Volume 15 Issue 55
Originally issued as B4

Global Journal of human-social science: B
Geography, Geo-Sciences, Environmental Science & Disaster Management
Volume 15 Issue 4 Version 1.0 Year 2015
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-460X & Print ISSN: 0975-587X

Length of Rainfall Season and its Implication over Enugu South - East Nigeria

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Abstract- The study length of Rainfall (RF) season in Enugu, South East, Nigeria from 1916 – 2012 examines the trend in RF pattern over Enugu. Data for this work were extracted from the Nigerian Meteorological Agency (NIMET) Oshodi, Lagos archive for analysis. The results show that the date of Onset of RF over the years has extended or delayed slightly from 12th March (71) day of the year in 1916 to about 15 in 2012. In analysing RF cessation, it was observed that RF cessation has reduced or shifted forward from 21st October to 10th October. The study further observed that the duration of RF over Enugu has reduced. The duration in 1916 was 256 days, in 2012 duration accounted for just 223 rainy days during the period, representing a decrease of about 30 days as shown by the trend line for RF duration. It was also discovered that the RF distribution of Enugu skewed positively an indication that total RF is reducing slowly. The RF season or duration over Enugu covers 7 months. This work discovered that, onset of RF has extended, while cessation date reduced, and duration of RF has also reduced pointing to high RF intensity, this can trigger flooding and soil erosion, therefore, the work suggests that every environmental related policies need to consult RF data and take account the benefits and demerits associated with it.

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GJHSS-B Classification : *FOR Code: 059999*

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I. Introduction

The study of RF is multidimensional in nature, because RF as an element of climate has a lot of impact on the environment and human within the environment. Therefore, any study of RF in the tropic must clearly state the aspect under consideration. The elements of climate are temperature, precipitation, sunshine duration, wind, cloud cover, humidity and pressure. The fluctuation of these elements can affect the climate of an area for good or for bad.

The examination of these variables in a single paper or study is difficult; therefore researchers tend to study single or fewer variables, knowing that variation in one will also affect the others and indeed the climate.

Rainfall is a form of atmospheric precipitation that is composed of large drops of liquid water; it consists of water droplets ranging from 1 - 5mmin diameter (Alexander, 2012). The types of rain produce reflect the circumstances in which it is formed (Mayhew, 2004).

Rainfall is one element that influences, the tropical ways of life, it dictates the agricultural calendar, impact on hydrologic circle, social life and even food distribution and transportation. It is very pertinent for economic growth and development in Enugu and Nigeria at large (Enete and Ebenebe, 2009). The amount of rainfall that is normally received determines which types of agriculture that can be carried out and which crops can be cultivated in a region. The seasonal distribution of rainfall regulates the agricultural calendar in the tropics (Alexander, 2012; Alexander et al, 2015; and Ajayi and Ojeleye). The relationship that exists between Rainfall and the tropical occupation of agriculture, especially in Enugu State of Nigeria that employ over 80% of the work force, this makes it important to study RF which determines agricultural calendar in the tropics. Odjugo (2010) argues that climate change has caused a shift in the normal timing and length of wet and dry seasons, shift in the seasonal variability of weather and climate; and increase in the seasonal fluctuation of the water bodies. Rainfall variability refers to variations in the mean state and other rainfall statistics on all spatial and temporal scales beyond that of individual precipitation events.

The earth's atmosphere consists of a mixture of various gases surrounding the earth to the height of many kilometres. However, the man's surface environment is a shallow but highly complex zone in which atmospheric conditions exerts control upon the land surface, while at the same time the surface of the land exert an influence upon the properties of the immediately adjacent atmosphere (Ukpong, 2009; Hardy, 2004; Bradshaw and Weaver, 1995).The earth's climate is dynamic and naturally varies on seasonal, decadal, centennial, and longer timescale. Each "up and down" fluctuation can lead to conditions which are warmer or colder, wetter or drier, more stormy or quiescent (NOAA, 2007).

The importance of RF on a given area depend on how it affects the peoples live and what the researchers seeks to achieve. The study could be for just an academic exercise, but most of the studies emanate as a solution to identified problems.

Most of the available work on RF are on trends, for instance, Abaje et al, 2010; If abiyi and Ojoye, 2013; Abaje et al, 2012; Imo and Ekpenyong, 2011, all discussed trend. Rainfall trend gives a picture of rainfall pattern annually. It is important in the study of hydrologic cycle and water resources; however, it is not very important for agriculture and understanding seasonal distribution of RF. It does not also explain the facts on

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drought and flooding. It is actually an illusion to the true distribution of rainfall. (Alexander, 2015; Ayoade, 2003)

Other scholars such as (Srivastava, 1975 and Akinyemi et al, 2013) worked on seasonality of rainfall. Seasonal rainfall is vital in the field of agriculture and even monitoring of drought and flood incidences, however, most of the work did not use the results for predictions. It is also observed that the seasonal rainfall on its own cannot explain much and therefore will be usefully limited. It is like a sort of fluctuation or monthly variations.

The present study tends to investigate the length of RF over Enugu, using parameters such as Onset, Cessation and Duration for analysis. Attempt shall also be made using Pearson coefficient of skewness to determine the dispersion of RF during the study period over the study area. The few works carried out on the length of RF were targeted on planting season and harvest (Agriculture), this work goes beyond agriculture as it proposes application in the field of construction, water resource, etc.

II. The Study Area

Enugu is one of the oldest cities in Nigeria. It was the capital of the defunct Eastern Region and East Central State of Nigeria. Presently the city of Enugu is the capital of a State bearing its name 'ENUGU STATE'. Enugu has two local government areas. It is the home of the Akanulbiam International Airport, Enugu State University of science and technology, Enugu State Institute of Management, home of Enugu Rangers Football Club (http://www.enugustate.gov.ng, 7-8-15).

Enugu is located on longitude 7°30'53.5"E - 7°34'40.54"E and latitude 6°24'14.62"N - 6°24'26.94"N, and on altitude of 152 meter above sea level.

Enugu has tropical wet climate. This implies that it has double maxima of RF pattern. It has a moderate temperature, with a mean temperature of 27°c, and a range of 4°c - 5°c. It has aRF of about 1500mm – 2100mm. Wet season lasted for about 7 – 8 months with a break or dry spell around August, the so called August break also known as dry spell.

Enugu falls within the farraginous soil within the interior zone of the late rite zone of Nigeria. Her major crops include Palm trees, Cassava, Maize, Bean seed, etc. Other economic activities includes, trading, mining, and transportation. The city of Enugu came into prominence as a result of coal discovery within and around it. The mineral resources within Enugu are Coal, Lead, and Zinc.

The population of Enugu stands at 722,664 in 2006 with a population density of 6,400 persons per square kilometre (NPC, 2006; http://en.wikipedia.-org/wiki/Enugu). Figure 1a shows the map of the study area within Nigeria, and Figure1b shows the area of study.



Figure 1a : Map of Nigeria showing Enugu State



Figure 1b : Map of Enugu State

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III. Material and Methods

Rainfall data for this work were extracted from the Nigerian Meteorological Agency (NIMET) Oshodi, Lagos from 1916 – 2012 (97 years) for analysis. The onset, end, and duration of RF were calculated using Walter's formula (Walter, 1967). The results of each of the 98 years were calculated.

$$\text{Onset/End of RF} = \text{NDM } (51 - \text{PAR})/\text{ARM} \quad (1)$$

Where NDM is the number of days of the when the constant 51 is reached or exceeded. 51 is the minimum RF accepted as the start of RF. Whereas PAR is previous accumulated RF before the 51mm target is reached or exceeded. ARM means the amount of RF recorded within the month that the 51mm target was reached.

$$\text{Duration of RF} = \text{End} - \text{Onset} \quad (2)$$

For Pearson coefficient of skewness Microsoft excel approach was adopted, the same was adopted in calculating seasonality index of RF.

$$\text{Seasonal percentage} = \text{SATRF/TRF} \times 100 \quad (3)$$

Where SATRF is the seasonal amount of RF, and TRF is the total RF for the period.

IV. Result and Discussions

a) Onset, Cessation, and Duration of Rainfall

Analysis of onset of RF shows a great deal of fluctuation over the study period. However, the mean ($\bar{x}$) onset date is the 77th day of the year, which is March 18th. Generally the study shows a delay in onset of RF over the study period. This implies that RF has shifted from the earliest date to a later date. Table1a shows the onset distribution of RF over the study period (1916 – 2012). The fluctuation shows the different dates of onset and the trend line points to the trend or pattern over the years. The line shows a slight increase in onset dates. This gradual shift can hardly be noticed by local people and farmers and thus may affect agricultural yield. The best RF onset period target would be 77± a week. The implication is that RF could start a week to or after the 77th day of the year.

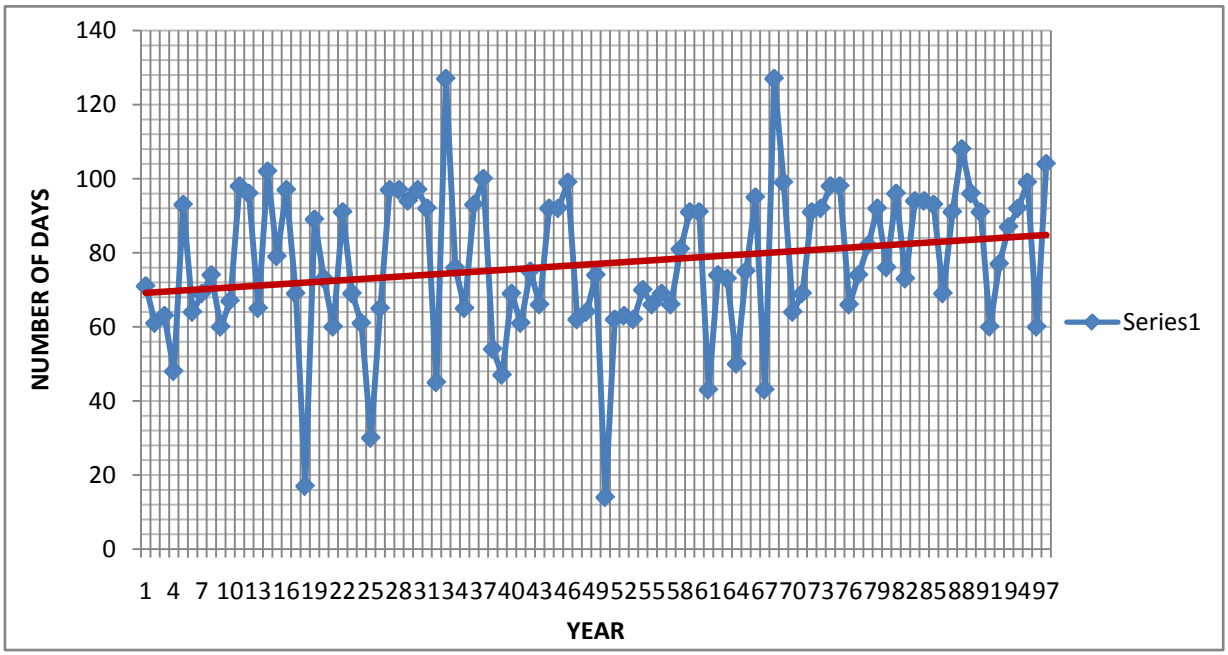


Figure 1a : The Variation of Enugu Rainfall Onset date and Trend over the Study Period (1916 – 2012)

Note the line started below the 80th day and ended above the 80th day, which is an indication of delayed RF onset date.

A further analysis using 10 years running mean to observe the trend and pattern shows that RF onset date is shifting to a later date.Figure1b explain the trend using 10 years running mean.

The earliest RF onset dates during the Period of study were the 14th day of the year (14th January) in 1965, 17th day of the year (17th January) in 1933 and the 30th day of the year (30th January) in 1940.While the latest RF onset date includes the 127th day of the year (6th and 7th May) in 1948 and 1983, and the 108th day of the year (19th April) in 2003.

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Late Onset date implies a delay in planting date. The traditional date for planting is gradually shifting; by implication farmers that stick to the local date of planting may likely have poor harvest.

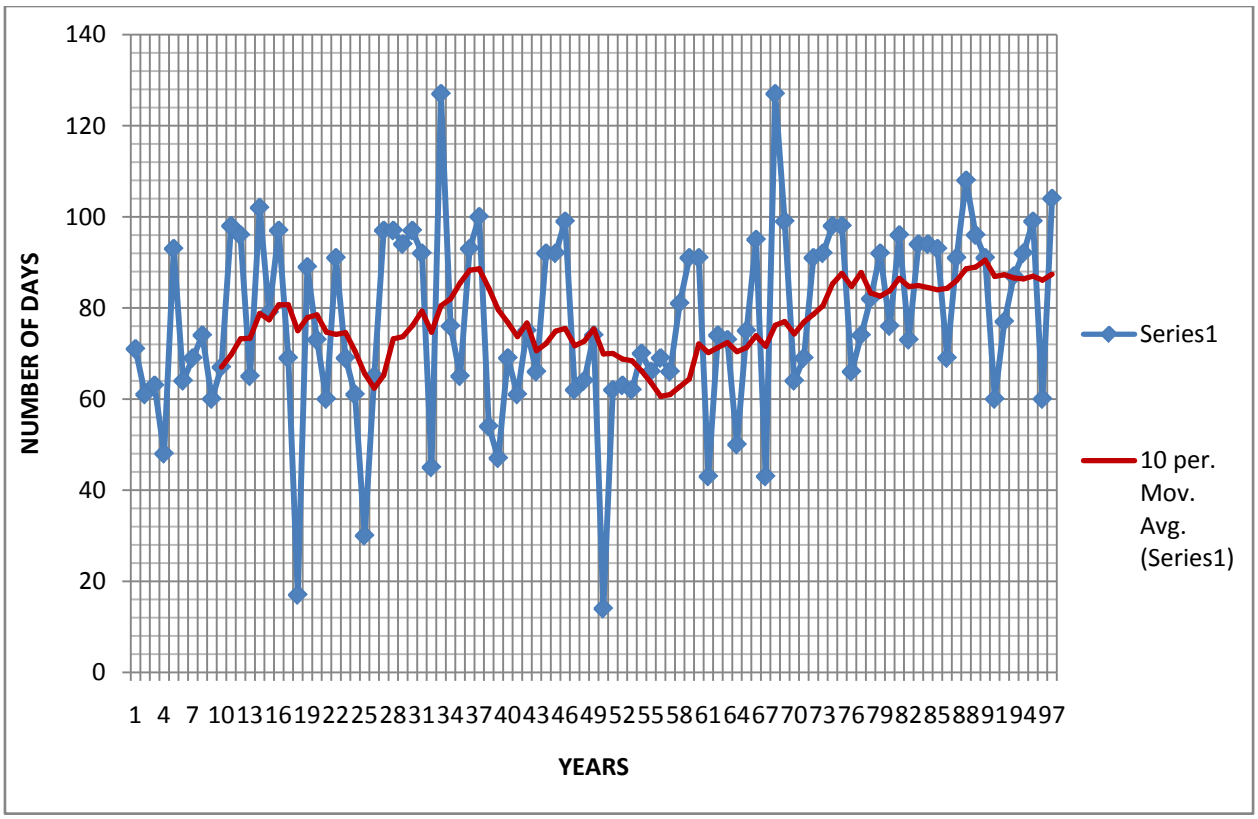


Figure 1b : The Distribution of Enugu RF onset date and 10 years Running Mean

Note- from table1b only few dates before 1988 crosses the 80th day of the year, however, from 1988 onward exceeded the 80th day of the year. This is an indication that onset date is increasing.

Increase in onset means a delayed in the date of RF onset which will directly planting of crops.

Similarly, it was observed that cessation or the end of the RF has slightly shifted forward. That is the end of RF occurs earlier. The latest cessation date, over the study period among others were, the 356th day of the year, 21st December in 1936, the 349th day of the year, which is 15th December in 1947 and 331st day of the year (27th November) 1975 and 1986 respectively. On the other hand the earliest RF cessation date includes the 246th day of the year, which is 3rd September, and the 274th day of the year, 1st October which occurred in 1925, 1937, 1967and 1979.

The mean ($\bar{x}$) RF cessation date for the study period is the 290th day of the year. Figure2a and Figure2b show the trend and distribution pattern of Enugu RF cessation dates during the study period.

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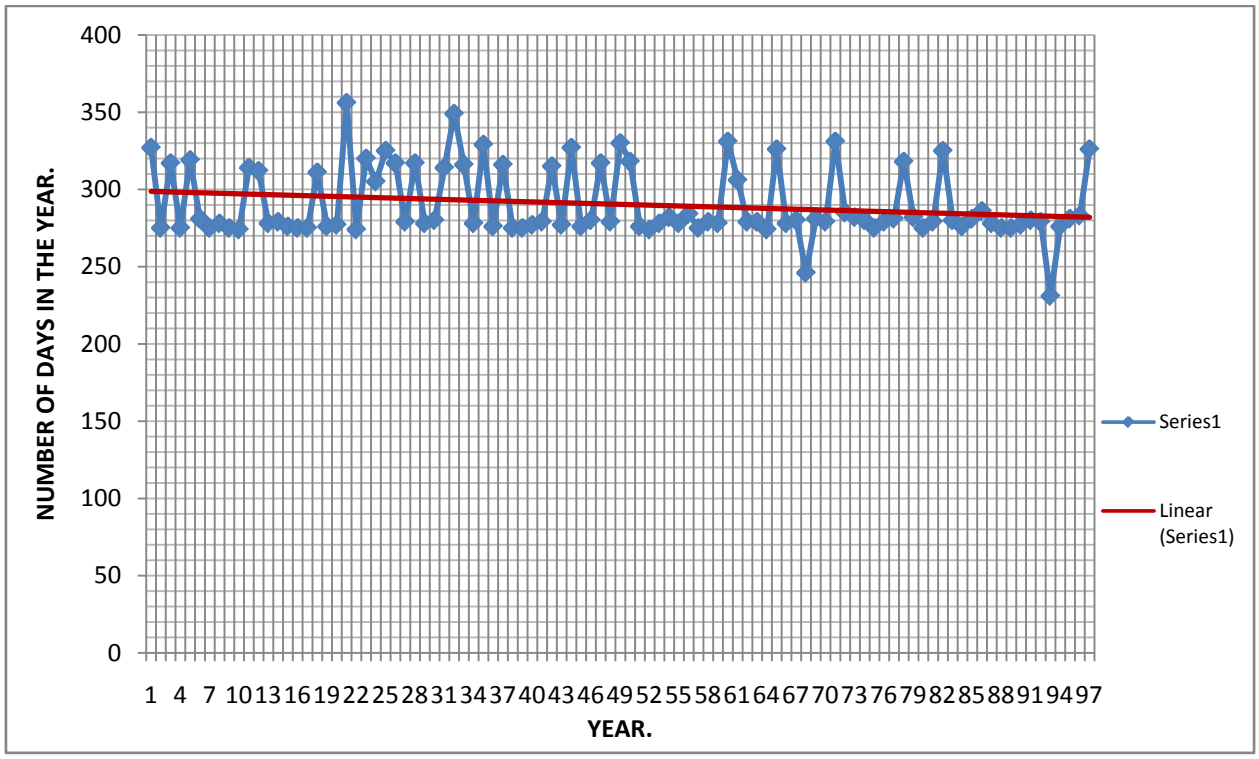


Figure 2a : The Distribution of Enugu RF Cessation date and Trend line indicating a shift over the years

The red line is a linear series pointing to the general trend or direction of shift of RF cessation over Enugu during the study period. The trend line started very close to the 300th day of the year in 1916,and shifted gently with 10 days by 1951(36 years) later. The shift gradually reduced to 20 days in 2012 after about 62 years. The shift or dispersion is very slow that even in a graph it seems to be ignored or very difficult to notice, but a reduction of about 3 weeks is a serious concern in climatology. This implies that Enugu RF cessation date will occur 3 weeks earlier on the $\bar{x}$.

The 10 years running $\bar{x}$ analysis shown in figure2b support the aforementioned result.

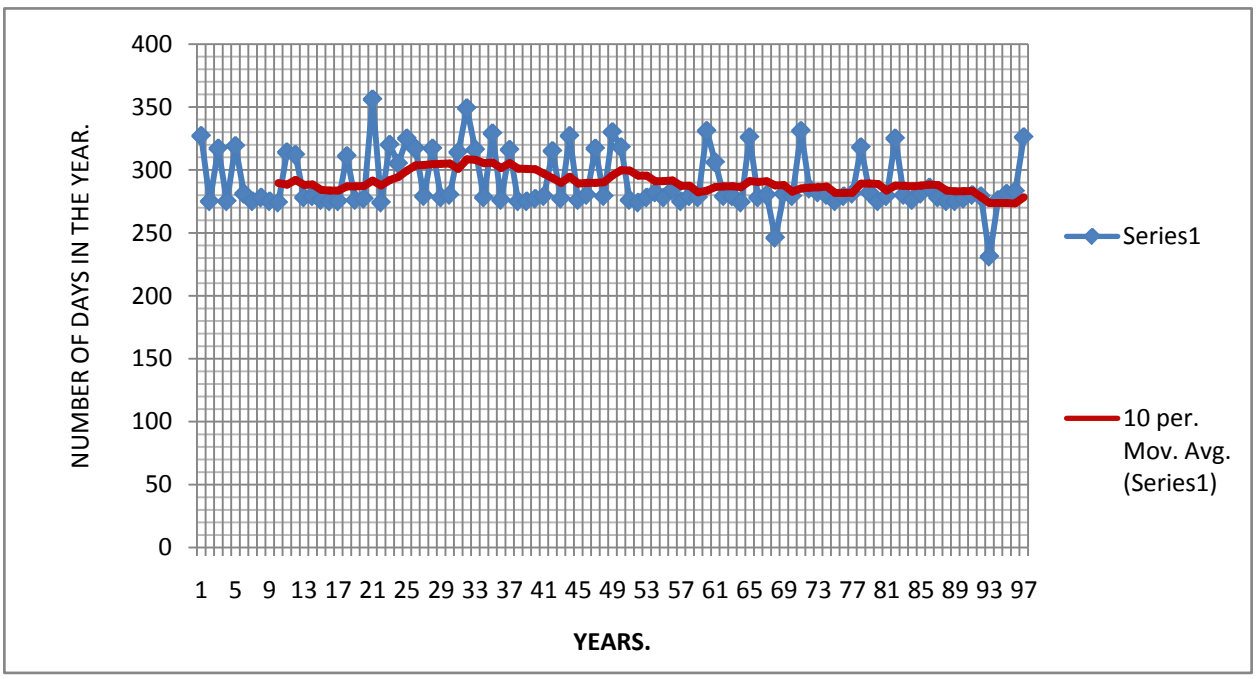


Figure 2b : The Distribution of Enugu RF cessation date and 10 years Running Mean

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More of the cessation date falls below the moving $\bar{x}$ line. The cessation date reduces from the 300th day of the year to nearly 270th day in 2012.

The RF condition of Enugu shows that policy makers, farmers, and developers need to consider the Onset of RF and End in their plans. For instance, in road construction, especially the local roads, work should start about a week after the end of RF. There is the need for water to be conserve which can be used after RF cessation or during the dry months.

The analysis base on RF duration generally revealed a drop in days (i.e. Number of days). This implies that RF duration has decreased or shortened over the study period. Figure 3a shows RF duration fluctuations over the study period in Enugu and the trend line showing the direction of shift (i.e. the direction the trend is tilting to). Note, this does not account for the total RF in Enugu, whether it was reducing or increasing, rather, it shows that the rainy period is reducing or decreasing over the years. This shows a gradual but steady decrease in duration of RF over the study period.

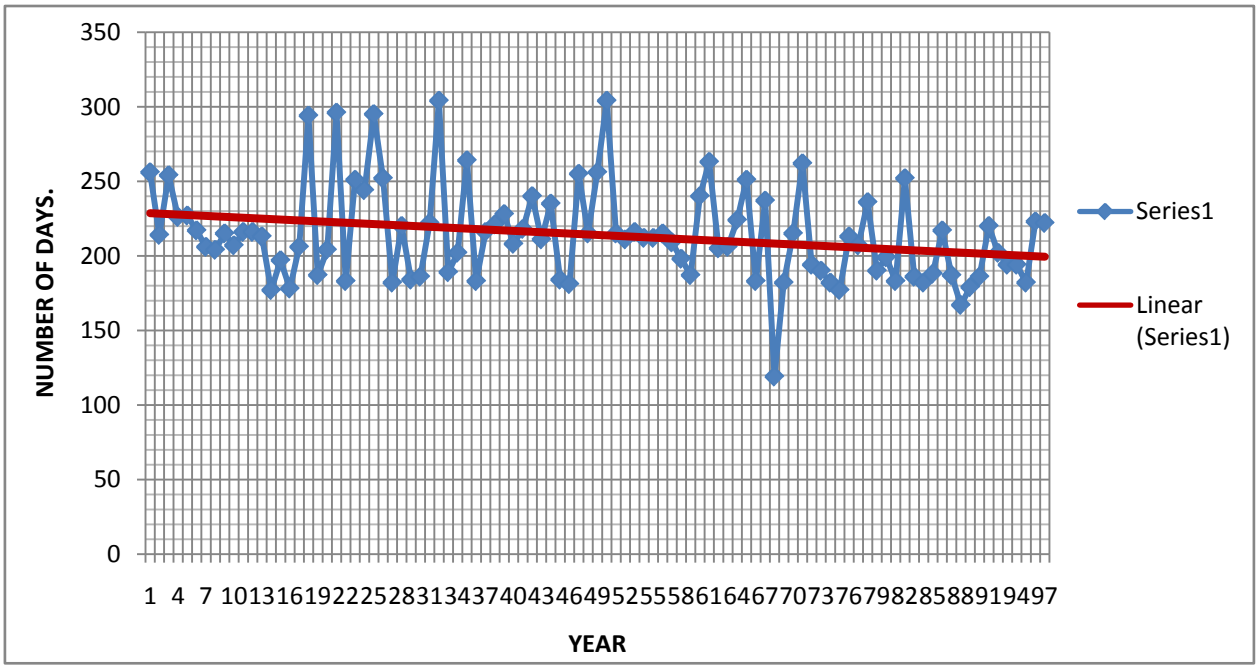


Figure 3a : The Distribution of Enugu RF Duration date and Trend line indicating a shift over the years

The 10 years moving $\bar{x}$ also shows that RF duration days is decreasing over time. The duration of RF is the difference between cessation date and onset date. A shift in one will affect the others, especially when the shift is in the opposite direction as shown in this study.

The study also shows that RF has shifted in all ramifications over the period of study in Enugu; this will affect water use, agriculture, constructions, and even outdoor activities.

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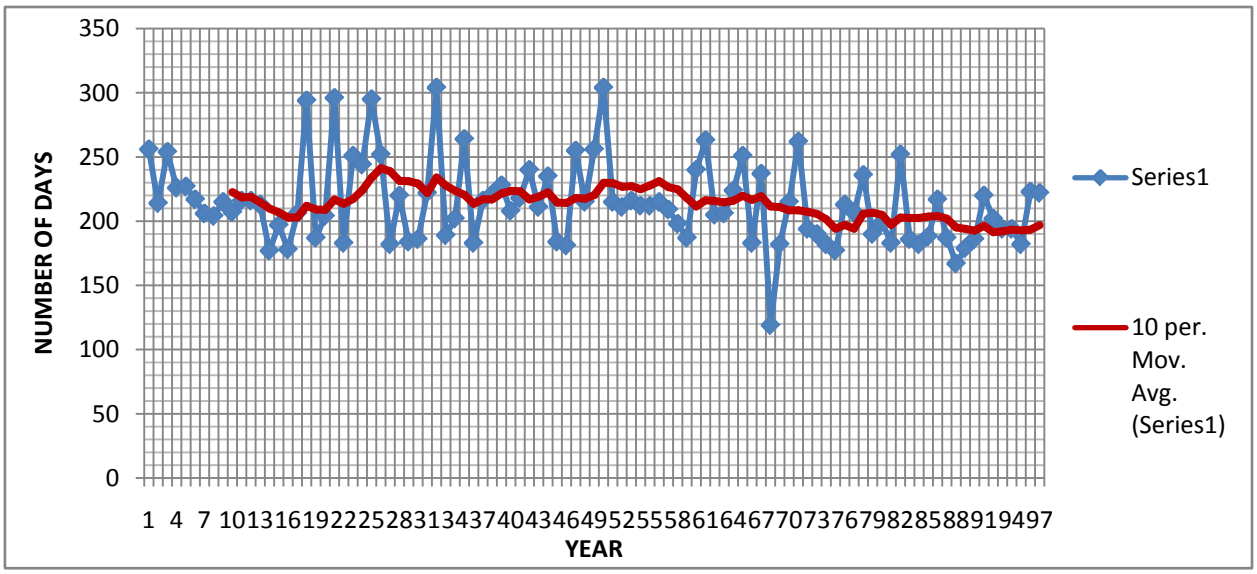


Figure 3b : The Distribution of Enugu RF Duration date and 10 years Running Mean

The comparative study of the three RF parameters shown in Figure 4, suggests that there is a shift or fluctuation in the parameter distribution during the study period, the trend lines show a divergence, an indication of variation from the normal state. The lines are closer toward the right or later years, showing a reduction in the RF duration period, as against wider lines on the left or earliest years.

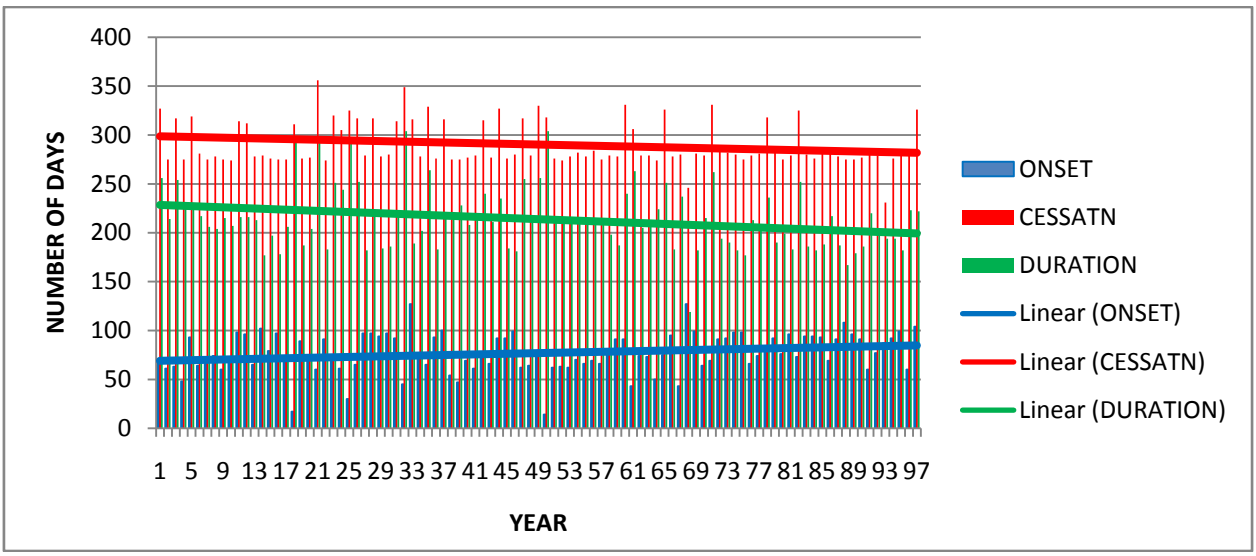


Figure 4 : Comparative Analysis of Enugu RF Parameters

The analyses so far show that Onset of RF is late, the Cessation or End is early, these are responsible for the reduction in RF Duration over the study area and period. The climate of Enugu is gradually shifting, because alteration of the existing RF pattern will also affect other climatic variables.

The rainy season contributed a total of 157692.79mm of RF out of the total of 172076.3mm recorded during the 97 years of study, representing 91.64%. The rainy season includes, April, May, June, July, August, September, and October. Logically March could have been included as part of rainy reason, since RF onset began in March. For convenience the study included October which is the end with the assumption that RF started half way in the month and ended half way of the month. When rationally we divided the year into half, the rainy season also accounted for 83.34% of the total RF.

This study reveals that the present RF duration in Enugu is about 59% of the year, which implies that RF or rainy season will last for about seven (7) months. Mean RF duration of Enugu is 212 days.

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Harper (1977) stated that when a distribution skewed to the left it is positive, but when skewed to the right that it is a negative skew. The result of Pearson coefficient of skewness using Microsoft Excel is 0.220276 approximately 0.22. This implies that Enugu's RF distribution skewed to the left very slightly, which is an indication that RF occurrences and amounts are declining over the years in the study area. This is expected since the duration RF has reduced.

V. Conclusion and Recommendations

The study observed that RF parameter varies within months and years; however, set pattern has been established. That the date of RF onset has increased over the study period, which implies that RF onset, will be late or start late. It was also observed that RF cessation has shifted in the opposite direction with onset. The implication is that RF tends to stop or end earlier. Which means that crops that matured very late may hamper productivity?

In analysing the duration of RF distribution, it was observed that the duration has reduced. This simply means that the RF period has reduced. It was also revealed that RF distribution skewed leftward an indication that RF distribution is also decreasing over the years. These revelations calls for urgent reorganization of climate related sectors, especially Agriculture, Water Resources Management and Road Construction. The shift is very slow as shown in the relevant figures. The shift presently has not been identified as a problem or blessing, that is beyond the scope of this paper.

The paper suggests that the shift observed in this work should be reviewed or reinvestigated with the aim to knowing if such shifts in RF parameters are for humans' advantage or warning to climatic havoc in Enugu, indeed the entire country. Besides, RF parameters data should be consulted before any serious environmental related decisions are made. There is a need to embark on a forecast of RF parameters over Enugu and in fact the whole Nigeria, because 4 – 6 month forecast is not always very useful in climatology, especially in Agro climatology.

Farmers have to work with RF parameter data to optimize yield; Road construction contractor should also be mindful of this vital tool before going to the field. Finally, the climatological data should be made available and free for researchers, the States, Corporate bodies and NGOs should assist researchers, especially those working on Weather and Climate, because life and human welfares are involved.

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