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Investigation of Temporal Variations in Precipitation Erosivity in Owerri, Imo State Nigeria

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ABSTRACT

The precipitation (rainfall) erosivity of a tropical rain forest constituency has been investigated. The study established the erosivity index for Imo state southeastern Nigeria. Rainfall erosivity is the potential ability of the rain to cause soil loss or erosion. Modern definitions of rainfall erosivity began with the development of the Universal Soil Loss Equation (USLE), where rainfall characteristics were statistically related to soil loss from thousands of plot-years of natural rainfall and runoff data. This has not been given serious attention by the relevant authorities, hence it has caused more harm to the agricultural sector and has reduced crops yield drastically. The general objective of the study is to analyze the temporal changes in rainfall erosivity in owerri, Imo state. The result from the tables and figures shows that the amount of rainfall in Imo State was high from 1986 – 2015 the years under consideration. The annual mean rainfall erosivity calculated as 327.32mm, shows that the high rainfall erosivity in Imo State is a major contributor to the high soil loss in the State. The skewness value of 1.1, Show that there is a positive impact of high rainfall erosivity on soil erosion.

Keywords: *Precipitation erosivity, Rainfall trends, variations, Imo state*

INTRODUCTION

The potential for erosion is based on many factors including soil type, slope, and the energy or force of precipitation expected during the period of surface disturbance. Rainfall erosivity is a term that is used to describe the potential for soil to wash off disturbed, de-vegetated areas and into surface waters of the state during storms The identification of some climatic inputs for rainfall erosivity modeling and scenarios at regional scales is important for understanding the rainfall and storms characteristics and their potential impact on local agricultural and ecological systems (Diodato and Bellocchi, 2010). Under particular environmental conditions, rainfall is the main factor driving soil degradation because it can erode soils and nutrients by the force of raindrops, surface and subsurface runoff (Zachar, 1982). In the tropics, studies have shown that the most important factor that is of direct relevance to erosion studies is rainfall, while other factors include topography, soil, geology and land management techniques (Jeje and Agu, 1990).

Several attributes of rainfall bear direct relevance to the incidence of erosion in the human landscape. Such attributes include: rainfall intensity, drop size, duration of fall, annual total amount, and frequency of fall, kinetic energy and terminal velocity, among others (Oyegun, 1980). Soil erosion is basically initiated by detachment, which is mainly controlled by shear forces of the falling raindrops, and represented by rainfall erosivity factor (Asadi *et al.*, 2008). However, studies on soil erosion only started in the first decades of the 20th century and have increased in number and variety since then, especially targeting at isolating the role of different natural factors on soil erosion (Angulo-Martinez *et al*., 2009). In recent years, the analysis of rainfall extremes and aggressiveness has attracted the attention of researchers across the world (Garcia-Oliva *et al*., 1995; Sauerborn *et al.,* 1999; Schutt *et al.,* 2007). It has been with the advent of mathematical models of soil erosion that rainfall aggressiveness, defined under the name of ‘‘rainfall erosivity (R index)”, has been systematically analyzed. Onwualu et al. (2006) posit that the rainfall erosivity factor is used to quantify the ability of rainfall to cause soil loss under different conditions and it is one of the six factors that could be related to average annual soil loss on crop land. The equation is given by:

$$A= R.K.L.S.C.P \qquad (1)$$

Both methods are employed to predict soil erosion (Loureiro and Coutinho, 2001; Yu *et al*., 2001). Panagos *et al*., 2015 posit that besides (R)USLE, the rainfall erosivity can be used as input in other models such as USPED, SEMMED and SEDEM. Further, this dataset could also be interesting for natural hazard predictions such as landslide and flood risk assessment that are mainly triggered by high intensity events. A precise assessment of rainfall erosivity requires recordings of precipitation at short time intervals (1–60 min) for a period of at least several years. The rainfall erosivity is calculated by multiplying the kinetic energy by the maximum rainfall intensity during a period of 30-minutes for each rainstorm. The R factor accumulates the rainfall erosivity of individual rainstorm events and averages this value over multiple years. Unfortunately, rainfall erosivity studies in Nigeria have received very little attention especially as regards their spatial patterns. The need for quantification of rainfall erosivity is therefore imperative. The general objective of the study is to investigate the temporal variations in precipitation (rainfall) erosivity in owerri, Imo state and the specific objectives includes to; Evaluate the trends of meteorological variables that control the rate of rainfall erosivity in Owerri and to investigate and develop average annual rainfall erosivity for Owerri, Imo state using data from Nigerian Meteorological agency (NIMET)

MATERIALS AND METHOD

The study area is Owerri, Imo State Nigeria. It is located between latitudes 50' 48''E and 7' 03''N, and longitudes 5' 3''E and 9' 27′ N. It has six major entrances and exit routes, which are Okigwe, Orlu, Umuahia, Aba, Onitsha and Port Harcourt roads (Statistics and Planning Owerri Municipal,2006) For the purpose of this study the focus is on only the states with climatic data (they serve as climatic stations. These are Anambra, Enugu, Owerri, Port-Harcourt, Calabar, Akwa- Ibom States.

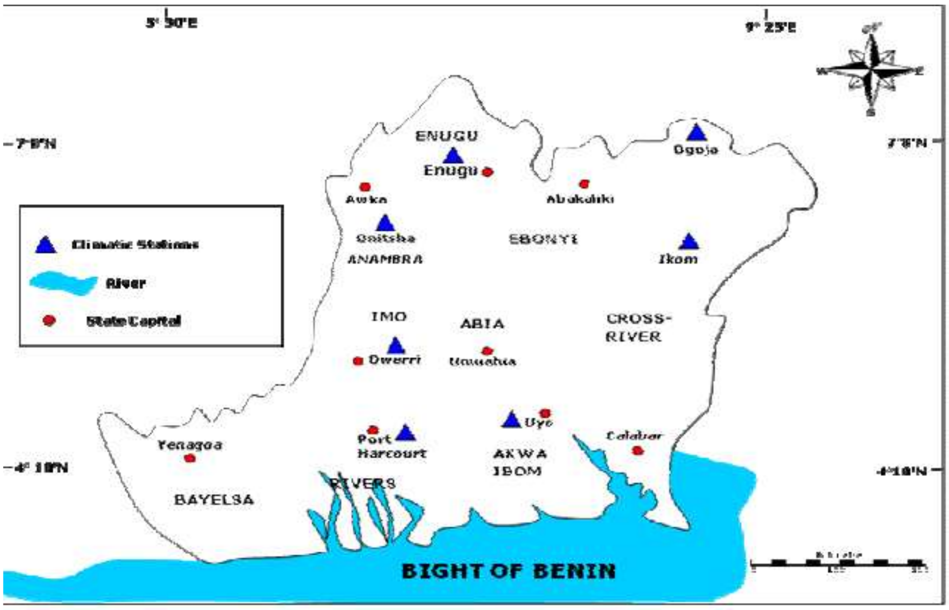


FIG.1 Southeastern Nigeria showing climatic stations

Climate and Temperature

The major seasons experienced in the city are the dry and rainy seasons. The dry period starts from October and ends on March, while the rainy seasons starts from April to September. The area is characterized by a high surface temperature which varies from day to day and season to season. The mean temperature annually is 30^0C, while the annual temperature is 37^0C in Owerri Municipal. The annual relative humidity is 87% and mean relative humidity is 73% respectively (Federal Ministry of Aviation, 2007)

Data Collection

The basic data required for this study includes rainfall data for a period of thirty years, which will be collected from NIMET Owerri. It includes daily, monthly and yearly data for the identified stations will be collected for a period from 1990 – 2020.

Methods of Data Analysis

Modified Fournier Index method will be used to calculate for the annual rainfall erosivity, rainfall erosivity index classification which states that;

$$\text{MFI} = \sum_1^{12} \frac{P^2}{P} \qquad (2)$$

Where;

P^2 = Monthly rainfall amount

P = Annual rainfall amount

The erosivity index R for the study area was estimated using the modified Fournier index (Arnoldus, 1977) given as:

$$EI_{30} = 0.0302 \times (R)^{19} \qquad (3)$$

Where RI = $\sum (MR)^2/AR$; MR = monthly rainfall, AR = Annual rainfall, and 0.0302 (constant for kinetic energy for places with limited rainfall)

3.3.1 Statistical Analysis

The data generated were subjected to statistical analysis using Microsoft excel and graphs to represent some outcomes. The other parameters determined include the mean, variance, standard deviation and skewness of the result.

Variance (S^2) = $\sum u^2/n - (\bar{u})$ 4

$\frac{3286417.85}{30} - (327.32)^2 = 2408.88$

Standard deviation (S) = $\frac{\sqrt{\sum u^2 - u^{-2}}}{n}$ 5

Skewness (Sk) = 3(mean – median/s)

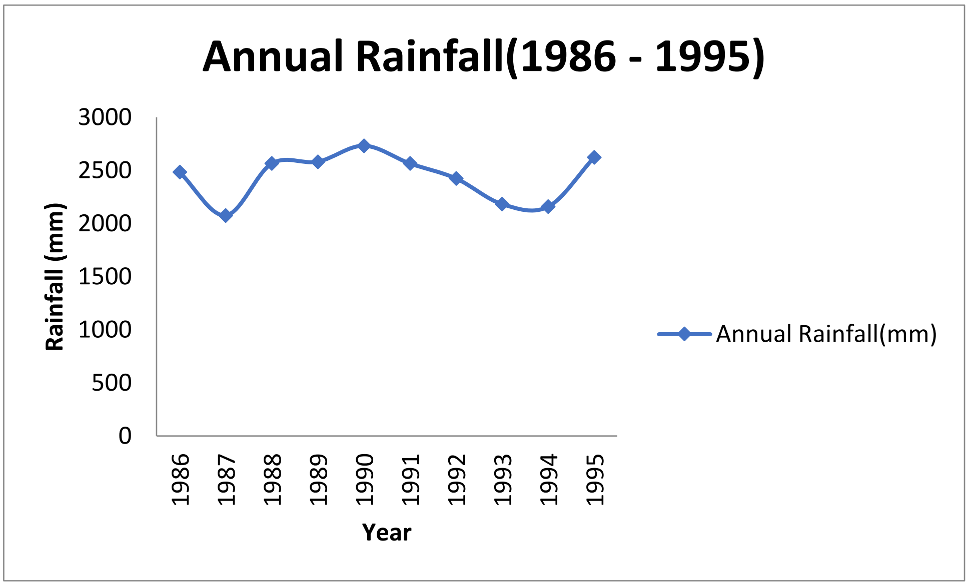
$= \frac{327.32 - 309.2}{49.08} = 1.10$

RESULTS AND DISCUSSION

The annual rainfall and rainfall erosivity data as obtained and calculated from the Nigeria Meteorological Agency (NIMET), Imo State for the year 1986 to 2015 are as shown.

Table 1 and figure 4: Annual Rainfall Amount for Imo State, Nigeria 1986 to 1995

Number	Year	Annual Rainfall(mm)
1	1986	2482.7
2	1987	2076
3	1988	2563.7
4	1989	2581.5
5	1990	2731.9
6	1991	2565.1
7	1992	2424.1
8	1993	2182.8
9	1994	2158
10	1995	2622.3



The result shows that the amount of rainfall was highest in the year 1995 and lowest in 1987 within the 10 years when compared with other years under review, with 2622.3 mm and 2076 mm respectively.

Table 2 and figure 5: Annual Rainfall from 1996 to 2005

Number	Year	Annual Rainfall(mm)

1	1996	2691.1
2	1997	2889.9
3	1998	1641.5
4	1999	2515.4
5	2000	2337.2
6	2001	2304.3
7	2002	2082.6
8	2003	2370.3
9	2004	2265.3
10	2005	2246.8

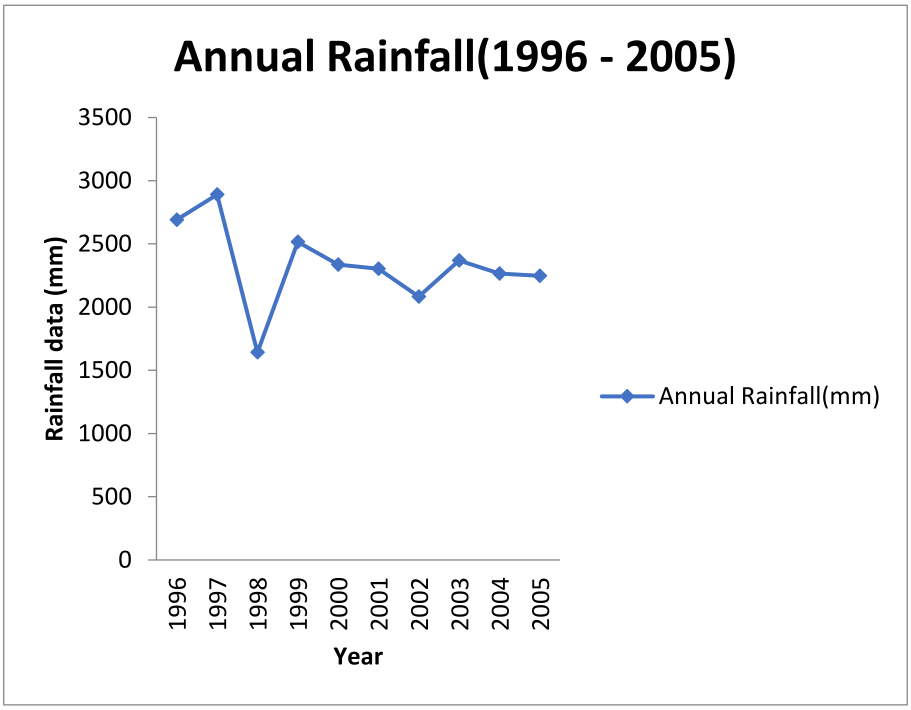


Figure 5

The result of the amount of rainfall from 1996 to 2005 indicates that the rainfall amount was highest in the year 1997 and lowest in 1998 with 2889.9 mm and 1641.5 mm when compared with other years.

Table 3 and figure 6: Annual Rainfall from 2006 to 2015

Number	Year	Annual Rainfall(mm)
1	2006	2350.2
2	2007	2315.3
3	2008	2818
4	2009	2979.1
5	2010	2979.1
6	2011	2104.4
7	2012	2544.1
8	2013	2029.6
9	2014	1781.8
10	2015	2246.6

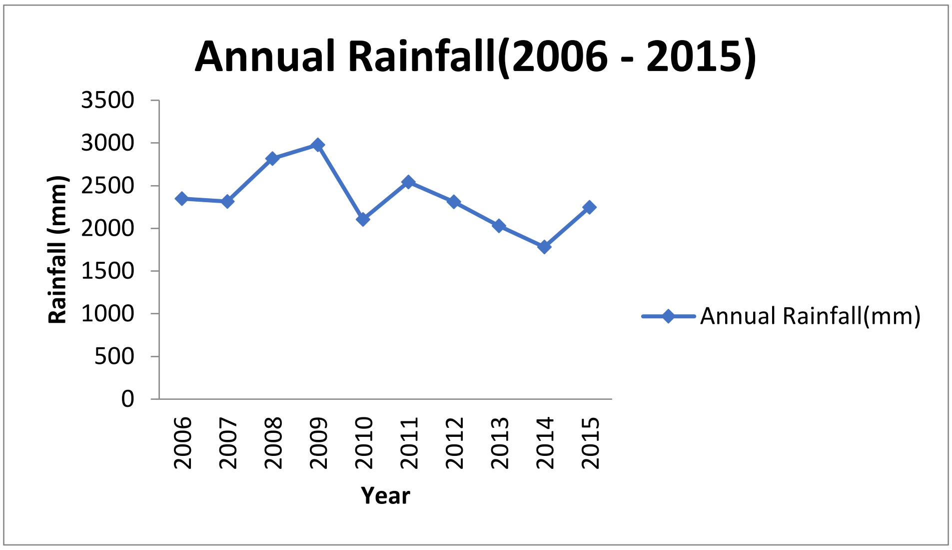


Figure 6

The result of 2006 to 2015 annual rainfall shows that in the year 2009, the amount of rainfall was highest and lowest in 2014 with 2979.1 mm and 1781.8mm when compared to the other years under review.

Table 4 and Figure 7; shows the result of the Annual Trends Rainfall Erosivity for Imo State (1986 – 2015)

Year	Annual Rainfall Erosivity(u)	u^2
1986	336.9	113501.6
1987	322.9	104264.41
1988	326.8	106798.24
1989	345.5	119370.25
1990	435.8	189921.64
1991	368.9	136087.21
1992	313.2	98094.24
1993	280.8	78848.64
1994	375.1	140700.01
1995	360.5	129960.25
1996	386.2	149150.44
1997	356.5	127092.25
1998	229.3	52578.49
1999	330.6	109296.36
2000	319.9	102336.01
2001	298.5	89102.25
2002	309.8	95976.04
2003	324.5	105300.25
2004	287.7	82771.29
2005	287.7	82771.29
2006	328	107584
2007	368.2	135571.24
2008	410.9	168838.81
2009	391	152881
2010	292.3	85439.29
2011	352.5	124256.25
2012	318.6	101505.96
2013	243.6	59340.96
2014	218.9	47917.21
2015	298.6	89161.96
Total	9819.7	3286417.85
Long Term Mean	327.3233	109547.2617

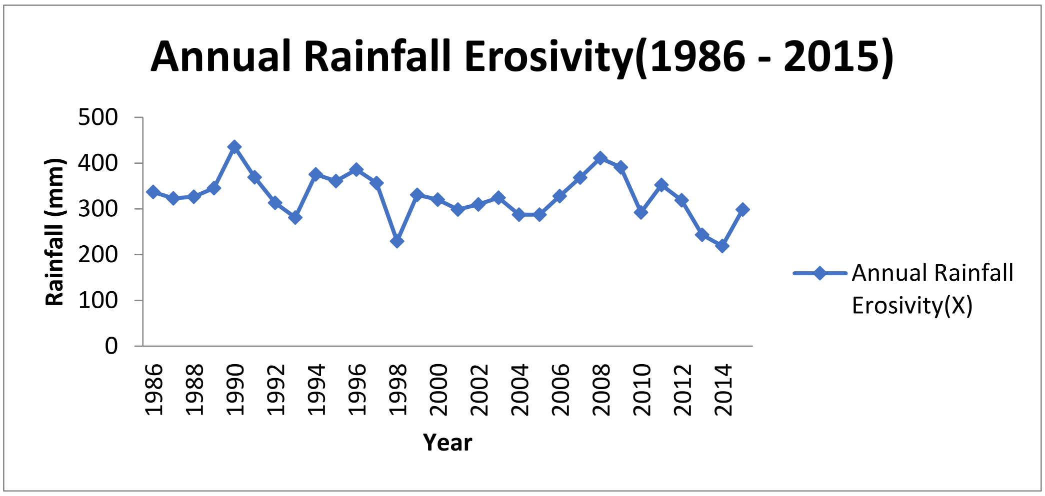


Figure 7: Annual rainfall erosivity 1986 -2015

The result shows that the rainfall erosivity was highest in 1990, when compared with other years under investigation with 435.8 mm, followed by 2008 with 410.9 mm respectively, while the lowest rainfall erosivity was found in 2014 with 218.9 mm. The long term mean rainfall erosivity was found to be 327.32 mm

Table 5: Rainfall Erosivity index classification based on the modified Fournier index

Rainfall Erosivity Range	Interpretation
< 60	Very Low
60 - 90	Low
90 - 120	Moderate
120 - 160	High
> 160	Very High

Table 5: Shows the result of the statistical analysis

Parameter	Table
Mean	327.32
Skweness	1.1
Standard deviation	49.08
Variance	2408.88

CONCLUSION AND RECOMMENDATION

Conclusion

The precipitation erosivity of a tropical rain forest region has been investigated. The study established the erosivity index for Imo state southeastern Nigeria. Precipitation erosivity considering the amount of rainfall and intensity is an important parameter for soil erosion risk assessment under future land use and climate change. Thus the reason for the severity of soil erosion in Imo state can be equated to rainfall erosivity which is controlled by the rainfall characteristics. The result from the tables and figures shows that the amount of rainfall in Imo State was high from 1986 – 2015 the years under consideration.

The annual mean precipitation erosivity calculated as 327.32mm, shows that the high precipitation erosivity in Imo State is a major contributor to the high soil loss in the State. The skewness value of 1.1, Show that there is a positive impact of high rainfall erosivity on soil erosion.

Recommendations

The fact that Imo State under review recorded more month of very high erosivity index portrays the potential ecological crisis in the area with increase in rainfall amounts and further disturbance of land cover. There is need for monitoring of hydrologic regime and climate –related factors in the state as well as define areas most vulnerable to erosion. Land use management in relation to soil vulnerability is highly necessary. Also Engineering structures such as the design of grassed- waterways and stream-bank reinforcement will aid in the reduction of water erosion. Cover crops should be used during periods when the soil would have sufficient residue. Finally terraces which are cross slope channels that controls erosion on crop land should be built within the most vulnerable areas so that crops can be grown on them as this is also applicable to regions and countries with the same topography as the study area.

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