Hydrology for Disaster Management

Special Publication of the Nigerian Association of Hydrological Sciences, 2012

An Assessment of Rainfall Erosivity in Parts of Eastern Nigeria: A Case Study of Owerri and Enugu

Balogun I., Adegun O. and Adeaga, O.

Department of Geography, University of Lagos, Lagos, Nigeria

Corresponding author : E-mail - idowubalogun@yahoo.com, Phone- 08052293938

Abstract

Information on the aggressiveness and erosive power of rains received within eastern Nigeria is necessary for the proper management of soil erosion hazard within the region. In recognition of the role of rainfall as an inceptor and facilitator of soil erosion, rainfall erosivity of Owerri and Enugu was estimated using the Modified Fournier Index (MFI). The results showed that the rains received between 1974 and 2011 were highly erosive, with the annual rainfall erosivity computed of the study period being consistently greater than 160 mm.

The degree of relationship between annual rainfall and annual rainfall erosivity for the study period which was established using the Karl Pearson's Coefficient of Correlation revealed a moderate (r = 0.609) and a high (r = 0.795) degree of positive relationship for Owerri and Enugu, respectively. In the light of the results obtained, an improved understanding of the climatic and hydrologic regime of the area is advocated in order to evolve better soil protection and management strategies.

Key words: Rainfall, Rainfall Erosivity, Erosion, Modified Fournier Index, Decade

Introduction

Rainfall constitutes an important climatic factor of land degradation such as soil erosion. This is due to ability of rainfall to erode soil by the force of raindrops (occasioned by the velocity of rain hitting the soil, and the amount of kinetic energy generated), surface and subsurface runoff, and river flooding (WMO, 2005).

Among the factors influencing rain erosion hazards which include relief effect, soil erodibility, soil cover, soil conservation and agroforestry, rainfall erosivity plays a major role. This is because the initiation of the erosion process primarily depends on the intensity of rainfall and the total amount of rain received within the environment (Stanga, 2011).

Rainfall erosivity is described as the capability or potential ability of rainfall or rainstorm to cause erosion. It is a link between the dynamic properties of rainfall as a consequence of rainfall generating processes and their impact on soil. It is an indication of precipitation aggressivity. This characteristic of rainfall is a function of its amount, duration, drop size and drop size distribution, terminal velocity, intensity and kinetic energy. The importance of rainfall erosivity in the assessment of soil erosion risks stems from the fact that, unlike other natural factors that affect soil erosion, the erosive capacity of rainfall is not subject to human modification (Salako, 2003; Angulo-Martinez & Begueria, 2009).

El-Swaify et al. (1982) identified the major consequences of rainfall erosion to be changes in farm productivity, siltation of water channels and storage reservoirs, and environmental alterations at sediment destinations such as oceans, lakes or estuaries.

In eastern Nigeria soil erosion is a prominent ecological problem and the torrential nature of the rains during the wet season, has been identified as one of the facilitators of soil

erosion within the region. This has often resulted in inter-rill and rill erosion, as well as gullying.

The recognition of the erosion-inducing and magnifying role of rainfall in the eastern parts of the country, therefore, calls for the quantification and estimation of rainfall erosivity, as its estimation is central to the assessment of soil erosion risk within the region.

This study, therefore, estimates the rainfall erosivity of Owerri and Enugu using the Modified Fournier Index (Arnoldus (1980). It also establishes and the degree of relationship between annual rainfall amount and the estimated annual rainfall erosivity at the study locations.

Study Area

The study locations are Owerri (approximately Latitude 06 26′ 54′′; Longitude 07 30′ 00′′) and Enugu (approximately Longitude 05 29′ 00′′ ; Longitude 07 02′ 15′′) in eastern Nigeria (Figure 1). In terms of relief, the land surface of eastern Nigeria can be classified into three broad units. These are the plains and lowlands (including the river valleys), the cuesta landscapes and the highlands (Ofomata, 1975a).

Climate-wise, eastern Nigeria is characterised by seasonal distribution of rainfall which depends on the interaction of the Tropical Continental air mass, the Tropical Maritime air mass and the Equatorial Easterlies. The rainfall pattern which is controlled by the movement of the Inter-tropical Convergence Zone (ITCZ) is characterised by a long wet season from April to July, with a short dry season in August, followed by a short wet season from September to October (Monanu, 1975). The rainfall of utmost importance for soil erosion within the region are the short duration rains that fall at the beginning and at the end of the rainy season due to their intensity and violence (Ofomata, 1975b).

Five major soil classes are recognised within eastern Nigeria based on morphology, degree of profile development, mineral properties of the underlying rocks, and the slope of the terrain. These are the lithosols, young soils derived from recently deposited materials, ferruginous tropical soils, ferrallitic soils and hydromorphic soils (Ofomata, 1975a).

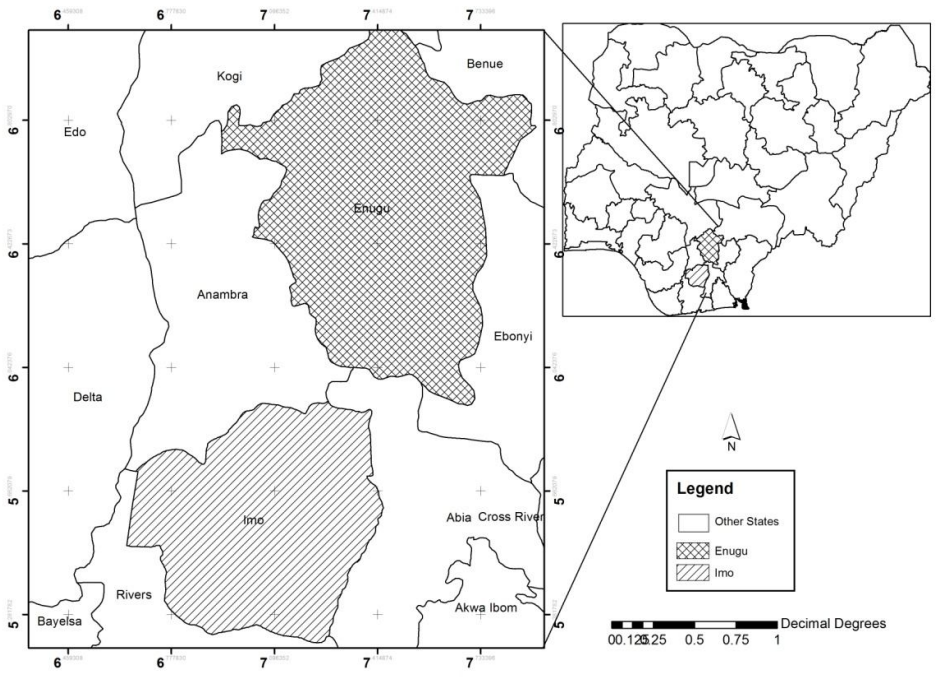

Fig. 1: Imo and Enugu States of Eastern Nigeria

Methodology

Monthly rainfall data for the period 1974-2011 for Owerri and Enugu was obtained from the Nigerian Meteorological Agency (NIMET), Lagos. The rainfall data was used to estimate the rainfall erosivity of the study locations based on Arnoldus (1980) Modified Fournier Index (MFI). The Modified Fournier Index is expressed as:

$$MFI = \sum_{1}^{12} \frac{p^2}{P} \quad (1)$$

where
p= Monthly rainfall amount
P = Annual rainfall amount
To determine degree of relationship between the annual rainfall amount and the estimated annual rainfall erosivity, Karl Pearson's Coefficient of Correlation was utilised. The Karl Pearson's Coefficient of Correlation is expressed as:

$$r = \frac{\Sigma XY}{N\sigma_x\sigma_y} \quad (2)$$

where
r = product moment correlation coefficient
x= $(X-\overline{X})$
y =$(Y-\overline{Y})$
σx = Standard deviation of series X

σx = Standard deviation of series Y
N= No of pairs of observations.

Results and Discussion

Rainfall Erosivity

The results of the annual rainfall erosivity (R) estimated for Owerri and Enugu (1974 -2011) through the adoption of the MFI is presented in Tables 1 and 2, respectively. As shown in the Tables, the annual rainfall erosivity at Owerri and Enugu fell within the very high erosivity category, as can be interpreted from Table 3. For Owerri, the highest rainfall erosivity of 464.32 mm was recorded in 1990 while the lowest rainfall, 159.39 mm, was recorded in 2001. For Enugu, the highest rainfall erosivity of 336.45 mm was recorded in 1980, while the lowest, 184.05 mm, was recorded in 1986. As also shown in Tables 1 and 2, the erosivity of rainfall in Owerri (mean = 310.44 mm) is generally higher than the erosive power of rainfall at Enugu (mean = 257.05 mm).

Furthermore, the decadal rainfall erosivity for Owerri (Figure 2) was highest in the 1990-1999 decade, with a mean of 334.11 mm compared with the 284.28 mm and the 312.39 mm of the 1980-1989 and 2000-2009 decades, respectively. For Enugu, mean decadal erosivity (Figure 3) was highest in the 2000-2009 decade with a value of 269.32 mm. It was 245.22 mm and 254.71 mm for the 1980-1989 and 1990-1999 decades, respectively.

Table 1: Annual Rainfall Erosivity for Owerri, 1974-2011

Year	Annual Rainfall Erosivity (mm)	Year	Annual Rainfall Erosivity (mm)
1974	352.2	1993	281.46
1975	287.64	1994	404.92
1976	283.19	1995	361.03
1977	297.42	1996	383.43
1978	298.3	1997	365.43
1979	344.01	1998	225.79
1980	337.71	1999	335.14
1981	336.11	2000	355.37
1982	287.3	2001	159.39
1983	256.16	2002	294.02
1984	214.28	2003	379.92
1985	232.48	2004	230.3
1986	330.54	2005	288.26
1987	165.30	2006	327.78
1988	327.41	2007	323.22
1989	355.54	2008	411.56
1990	464.32	2009	354.1
1991	208.29	2010	286.94
1992	311.32	2011	339
Long Term Mean (1974-2011) = 310.44mm			

Table 2: Annual Rainfall Erosivity for Enugu, 1974-2011

Year	Annual Rainfall Erosivity (mm)	Year	Annual Rainfall Erosivity (mm)
1974	295.88	1993	187.15
1975	193.3	1994	207.70
1976	227.34	1995	298.82
1977	232.7	1996	271.17
1978	315.31	1997	297.60
1979	238.69	1998	217.38
1980	336.45	1999	224.63
1981	247.74	2000	302.22
1982	221.16	2001	256.66
1983	198.71	2002	252.14
1984	299.37	2003	292.23
1985	291.34	2004	243.65
1986	184.05	2005	239.14
1987	211.61	2006	298.17
1988	204.64	2007	275.34
1989	257.11	2008	255.91
1990	336.08	2009	277.71
1991	258.72	2010	324.45
1992	267.63	2011	247.67
Long Term Mean (1974-2011) = 257.05mm			

Table 3: 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

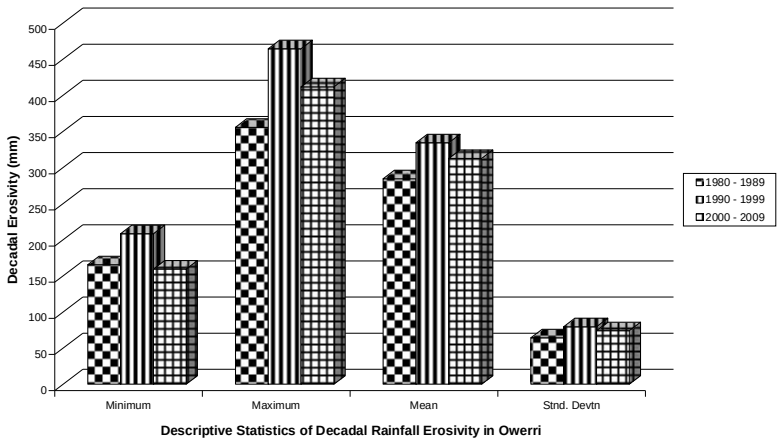

Fig. 2: 1980 – 2009 Descriptive Statistics of Decadal Rainfall Erosivity in Owerri

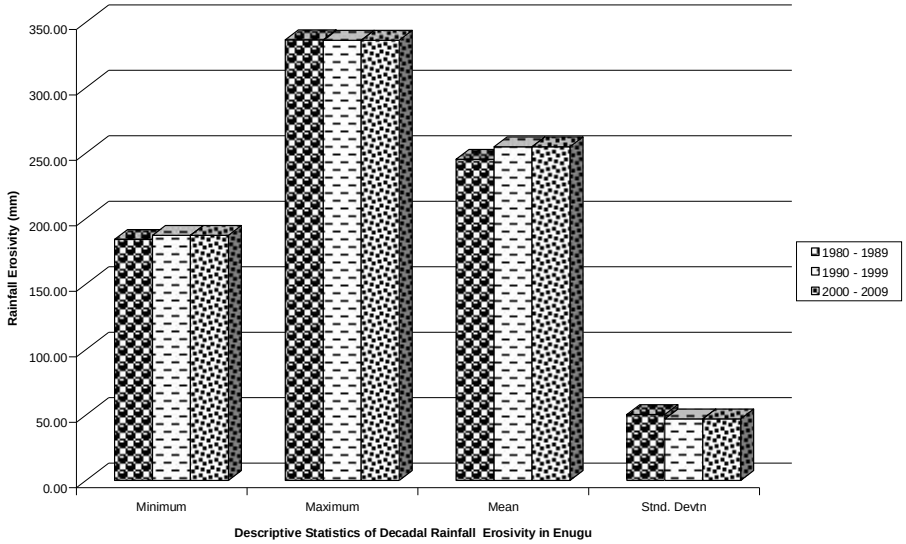

Fig. 3: 1980 – 2009: Descriptive Statistics of Decadal Rainfall Erosivity in Enugu

Rainfall-Rainfall Erosivity Relationship

The results of the Karl Pearson's coefficient of correlation (Table 4) indicate a positive degree of relationship between annual rainfall and annual rainfall erosivity for the 38-year period, for both Owerri and Enugu. As shown in Table 5, the r value (0.609) for Owerri indicates a moderate degree of positive relationship between annual rainfall and rainfall erosivity between 1974 and 2011, while the for Enugu, the r value of 0.795 indicates a high degree of positive relationship between annual rainfall and rainfall erosivity for the same time period.

Table 4: Product Moment Correlation Coefficient for Owerri and Enugu

Location	r value
Owerri	0.609
Enugu	0.795

* r was significant at 0.01 level of significance

Conclusion

The results of the study show that rainfall received within Owerri and Enugu is highly erosive as indicated by the > 160mm erosivity index computed for the study locations for each year. Furthermore, the results of the correlation analysis revealed a positive degree of relationship between rainfall and rainfall erosivity.

The estimated high erosivity index for the study locations portends further risk of soil erosion hazards, especially under conditions of increasing rainfall and some anthropogenic activities such as soil excavation, which takes place in parts of eastern Nigeria. The continued vulnerability of the soil of the region to erosion occasioned by the highly erosive power of the rains received within the region therefore requires an improved understanding of the climatic and hydrologic regime of the area, as well as other soil

erosion processes. This is with a view to developing soil protection and management strategies that would assist in minimising the risk of soil erosion within the region.

References

Anugulo-Martinez., M and Begueria, S. (2003). *Estimating rainfall erosivity from precipitation records: A comparison among methods using data from Ebro basin NE (Spain)*. Journal of Hydrology, 379(1-2), 111-121.

Lujan, D.L., and Gabriels, D. (2005). *Assessing the rainfall erosivity and rain distribution in Different agro-climatological zones in Venezuela.* Sociedade and Natureza, Uderlandia, Special Issue, 16-29, May, 2005, 16-29.

Monanu, P.C. (1975). Rainfall. In : Nigeria in maps: Eastern States, Ofomata, G.E.K. (Ed). Ethiope Publishing House, Benin City, Nigeria

Ofomata G.E.K. (1975a). Soil. In : Nigeria in maps: Eastern States, Ofomata, G.E.K. (Ed). Ethiope Publishing House, Benin City, Nigeria.

Ofomata G.E.K. (1975b). Soil Erosion. In : Nigeria in maps: Eastern States, Ofomata, G.E.K. (Ed). Ethiope Publishing House, Benin City, Nigeria .

El-Swaify, S,A, Dangler, E.W and Amstrong, C.L (1982). Soil Erosion by Water in the Tropics. College of Tropical Agriculture and Human Resources, University of Hawaii

Salako, F.K. (2000). Susceptibility of coarse textured soils to erosion by water in the tropics. Lecture given at College on Soil Physics, Triste, 3-21 March, 2003.

World Meteorological Organisation (2005).

Stanga, I.C. (2011). *Climate aggressiveness and rainfall erosivity*. Riscuri Şi Catastrofe*,* N.R. X, 9 (NR.2/2011), 21-32.

World Meteorological Organisation (2005). Climate and Land Degradation. WMO-No.989.