Hydrology for Disaster Management

Special Publication of the Nigerian Association of Hydrological Sciences, 2012

Precipitation Concentration Changes in Owerri and Enugu

Adegun O., Balogun I. and Adeaga O.

Department of Geography, University of Lagos, Lagos, NIgeria.

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

Abstract

The precipitation concentration index (PCI) of Owerri and Enugu for 1974 to 2011 was computed. The PCI was estimated on an annual and seasonal scale. The seasonal estimation were based on the categorisation of the seasons in eastern Nigeria into long wet season, short wet season, short dry season and dry season.

The results of the PCI computed for Owerri showed that 87% of the years for which annual PCI was computed fell within the moderate concentration category range, while for Enugu 71% of the years fell within the moderate concentration category. For the long wet season for the study period, 74% and 66% of the years fell within the uniform precipitation concentration category at Owerri and Enugu, respectively, while 13% of the years at Owerri, and 16% of the years at Enugu fell within the moderate precipitation category.

Information derived from the PCI computation can be used for hydrological, water resources and environment management programmes, as well as serve as a warning tool for disaster preparedness in relation to flooding and erosion.

Key words: Precipitation Concentration Index; Owerri, Enugu, Rainfall; Variability.

Introduction

The characteristics and variability rainfall received within an environment has a strong influence on a number of natural processes such as groundwater recharge and water availability, modification of the fluvial regime, and the likelihood and severity of soil erosion. Furthermore, the spatial and temporal variability of rainfall represent an important component of gaining knowledge of the water balance dynamics on different scales for water resources management and planning (De-Luis et al., 2011; Ezemonye & Emeribe, 2011).

Similarly, information derived through a good understanding of the spatial and temporal characteristics of rainfall is also very important for agricultural planning, flood frequency analysis, hydrological modelling, water resources assessments, assessing and understanding climate change impacts and other environmental assessments (Michaelides et al, 2009 as cited in Ngongondo et al., 2011).

In eastern Nigeria, there is considerable variation in the total annual rainfall from year to year. In some years, the rains may be prolonged, while in others, their onset may be delayed by 4 to 5 weeks. Also in some years, the August break may not be experienced. The highest total annual rainfall in eastern Nigeria is received around the eastern highlands due to the convectional and orographic nature of the rains received (Monanu, 1975). According to Monanu (1975), variations in the amount, seasonal distribution and annual rainfall variability affect peasant farming within communities adversely. Furthermore, the total amount of rains received within the eastern part of Nigeria diminishes northwards.

This study assesses the concentration and variability of rainfall in Owerri and Enugu between 1974 and 2011 using the Precipitation Concentration Index (Oliver, 1980).

Study Area

Owerri and Enugu (Figure 1) are located in eastern Nigeria and are approximately bounded by Latitude 06 26′ 54′′ and Longitude 07 30′ 00′′ and Latitude 05 29′ 00′′ and Longitude 07 02′ 15′′, respectively. The seasonal distribution of rainfall in eastern Nigeria is controlled by the interaction of the Tropical Continental air mass, the Tropical Maritime air mass and the Equatorial Easterlies. The interaction and arrangements of these three air masses within the region is responsible for the convectional, orographic and frontal rainfall types, which are predominant within the region. 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 (Momanu, 1975). According to Ofomata (1975a), the short duration, high intensity rains that often occurs at the onset and retreat of the rainy season, are of great significance for soil erosion within the east.

Rainfall in Enugu is convectional in nature, and often occurs in quick alternate succession between sunny and dry conditions. The rainfall often occurs as violent downpours, which may be accompanied by thunderstorms, heavy flooding, soil leaching, erosion, gullying and groundwater recharge (Egboka, 1985). In Owerri, the peak rainfall occurs within the months of June, July, September or October, while the months of December to February are characterised by low rainfall.

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, 1975b). According to Hudec et al. (2006), the textural properties of the surficial soil and the horizontal to gently inclined bedrock of eastern Nigeria make them highly vulnerable to erosion.

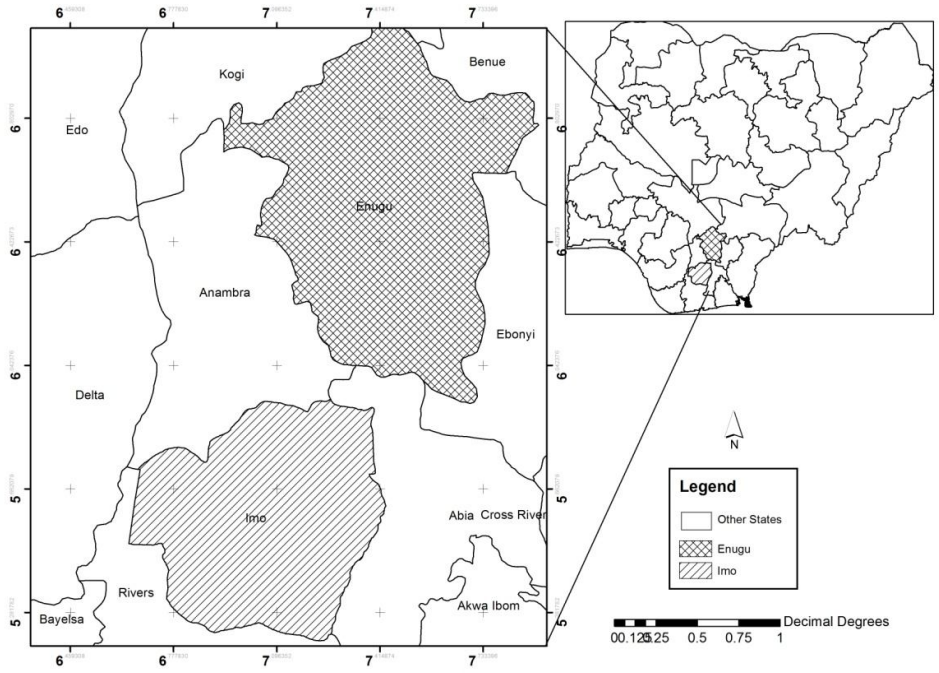

Fig. 1: Imo and Enugu States of Eastern Nigeria

Methodology

Monthly rainfall data for the period 1974-2011 for Owerri and Enugu was obtained from the Nigerian Meteorological Agency (Nimet), Lagos. The data was used to analyse the temporal distribution and concentration of rainfall at the study locations based on the Precipitation Concentration Index (PCI).

The PCI was estimated on an annual and seasonal scale, based on the division of the seasons into four categories as shown in Table 1. The number 100 in the formula for the annual PCI (Equation 1) represents 12 months of the year signifying 100%. The numbers 33, 17 and 42 in Equations 2 to 4 represent the number of months in each season as a percentage of 12 months of the year. The PCI for the short wet season (August) was not computed because the square of monthly precipitation and the total monthly precipitation was the same and their division equals one.

According to Oliver (1980), PCI values of less than 10 represent a uniform precipitation distribution or low precipitation concentration, values between 11 and 15 represent a moderate precipitation concentration or moderate precipitation distribution. Values between 16 and 20 represent irregular distribution of rainfall, while values above 20 represent a strong irregularity of precipitation distribution or high precipitation concentration. The Precipitation Concentration Index for the annual, long wet season (LWS), short wet season (SWS) and the dry season (DS) was computed according to equations 1, 2, 3 and 4, respectively.

$$PCI_{annual} = \frac{\sum_{i=1}^{12} P_i^2}{\sum_{i=1}^{4} P_i^2} \times 100 \quad (1)$$

$$PCI_{LWS} \quad \frac{\sum_{i=1}^{2} P_i^2}{} \quad (2)$$

$$PCI_{SWS} \quad \frac{\sum_{i=1}^{5} P_i^2}{} \quad (3)$$

$$PCI_{DS} = \frac{\sum_{i=1}^{5} P_i^2}{(\sum_{i=1}^{5} P_i)^2} \times 42 \quad (4)$$

Table 1: Seasons of the Year and their Percentage as a Function of a Year

Season	Months	Number of Months as a % of 12 Months
Long Wet Season	April-July (4 Months)	33%
Short Dry Season	August (1 Month)	8%
Short Wet Season	September-October (2 Months)	17%
Dry Season	November-March (5 Months)	42%

Precipitation Concentration Index

The results of the PCI for Owerri showed that 87% of the years for which the annual PCI was estimated fell within the moderate precipitation concentration range, while 13% fell within the irregular precipitation distribution range. The results of the PCI for the long wet season for the study period also shows that rainfall during the long wet season was mostly uniformly distributed as 74% of the 38-year data period showed PCI values less than 10, while 26% of the period under study exhibited moderate seasonal distribution

For the short wet season, rainfall was generally uniformly distributed, with 87% of the estimated PCI being within the uniform precipitation distribution category and 13% being within the moderate precipitation concentration category. For the dry season, rainfall was mostly strongly irregular, with 68.42% having PCI values above 20, while 26.3% and 5.26% of the period exhibited irregular and moderate distribution of rainfall.

On a decadal basis, the annual PCI for Owerri for 1980-1989, 1990-1999, and 2000-2009 decades mostly fell within the moderate concentration precipitation category, while for the long wet season and the short wet season, rainfall was generally uniformly distributed for all the decades. For the dry season, the PCI for the three decades were mainly in the strongly irregular distribution category. Figures 2 to 5 show the annual, long wet season, short wet season and dry season PCI estimation of Owerri from 1974-2011, while Table 2 presents the decadal summary for the same time period.

For Enugu, the annual PCI values showed that rainfall was predominantly moderately distributed, with 71% of the annual rainfall for the 38-year period having values ranging between 11 and 15. Furthermore, 26% of the annual PCI values denoted irregular

distribution of rainfall, while strong irregularity of rainfall distribution occurred in 3% of the study period.

For the long wet season, 34% of the rainfall distribution of the study period was within the moderate precipitation concentration category, while 66% of the rainfall distribution fell within the uniform precipitation distribution category. For the short wet season, 84% of the study period fell within the uniform rainfall distribution category, while 16% was within the moderate rainfall distribution category. For the dry season, the rainfall was generally irregular with 95% of the rainfall distribution exhibiting strong irregularity and 5% exhibiting irregular distribution.

For the decades spanning 1980-1989, 1990-1999, and 2000-2009, the annual PCI for Enugu was mainly within the moderate precipitation concentration category, while the PCI for the long wet season fell mainly within uniform precipitation distribution category. For the short wet season the uniform precipitation distribution category was predominant, while for the three decades rainfall was strongly irregular.

Figures 6 to 9 present the annual, long wet season, short wet season and dry season PCI estimation of Enugu from 1974-2011, while Table 3 presents the decadal summary of the computed PCI for the same time period.

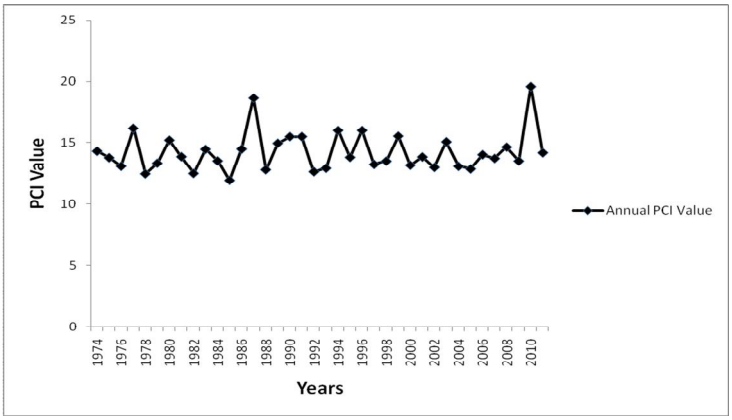

Fig.2: Annual PCI for Owerri at 1974-2011

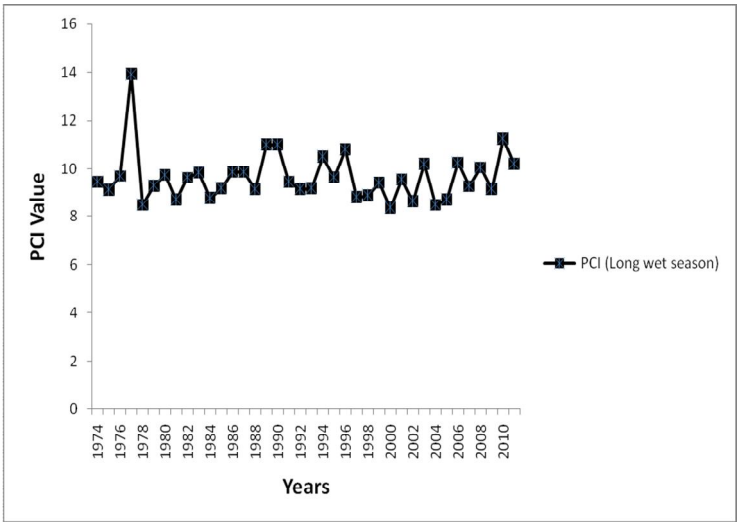

Fig.3: PCI for the Long Wet Season at Owerri (1974-2011)

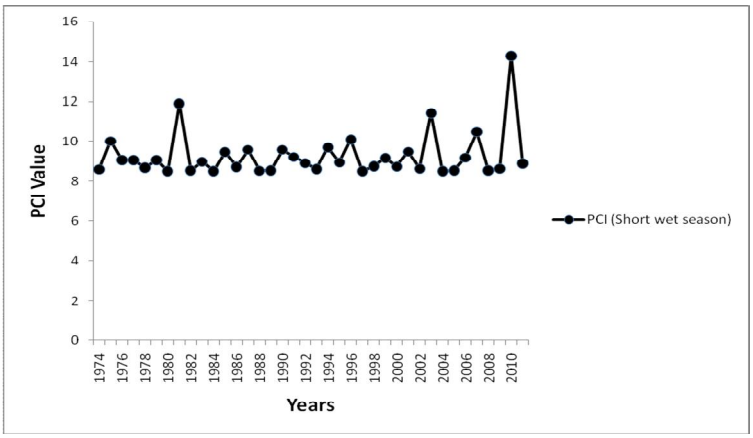

Fig.4: PCI for the Short Wet Season at Owerri (1974-2011)

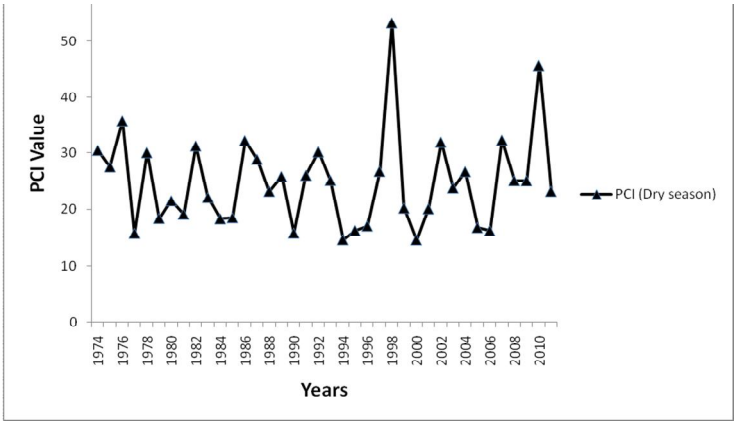

Fig.5: PCI for the Dry Season at Owerri (1974-2011)

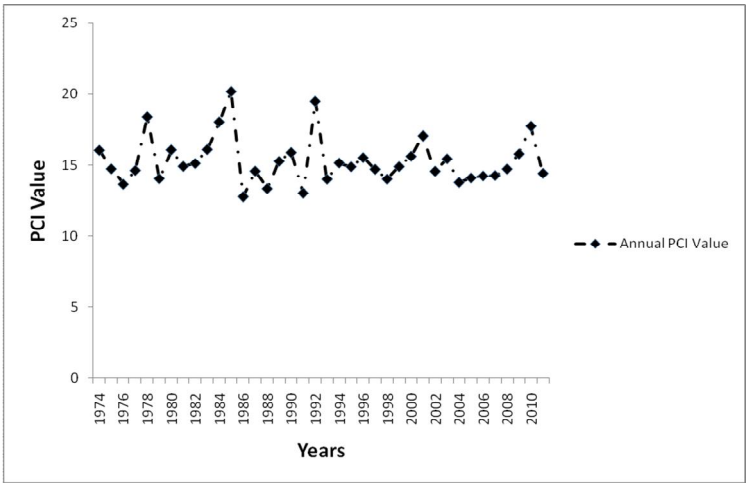

Fig.6: Annual PCI for Enugu at (1974-2011)

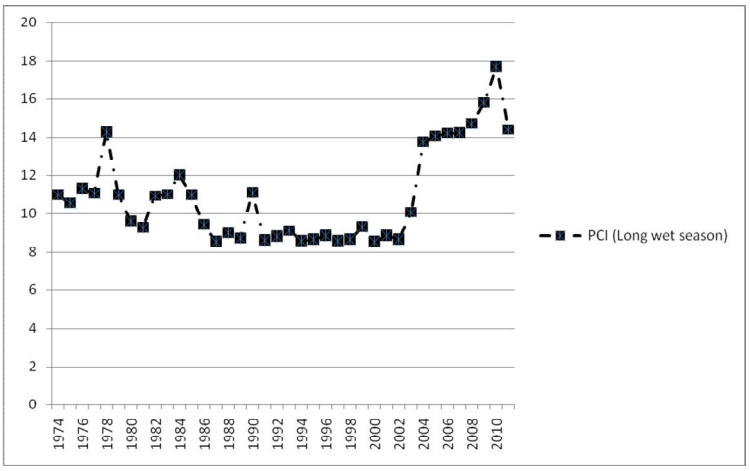

Fig.7: PCI for the Long Wet Season at Enugu (1974-2011)

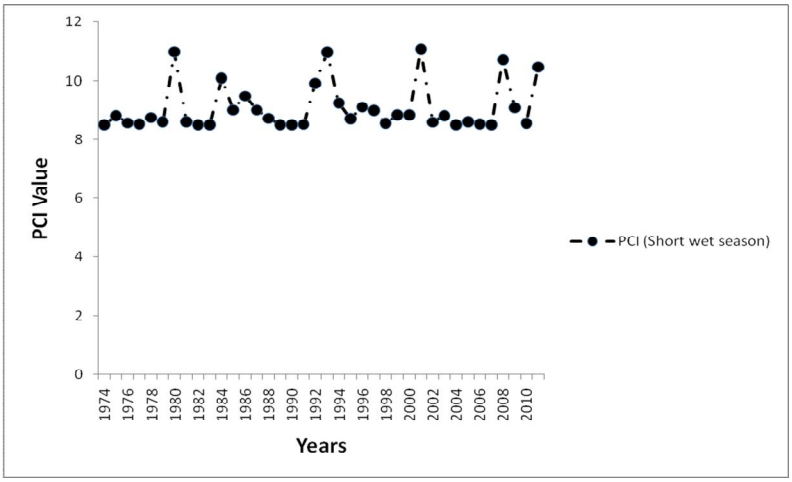

Fig.8: PCI for the Short Wet Season at Enugu (1974-2011)

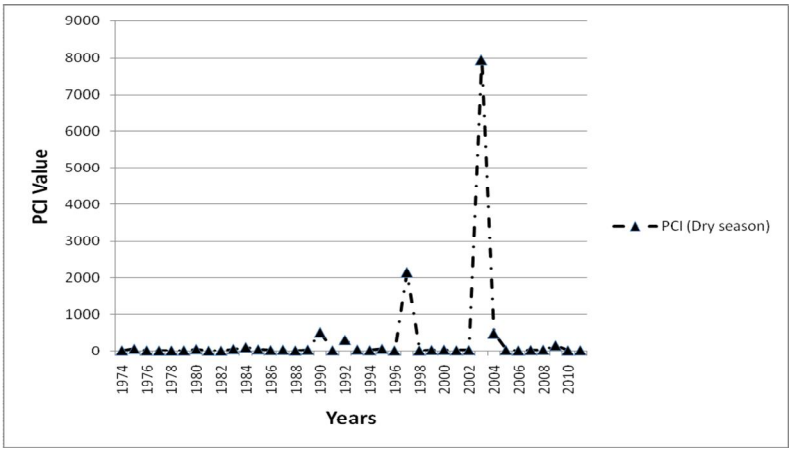

Fig. 9: Fig.5: PCI for the Dry Season at Enugu (1974-2011)

Table 2: Decadal Summary of PCI for Owerri (1974-2011)

Decade	Annual PCI	LWS PCI	SWS PCI	DS PCI
1980-1989	MO - 90%	MO – 10%	M – 10%	SI- 70%
	IR – 10%	U – 90%	U – 90%	IR – 30%
1990-1999	MO - 80%	MO- 30%	M – 10%	SI – 60%
	IR – 20%	U – 70%	U – 90%	IR – 30%
				MO – 10%
2000-2009	MO -100%	MO – 30%	MO – 30%	SI – 70%
		U – 70%	U – 70%	IR – 20%
				M – 10%

Table 3: Decadal Summary of PCI for Enugu (1974-2011)

Decade	Annual PCI	LWS PCI	SWS PCI	DS PCI
1980-1989	MO - 60%	MO – 40%	M – 20%	SI- 100%
	IR – 30%	U – 60%	U – 80%	
	SR – 10%			
1990-1999	MO - 80%	MO- 10%	M – 10%	SI – 100%
	IR – 20%	U – 90%	U – 90%	
2000-2009	MO -80%	MO – 10%	MO – 10%	SR – 100%
	IR – 20%	U – 90%	U – 90%	

*MO represents moderate precipitation concentration, U represents uniform precipitation concentration, IR represents irregular rainfall distribution, SI represents strong irregularity

Implications and Conclusion

Precipitation Concentration Index is an index or descriptor of rainfall variability, which in essence means that the index can provide information on water availability within an

Fig.9: PCI for the Dry Season at Enugu (1974-2011)

environment. This information can be used for a wide variety of hydrological, water resources and environmental management programmes. Furthermore, the index can be used as a warning tool for disaster preparedness in relation to flooding and erosion within the area.

References

De-Luis, M., Gonzales-Hidalgo, J. C., Brunetti, M., and Longares, L. A. (2011). *Precipitation concentration changes in Spain 1946-2005*. Natural Hazards and Earth Systems Sciences , 11, 1259-1265.

Ezemonye, M. N. , and Emeribe, C.N. (2011). Correlogram analysis of trends and cycles in rainfall over southeastern Nigeria. Pakistan Journal of Social Science, 8(6), 325-333.

Egboka, B. C. E (1985). Water resources problems in the Enugu area of Anambra State, Nigeria. Proceedings of the Jerusalem Symposium, September 1985, IAHS Publications no.153.

Hudec, P.P., Simpson, F., Akpokodje, E.G, Umenweke, M.O. (2006). Termination of gully erosion processes, southeastern Nigeria. Proceedings of the Eight Federal Interagency Sedimentation Conference, April, 2-6, 2006.

Monanu, P. C. (1975). Rainfall. In : Nigeria in maps: Eastern States, Ofomata, G.E.K. (Ed). Ethiope Publishing House, Benin City, Nigeria, pp. 25-26.

Ngongondo, C., Xu, C.Y., Gottschalk, L., and Alemaw, B. (2011). *Evaluation of spatial and temporal characteristics of rainfall in Malawi: a case of data scarce region.* Theoretical and Applied Climatology, 106, 79-93.

Ofomata, G. E. K. (1975a). Soil Erosion. In : Nigeria in maps: Eastern States, Ofomata, G.E.K. (Ed). Ethiope Publishing House, Benin City, Nigeria, pp. 41-42.

Ofomata, G. E. K. (1975b). Soil. In : Nigeria in maps: Eastern States, Ofomata, G. E. K. (Ed). Ethiope Publishing House, Benin City, Nigeria, pp. 43-45.

Oliver, J.E. (1980). Monthly precipitation distribution: A comparative index. Professional Geographer, 32, 300-309.