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***Research Paper***

# Statistical Study of Annual and Monthly Rainfall Patterns in Ekiti State, Nigeria

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**Abstract:** *Rainfall is a determinant factors of many human and natural resources, hence the need to study the anomaly in the trends. This paper examines the recent trends in the rainfall pattern for Ekiti State for 10 years (2001–2010) using data from Ekiti State Agricultural Development Programme, Ikole Ekiti. Descriptive and Time series analyses were used to depict the temporal distribution of rainfall. The results show that there is a significant change in the distribution and characteristics of rainfall such as occurrence and intensity in the monthly and annual rainfalls in Ekiti State. The results of the standardized anomaly, Moving Average and the linear trend show that there are fluctuations in the annual rainfall even though the positive and the negative deviations are evenly distributed.*

**Keywords:** Rainfall, time series analysis, Ekiti State, standardized anomaly index, trends.

## Introduction

Rainfall is very crucial for the economic development of Ekiti State as the integral percentage of the people (especially adults of 50 years $^{+}$) get involved in rain fed agriculture (crop and plantation). As a state whose economy is heavily dependent on productive rain fed agriculture, rainfall trends are often cited as one of the causes of socio-economic problems such as food insecurity. The changing climatic condition has been attributable to rainfall (Adger et al., 2003, Obot *et al.*, 2010), studies have also shown that the climate is changing based on the changing pattern of rainfall (Goswami *et al.*, 2006; Adger *et al.*, 2003). Studies of changing spatial pattern of annual and rainy season monthly rainfalls indicate a long run of dry years for sub-Saharan West Africa dating back to the 1940s (Gregory 1983). Climate classification system has been based majorly on the average annual rainfall to help

differentiate climate regimes; Ragab and Prudhomme (2002) examine the variability and uncertainty of rainfall across the globe amidst global warming. Ogolo and Adeyemi (2009) in their work on variations and trends of some meteorological parameters at Ibadan see rainfall as the most variable parameter and air temperature as the least. The highly variable nature of rainfall as compared with the relatively stable nature of temperature appears to have imbued more relevance to rainfall as the major component in the study of climatic change (Gbuyiro *et al.*, 2002; Kane 1999).

Many studies consider the long term structure of rainfall characteristics, for example Olaniran (1990) considers the changing pattern of rain-days in Nigeria between 1919-1985, Omogbai (2010) studies rain days in South Western Nigeria between 1970-2006, Guhathakurta and Rajeevan (2006) study the trends in the rainfall pattern over India between 1901-2003, Obot *et al.*, (2011) also consider the trends of rainfall in Abeokuta, Nigeria between 1981-2002 etc. Although many findings considering the long term structure of rainfall in Nigeria show significant trend in rainfall time series in the Northern part falling into Sahel climate and insignificant trend in the South and other Northern places outside the Sahel with steady regime of rainfall (Ati *et al.*, 2009; Obot *et al.*, 2010, 2011) despite the wide growing evidence of global change with regards to rainfall (Rupa Kuma et al., 1992; Lamb 1980, 1982; Hutchinson 1985, Enete and Ebenebe 2009; Ragab and Prudhomme, 2002; Subyani, 2004) and other climatic characteristics. Obot et al., (2011) posited that method adapted for analysis and period of study are two major factors to consider when studying the trend of rainfall.

Thus there is the need to study the short term structure of rainfall characteristics especially in the study area being a fairly new state (15 years) with recent development such as urbanization, deforestation, industrialization, civilization etc affecting rainfall and being affected by rainfall. The past short term performance of rainfall may give a better indication of the future scenario than that of past long term performance since human and natural activities over the past few years are more rapid than that of the long term.

## Study Area

Ekiti State, located within latitude $7.67^0$N and longitude $5.25^0$E was created out of the old Ondo in 1996 with its capital in Ado Ekiti in the south west geopolitical zone of Nigeria. The climate is of south-western Nigeria lowland tropical rain forest type with distinct wet and dry seasons. The dry season comes up between November and April while the wet season prevails between May and October. In the South, the mean monthly temperature is about $28^0$c with a mean monthly range of $3^0$c while the mean relative humidity is over 75%. However, in the northern part of the State, the mean monthly temperature may be over $30^0$c while the mean monthly range may be as high as $8^0$c. The mean monthly humidity is about 65%. The mean annual total rainfall in the south is about 1800mm while that of the northern part is hardly over 1600mm (Online Nigeria, 2003). As indicated under climate, the expected climate vegetation is the evergreen high forest composed of many varieties of hard wood timber such as Terminalia superba, Antiaris africana etc. This natural vegetation is hardly present now except for the few forest reserves that are established in the Southern part of the State by the government. The natural vegetation has been very much degraded as a result of human activities such as bush fallow farming system, felling of timber as a means of employment for the unemployed youths without any plan to replace them, poaching, bush burning, felling of trees as a major source of fuel (charcoal and firewood) etc. The major tree crops include Cocoa, Kola, Coffee, Cashew, Oil palm, Mango and Citrus. In the Southern part, Cocoa is the most prevalent while in the northern part; fruit trees such as mango and cashew are very common.

## Materials and Methods

Rainfall data for Ekiti State from 2001-2010 (10 years) was from the Ekiti State Agricultural Development Programme (ADP), Ikole Ekiti. ADP is a government establishment responsible for the extension services available to farmers in the State.

Time series analysis of the monthly and annual rainfall values are used to illustrate the trend in rainfall behavior and also in estimating seasonal variation. Although the trends in climatic data are seldom linear (Mitchell et al., 1966), the linear regression method has been used to investigate trends in many climatic time series ( e.g. Subbaramayya and Kumar 1987; Hutchinson 1985; Ayoade 1973). The Moving Average and least square model were used in trend line analysis while the additive model was used in the estimation of seasonal variation. Also, descriptive statistical analysis was used in the estimation of the standardized anomaly

## Results

## Trends in Annual Rain-Days in Ekiti

The annual and monthly rainfall data series from January to December are examined using time series analysis. The result in Table 1 shows that the monthly rainfall decreased progressively between January-April and November-December. Interestingly, the double maxima of June and September is still very much established while April that used to be the beginning of the raining season is tending towards dry month and October that used to be the beginning of dry season is also tending towards raining month. The shift in the beginning of raining season from March/April (Obot *et al.*, 2011, Odjugo 2010) and ending of raining season from October to November has significant implication on the ecosystem. These are critical months for annual agricultural cycles where early and late crops are planted. This causes crop failure and food shortage as most grains planted late are more prone to pests attack; this also leads to desert encroachment as uncontrolled bush burning by peasant farmers, hunters, nomads etc are more frequent with prolonged draught.

Table 2 illustrates the computed rainfall deviation and anomalies within the year under consideration (2001-2010). Figure 1 shows the standardized rainfall deviations; 2002, 2003, 2005, 2007, 2009 and 2010 are years with above average rainfall with 2003 showing the highest positive deviation while the other years show rainfall below normal with 2004 as the lowest.

Figure 2 shows the inter-annual variability over Ekiti State between 2001-2010; the trend suggests fluctuating and general decline in rainfall values in recent times. Figure 3 shows a noticeable reduction in August rainfall while October that used to be the beginning of the dry season recorded rainfall equivalent to July rainfall, slightly below the June maxima and above May and August rainfall. This further establishes the shift in the pattern of rainfall in the State. The bi-modal maxima of rainfall in June and September from the south-west is also supported.

**Table 1:** Seasonal Variation and Seasonal Index of Monthly Rainfall Data From 2001 -2010

| YEAR/ MONTH | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | TOTAL | SEASONAL INDEX | ADJUSTED SEASONAL INDEX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -116.961 | -118.053 | -119.145 | -84.187 | -117.729 | -81.061 | -123.513 | -124.605 | -118.497 | -126.789 | -1130.540 | -113.054 | -113.058 |
| 2 | -117.052 | -118.144 | -119.236 | -48.928 | -100.78 | -112.11 | -107.604 | -124.696 | -57.868 | -68.96 | -975.380 | -97.538 | -97.542 |
| 3 | -41.743 | -51.135 | -94.827 | -112.019 | -34.511 | -10.853 | -58.125 | -74.687 | -36.599 | -65.611 | -580.110 | -58.011 | -58.015 |
| 4 | 36.766 | -24.226 | -12.918 | 22.49 | 13.078 | -39.194 | 7.774 | -57.078 | 6.4 | -22.022 | -68.930 | -6.893 | -6.897 |
| 5 | 71.175 | -17.517 | 84.091 | 6.599 | -3.393 | -4.235 | 79.063 | 80.751 | 84.739 | 24.047 | 405.320 | 40.532 | 40.528 |
| 6 | 84.084 | 174.492 | 123.3 | 175.508 | 142.726 | 2.944 | -31.868 | 129.71 | 96.888 | 22.356 | 920.140 | 92.014 | 92.010 |
| 7 | 99.693 | 168.601 | 114.309 | -2.483 | 196.025 | 40.573 | 42.131 | -7.811 | 79.357 | 33.465 | 763.860 | 76.386 | 76.382 |
| 8 | -55.498 | 149.01 | -3.582 | 13.726 | -6.246 | 12.382 | 308.99 | -23.702 | -57.054 | 149.534 | 487.560 | 48.756 | 48.752 |
| 9 | 197.011 | 94.019 | 119.657 | 52.535 | 55.173 | 262.451 | 183.899 | 24.607 | 121.575 | 206.763 | 1317.690 | 131.769 | 131.765 |
| 10 | -72.68 | 101.528 | 374.376 | -45.026 | 20.502 | 63.9 | 60.148 | 75.276 | 88.204 | 66.152 | 732.380 | 73.238 | 73.234 |
| 11 | -79.271 | -66.863 | -57.155 | -94.587 | -41.239 | -123.33 | -108.613 | 18.185 | -89.727 | -71.219 | -713.820 | -71.382 | -71.386 |
| 12 | -113.262 | -119.054 | -120.146 | -121.238 | -85.53 | -123.42 | -124.514 | -96.006 | -126.698 | -127.79 | -1157.660 | -115.766 | -115.770 |

**Table 2:** Annual Mean Rainfall and Standardized Anomaly

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall (mm) | 108.48 | 132.94 | 143.71 | 100.94 | 125.00 | 113.59 | 134.66 | 110.10 | 125.42 | 128.95 |
| Anomalies(Xt-$\overline{x}$) /SD | -1.08 | 0.82 | 1.66 | -1.67 | 0.20 | -0.68 | 0.95 | -0.95 | 0.24 | 0.51 |

**Figure 1:** Standardized rainfall anomaly over Ekiti State between 2001 and 2010

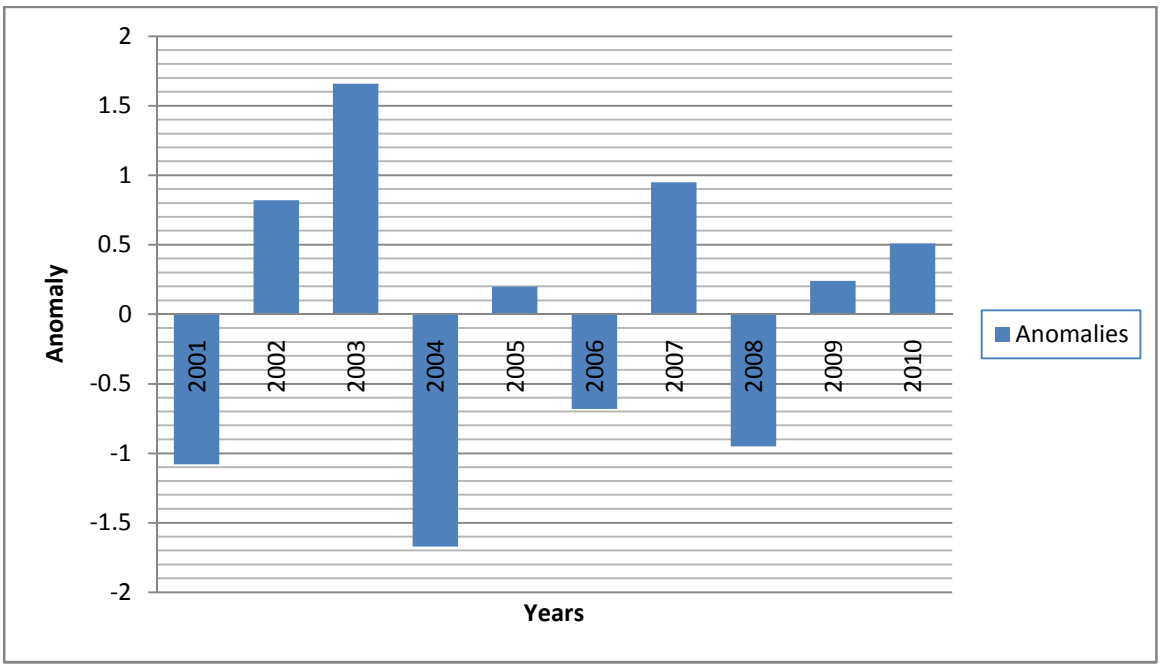



**Figure 2:** Annual mean rainfall for Ekiti State from 2001-2010

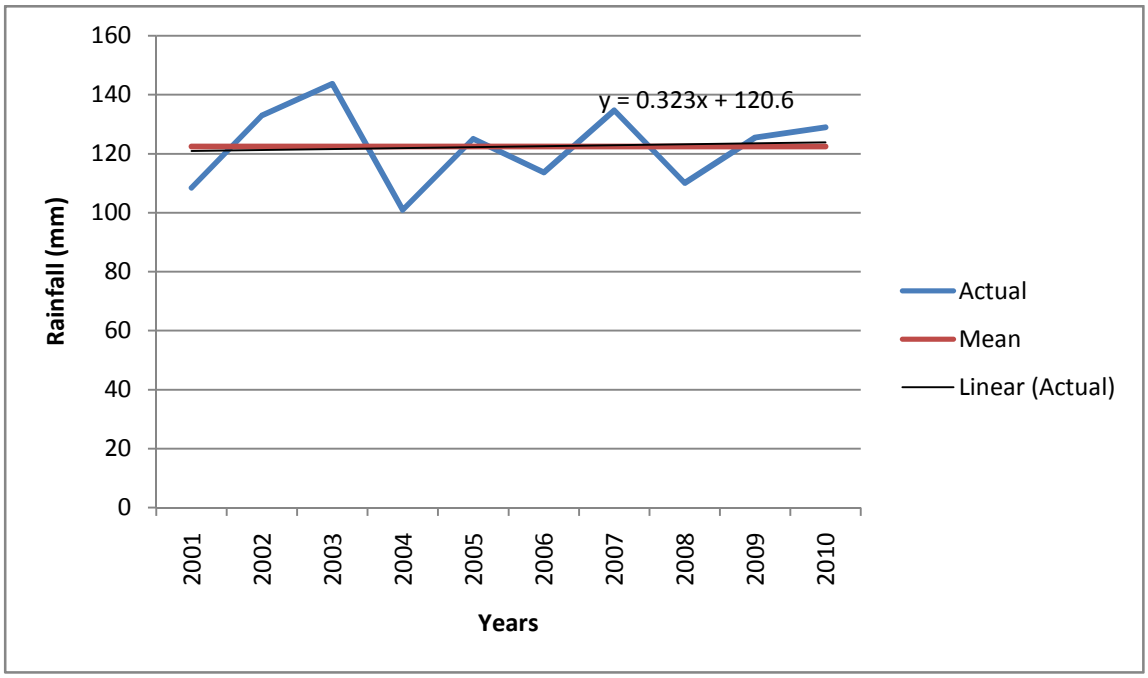
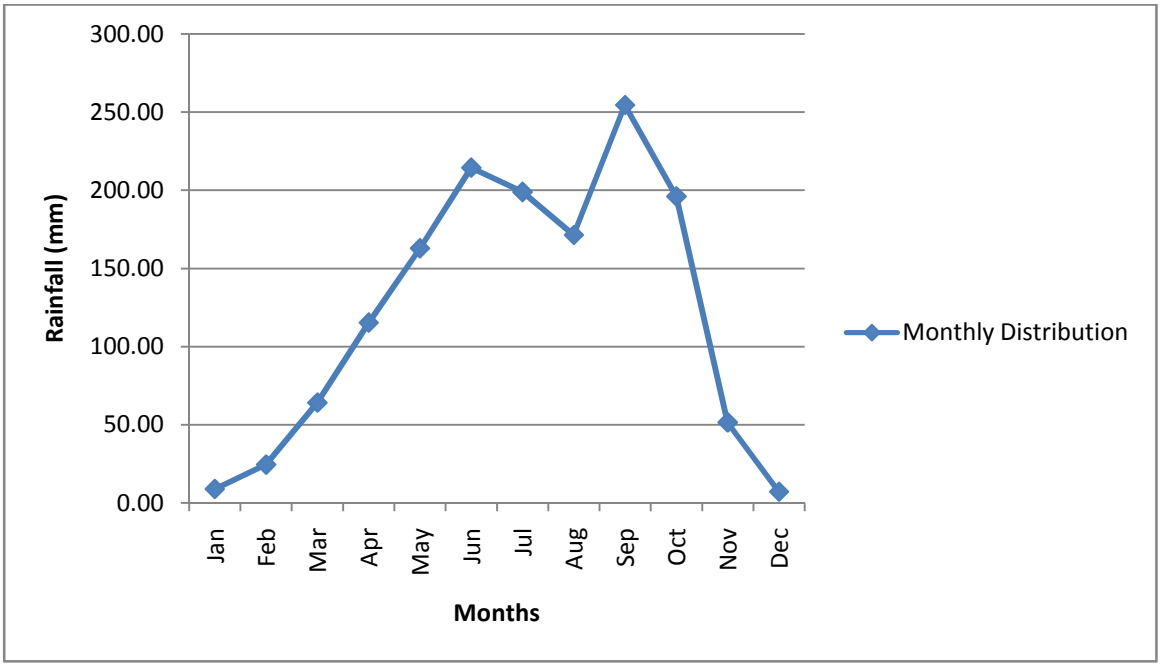


**Figure 3:** Monthly mean rainfall for Ekiti State (2001-2010)




## Conclusions

Evidence of change in the distribution and characteristics of rainfall can be examined in terms of frequency, intensity, amount etc. Present study brings out some of the interesting and also significant changes in the rainfall pattern of Ekiti State. The monthly rainfall series have been examined for fluctuations and trends based on data collected for the 2001-2010 period. It is clear from the results that there is shift in the beginning and ending of the raining season.

The result of the standardized anomaly shows a fluctuating rainfall pattern across the years under consideration; this makes it difficult to forecast the rainfall for a future season. The delay in rainfall till April force the cattle nomads to engage in incessant bush burning while farmers preparing farmlands for cropping also get involved in uncontrolled fire through bush burning thereby setting most of the tree crop plantations ablaze causing deforestation and environmental degradation. The high rainfall amount in October might have serious agricultural implications as late grains (e.g. maize, beans), early yam planting, cocoa pods and other farm products are adversely affected by heavy rainfall of August.

The facts are very helpful for redesigning seasonal agriculture and plantation management, flood control, constructions and water resources design and maintenance. There is need for sensitization of the farmers on the recent development in rainfall activities and government intervention in reducing dependence on rain-fed agriculture. Government activities such as construction and policies should take into cognizance the recent trends in rainfall.

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