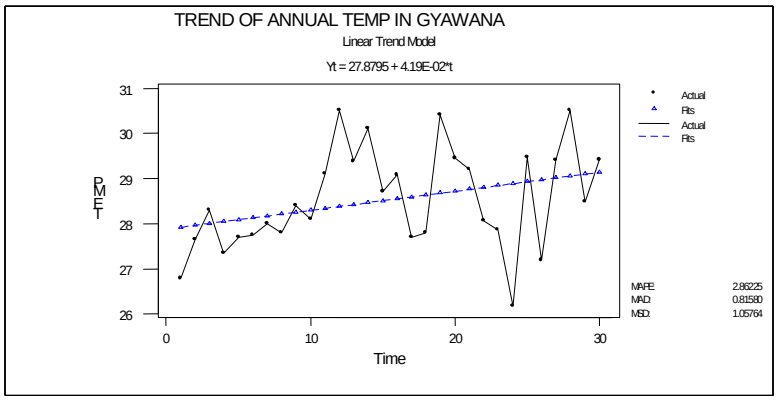


**Fig. 2:** Trend of Mean Annual Temperature in Gyawana

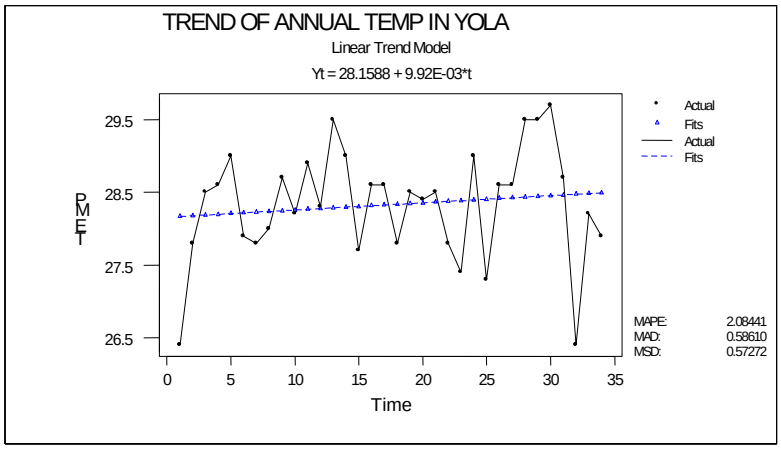


**Fig 3:** Trend of Annual Temperature in Yola

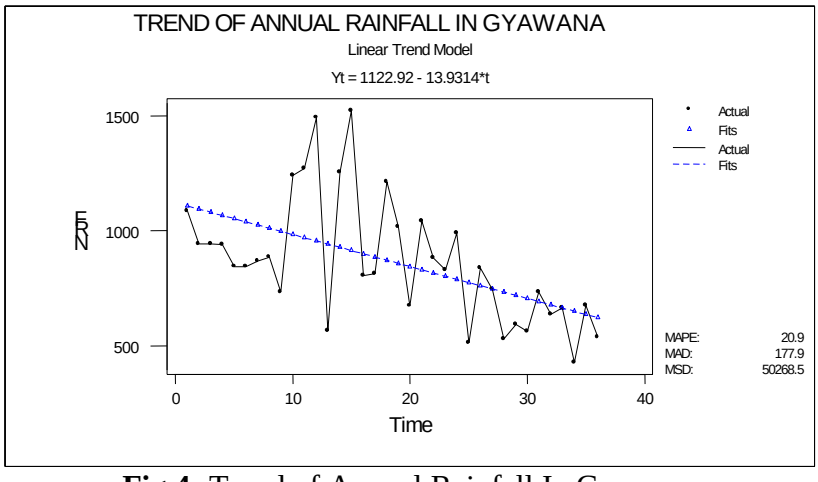


**Fig 4:** Trend of Annual Rainfall In Gyawana

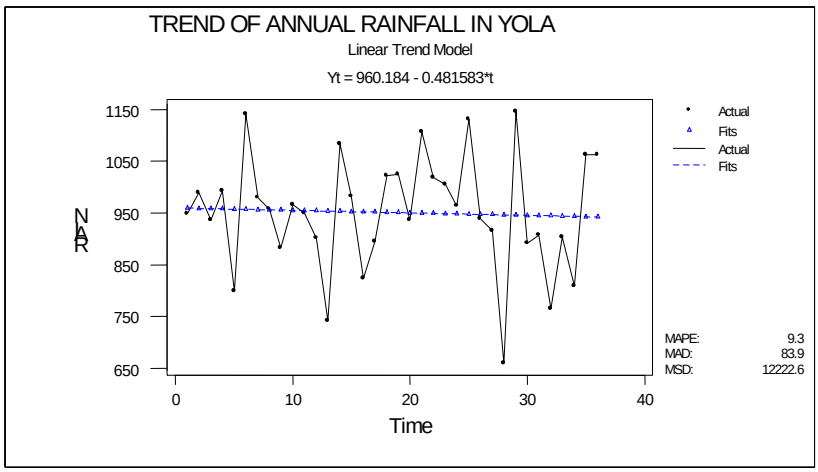


**Fig.5:** Trend of Annual Rainfall In Yola

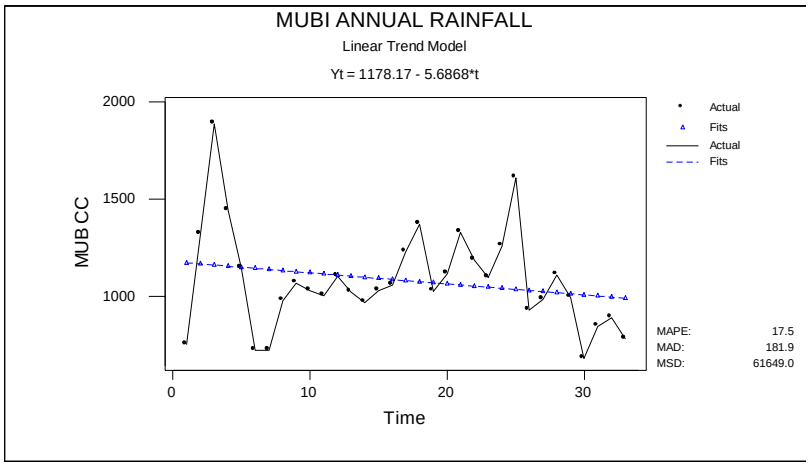


**Fig. 6:** Trend of Annual Rainfall in Mubi

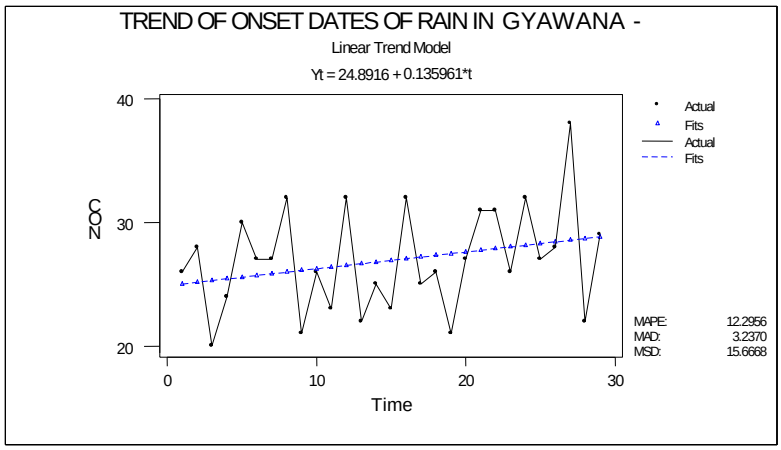


**Fig. 7:** Trend of Onset Dates Of Rains in Gyawana

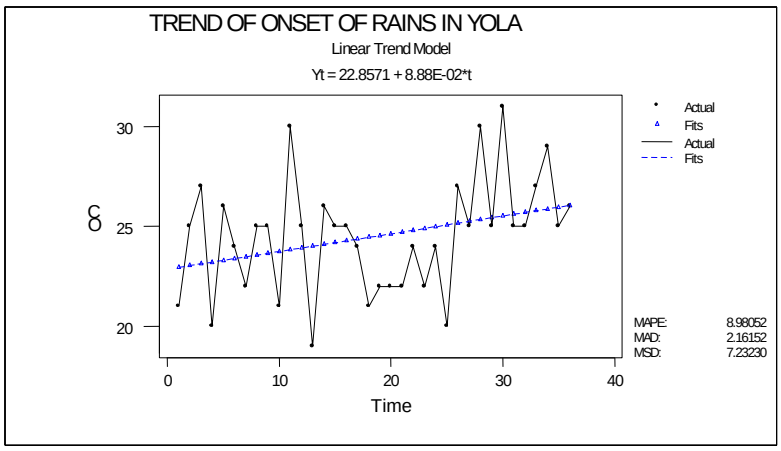


**Fig. 8:** Trend of Onset Dates of Rains in Yola

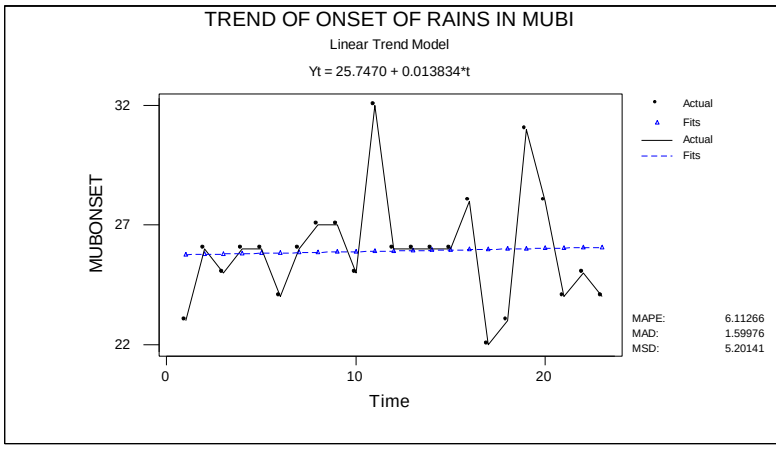


**Fig. 9:** Trend of Onset Dates of Rains in Mubi

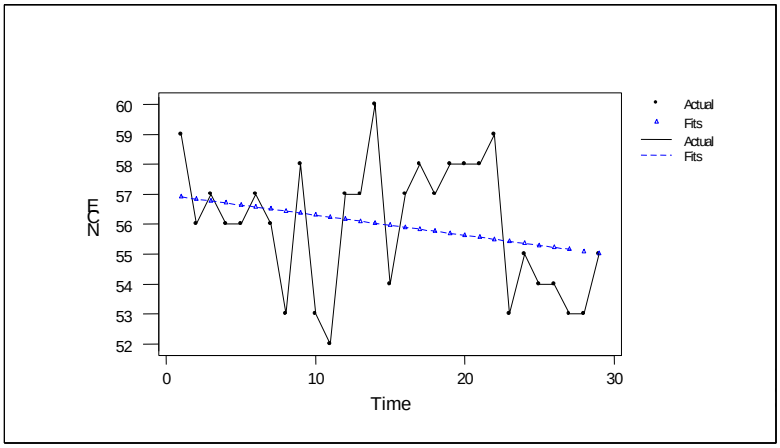


**Fig. 10:** Trend Of Cessation Dates of Rains in Gyawana

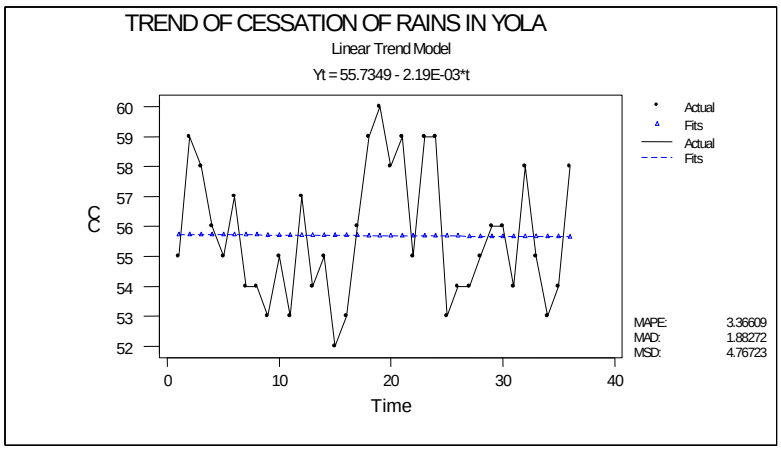


**Fig.11:** Trend of Cessation Dates of Rains in Yola

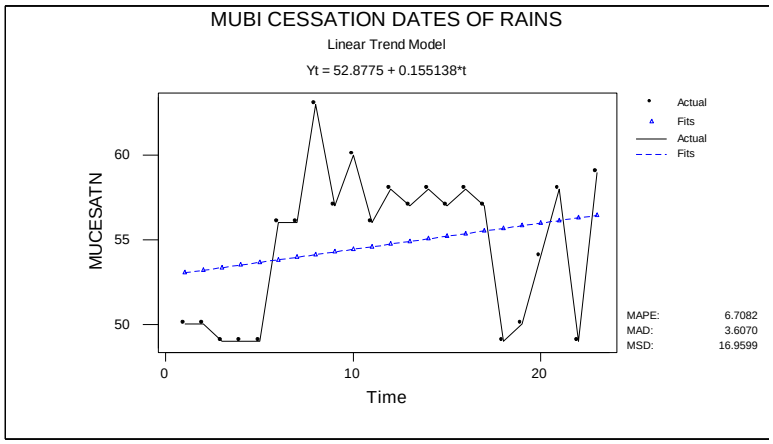


**Fig. 12:** Trend of Cessation Dates of Rains in Mubi

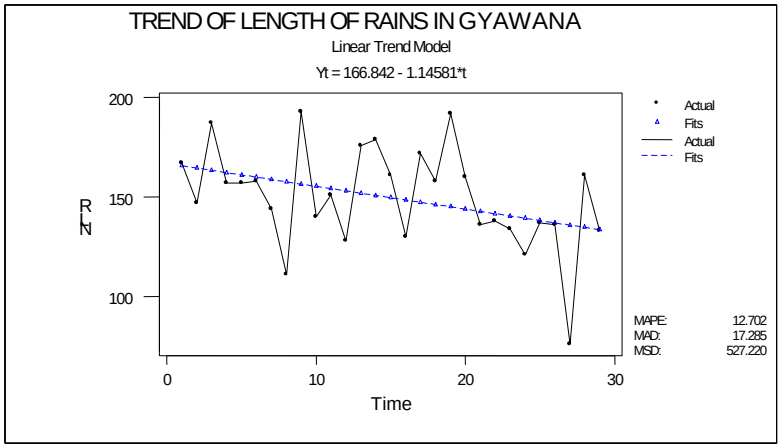


**Fig. 13:** Trend of Length of Rainy Season in Gyawana

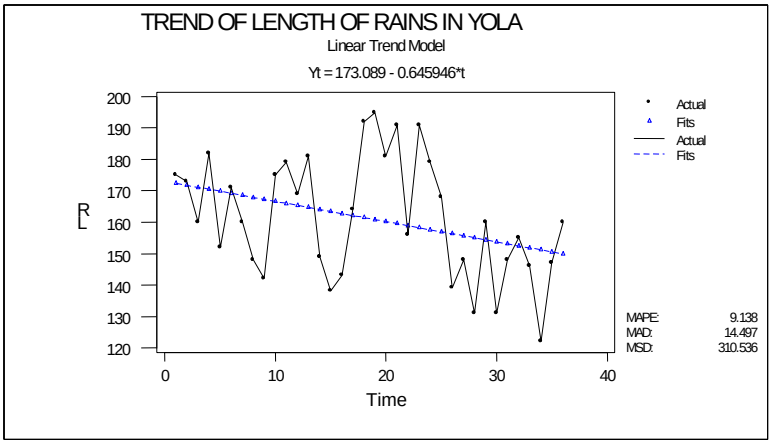


**Fig. 14:** Trend of Length of Rainy Season in Yola

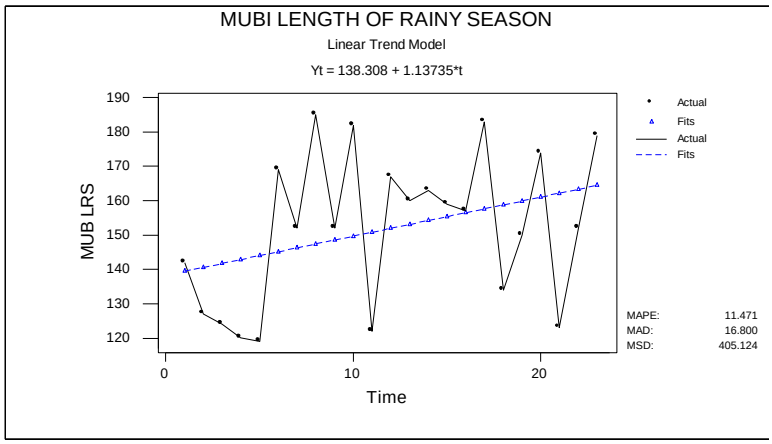


**Fig. 15:** Trend of Length of Rainy Season in Mubi

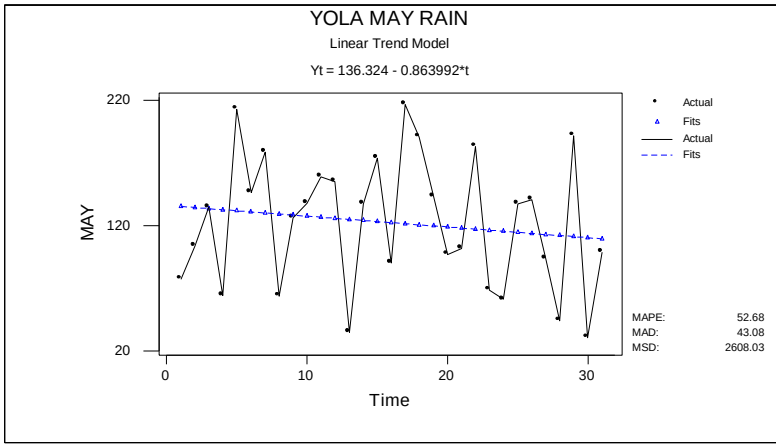


**Fig. 16:** Trend of May Rainfall in Yola

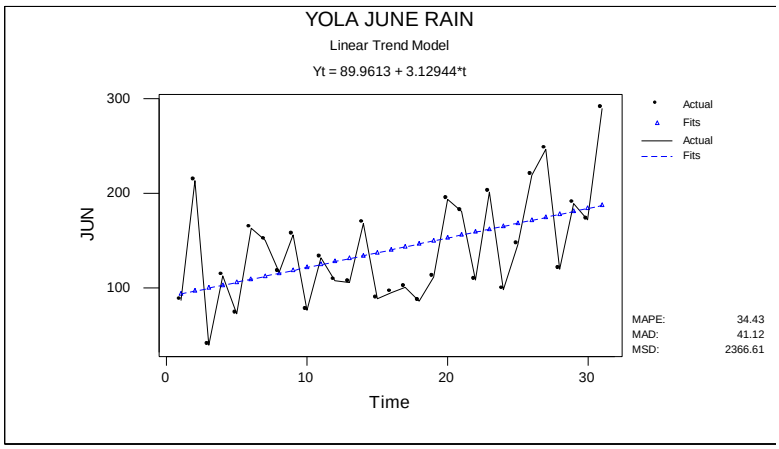


**Fig. 17:** Trend of June Rainfall in Yola

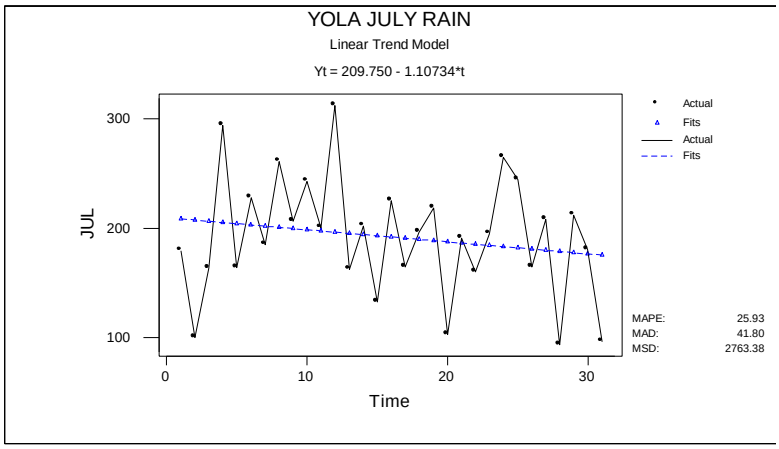


**Fig. 18:** Trend of July Rainfall in Yola

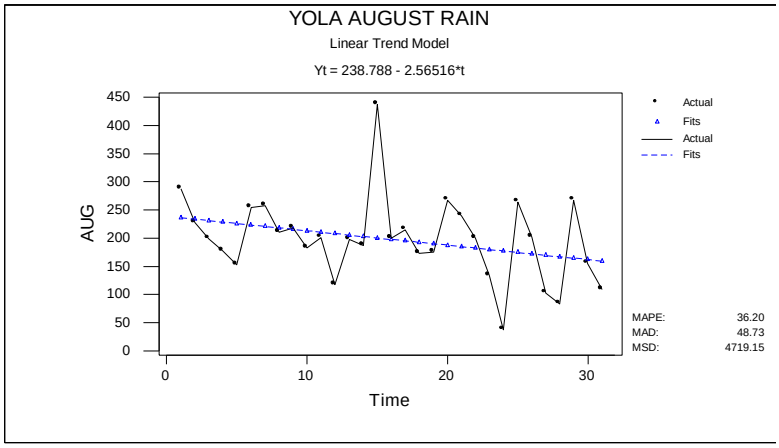


**Fig. 19:** Trend of August Rainfall in Yola

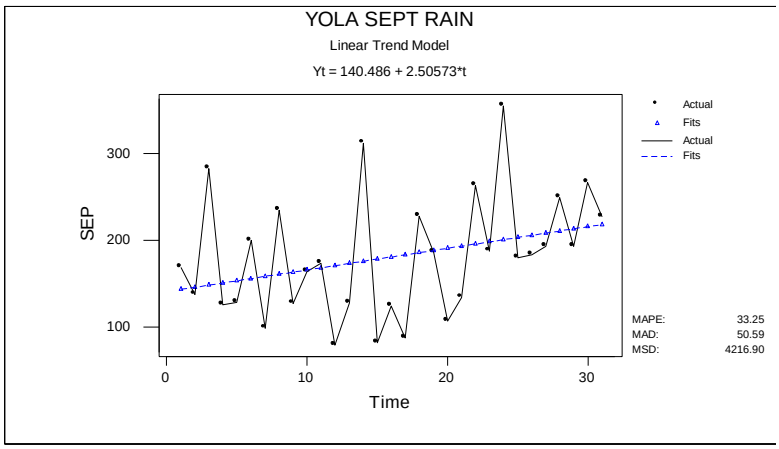


**Fig. 20:** Trend of September Rainfall in Yola

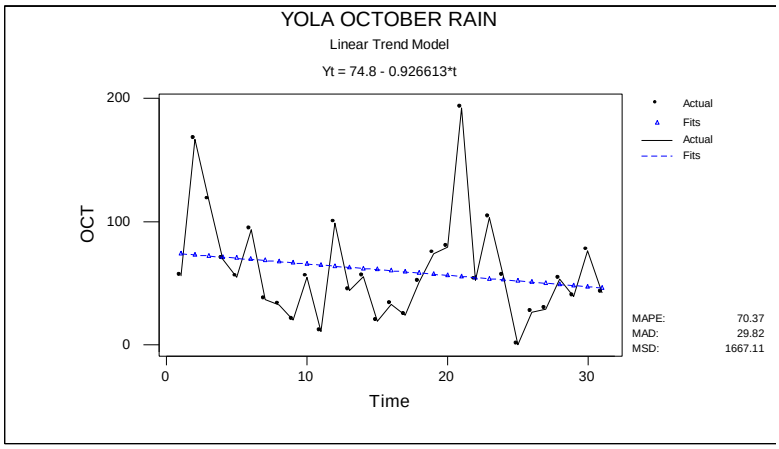


**Fig. 21:** Trend of October Rainfall in Yola