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Comparative Morphometric Analysis of Nyaba and Oji Drainage Basins Southeastern Nigeria

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ABSTRACT

Morphometry is the measurement and mathematical evaluation of earth's surface, form and the dimension of the landforms. The morphometric analysis of the drainage basin and channel network plays a significant role in comprehension of the geo-hydrological nature of drainage basin and expresses the prevailing climate, geological setting, geomorphology and structural antecedents of the catchment area. Morphometric analysis of the sub- watersheds in Enugu area, Southeastern Nigeria using GIS processed Remote Sensing data was carried out with the objectives of evaluating their morphometric characteristics. The present study involved the measurement of the linear, aerial and relief aspects of the dimensions of the sub-watersheds. Results indicated that Nyaba and Oji basins are 4th and 5th order basins respectively and each with dendritic pattern. Nyaba and Oji basins have basin area 921 km^2/928 km^2, basin length 63.33 km/63.59 km, basin perimeter 118.38 km/135.70 km, bifurcation ratio 1.23/3.65, length of overland flow 1.19 km/ 1.02 km, form factor 0.22/0.22, circulatory ratio 0.83/0.63, relief ratio 0.021/0.014, drainage density 0.42/0.49, elongation ratio 0.15/ 0.15 and infiltration number 0.07/0.13 respectively. The results show that some parameters such as elongation ratio and form factors are of same values for the two basins while others are very close with the difference not significant. The results as shown from the low form factor value (0.22) of the two basins confirmed their elongated shapes. So, the two drainage basins have flatter or low peak (flood) flows of longer duration that is easier to manage than of the circular basins hence, low incidences of flooding. The outcome of the study is fundamental for prioritizing proactive and sustainable urban flood management, appropriate land use planning and zonation especially along their flood liable areas, storm water management and other general urban environmental degradation management.

Keywords: Drainage Basin, Southeastern Nigeria, Morphometry, Geo-Spatial Technology.

INTRODUCTION

Drainage basin is an area of land drained by rivers and its tributaries. A drainage basin is a geomorphic or hydrologic unit that supplies water, sediments and fluvial materials to a river channel or a network of channels (Umeuduji, 2010). It is bounded by ridges of high land areas beyond which precipitation (rainfall and snow) drain into adjacent basins. The boundary of a drainage basin is called a drainage divide. Drainage basin morphometry can be regarded as the topographical expression of land by way of area, slope, shape, length among others (Ajibade, Ifabiyi, Iroye, & Oguntеru, 2010). These landscape parameters are significant because stream flow can be expressed as a general function of geomorphology of a catchment. Geomorphic characteristic of watersheds play key-role in controlling the watersheds hydrology. Morphometric analysis defines more clearly and precisely the general form of the basin landform as represented on a map and serve as a basis for demonstrating the effect of environmental control on fluvial system and for predicting the basin output variables such as discharge (Oruonye, Ezekiel, Atiku, Baba, & Musa, 2016). Hydrological response of a drainage basin is defined by the production of runoff against a given rainfall, which in turn is characterized by basin morphometric properties, soil characteristics and land use pattern (Oyatayo, Bello, Ndabula, Godwill, & Ademola, 2017). The soil characteristics and land use pattern control the infiltration loss, while the distribution of the remaining excess rainfall is controlled by basin morphometric properties.

Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms (Agarwal, 1998; Obi Reddy, Maji, & Gajbhiye, 2002). The morphometric analysis of the drainage basin and channel network play an important role in understanding the geo-hydrological behavior of drainage basin and expresses the prevailing climate, geology, geomorphology, structural antecedents of the catchment (Hajam, Hamid, & Bhat, 2013).

The most dominant geomorphic systems of earth’s surface are rivers and fluvial processes which leads to morphometric changes in drainage basin or the watershed. River drainage morphometry plays vital role in comprehension of soil physical properties, land processes and erosional features (Mangesh, 2013). The quantitative analysis of drainage system is an important aspect of characterization of catchments and such characterization of catchments plays an important role in the forecasting of the hydrological behavior and in the planning of hydrologic designs. Morphological studies of rivers are very important to study the behaviour of a river, its aggradations/degradation, shifting of the river course, flooding and erosion of river bank e.t.c. and to plan remedial measure for erosion, flooding and other related problems (Oruonye, et al 2016). Geographical Information System (GIS) techniques are now-a-days in use for assessing various terrain and morphometric parameters of the drainage basins and watersheds, as it provide a flexible environment and an important tool for the manipulation and analysis of spatial information. The objective of the present study is to analyze the linear, areal and relief morphometric attributes of Nyaba and Oji river drainage basins in southeastern Nigeria by using geo-spatial technology. This study is attempted to use the morphometric technique vis-a-vis GIS to give an insight to the different geo-hydrological characteristics of the drainage basin. This research is an attempt to understand the drainage basins by evaluating their morphometric parameters which includes their basin shape, length, area, stream order, number of stream segments, bifurcation ratio, drainage density, and frequency. It is an attempt to combine the geomorphologic and hydrological attributes of the drainage basins.

Study Area

Location and Extent

The two drainage basins of interest are Nyaba and Oji river basins. They have their sources from Enugu-Awgu escarpment, Enugu State and extend to Ebonyi and Anambra States, Southeastern Nigeria respectively. The study area is located within latitudes 6^0 4′ 0″N and 6^0 31′ 30″N and longitudes 7^0 5′ 30″E and 7^0 44′ 0″ E. Nyaba river is about 52.21 kilometers in length with a drainage basin area of 921km^2 (Fig.1.). Oji river is about 67.72km in length with a drainage basin area of about 927km^2 (Fig. 1.).

Climate

The climate of Nigeria is classified into meteorological zones with the study area in zone B (Menakaya and Floyd, 1965; Balogun, 2005). Enugu state is located in a tropical rain forest with a derived savanna. The city has a tropical savanna climate (Koppen: Aw). This area is characterized by relatively warm temperature days of 27^0C to 32^0C and moderately cool nights of 17^0C to 28^0C. The area experiences two main distinct seasons, namely the dry season and rainy season. Dry season prevails from early November to March, but between December and early February, the Saharan anticyclone from the northern hemisphere causes dry and dust-laden air mass blowing from across the desert through parts of northern Nigeria into the project area. The rainy season takes off from April to October with an August break or short period of no rain. Rainfall intensity is highest in September and lowest in December and January. The rains occur as violent downpours accompanied by thunderstorms, heavy flooding, soil and gully erosion and fast groundwater infiltration. The area has high relative humidity of about 65% to 80% with the highest in the rainy season when there is medium to low sunshine hours and low evaporation

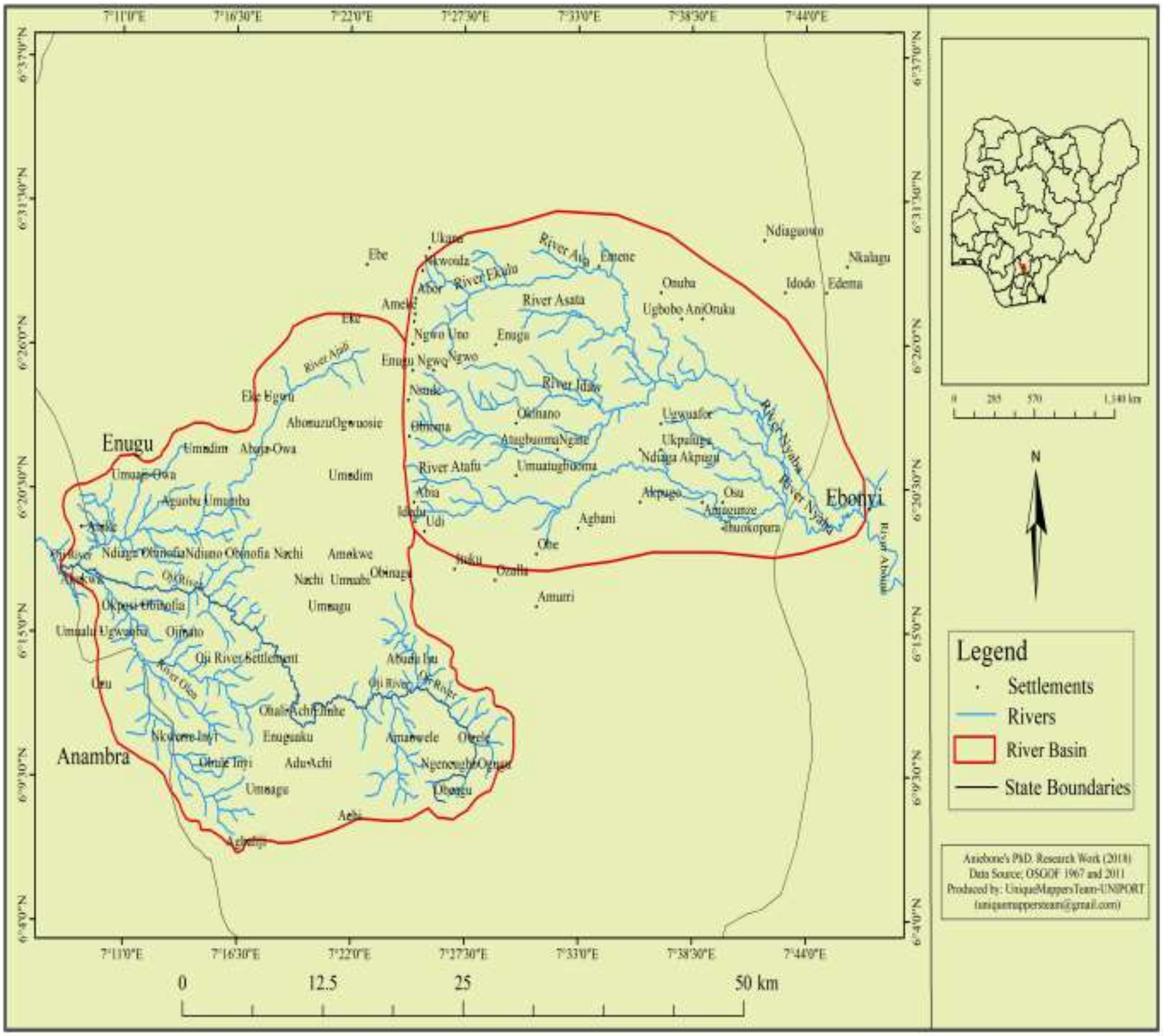

Figure.1: The study area showing Nyaba and Oji river basins

Physiography and Geomorphology

The topography is a reflection of the tectonic and geologic events that occurred over the years and, mildly, neotectonically continues today to shape the geomorphic landscape (Egboka, Nwankwo & Orajaka, 1989). The study area shows undulating relief with a high central zone, which lies over 370m above mean sea level. Some isolated peaks may reach over 580m. The landforms are categorized into cuesta, plains and lowland landscapes. The cuesta comprises the Nsukka-Okigwe cuesta, the Enugu and Awgu escarpments and the Udi-Nsukka plateau (Akamigbo,1987).

Geology and Soils

The geology of Enugu State where the Nyaba and Oji river basins are situated can be broadly classified into shales, false-beddded sandstones and coal measures(Akamigbo, 1887). The study basins, Nyaba and Oji river Basins are underlain by eight lithostratigraphic units. These are: Imo Shale, Nsukka Formation, Ajalli Sandstone, Lower Coal Measure (Mamu Formation), Asata/Enugu/Nkporo Shale, Awgu/Ndeaboh Shale, Ezeaku Shale and Asu River Group (Abakaliki Formation). The soils underlying the study area are of sedimentary origin with sandstones and shales as the two dominant parent materials. The major soil groups include hydromorphic soils derived from shales, deep red soils (ultisols) derived from sandy deposits, red and brown gravelly soils derived from sandstones and shales and shallow brown soils derived from sandy shales of lower coal measures (Akamigbo, 1987).

Hydrology

Enugu State is drained by many rivers. The presence of a north-south trending cuesta or escarpment that crosses Enugu State creates major surface and ground water divides for the two great drainage basins of Cross River and Anambra River east and west respectively. Nyaba and Oji river basins are on the different or opposite sides of the escarpment. Oji river and its tributaries flow westwards into Mamu and Anambra river basins while Nyaba and its tributaries flow eastwards into the Cross river basin. Nyaba and Oji rivers have their sources from the Enugu-Awgu Escarpment in Enugu state southeast, Nigeria. Nyaba flows through the southern parts of the Enugu, passing through various types of land uses from its source down to its confluence with Aboine river in Ebonyi state.

MATERIALS AND METHODS

An integration of remote sensing and geographic information system technology was adopted in this study. The required data were extracted from the published hardcopies of UDI-301 and NKALAGU-302 topographical maps on a 1:100,000 scale. These topo sheets were surveyed and prepared in the year 1967. Landsat imagery of the area was obtained from the United States Geological Survey Agency (USGS) Website as a secondary source to help delineate the Stream ordering, Digital Elevation Model (DEM) and the river basin. The Digital Elevation Model image shows the distribution and spatial variation of elevation values at every geographic point/location within the area. This enables the processing and delineation of drainage basin parameters which are deduced from the elevation values. Drainage basin morphometric parameters and stream order characteristics of the area were extracted from the digitized data using the Strahler’s method of stream ordering. The toposheets were scanned, georeferenced and mosaiced in ArcGIS platform. Drainage network maps were digitized from the toposheets; the maps were projected onto proper coordinate system, in this case it was WGS 1984 UTM Zone 32N using appropriate tools in ArcToolbox. The procedure used in deriving each of the variables is equally shown in table 1.

Table 1 Drainage Basin Characteristics (Morphometric Parameters with formulae)

S/No.	Parameters	Symbol	Formula	Ref
			Linear Aspect	
1	Stream Order	Sμ	Hierarchical rank	Strahler & Chow (1964)
2	Bifurcation Ratio	R_b	Rb = Nμ / Nμ +1, Where, Rb = Bifurcation ratio, Nμ = No. of stream segments of a given order and Nμ +1= No. of stream segments of next higher order.	Schumn (1956)
3	Stream Length	Lμ	Length of the stream (kilometers)	Horton (1945)
4	Basin Length	L	$L = 1.312 \times A^{0.568}$	Schumn (1956)
5	Basin Perimeter	P	P = Outer boundary of drainage basin measured in kilometers.	Schumn (1956)
			Areal Aspect	
6	Basin Area	A	Area from which water drains to a common stream and boundary determined by opposite ridges.	Strahler & Chow (1964)
7	Drainage Density	D_d	D_d = Lμ/A, Where, D_d = Drainage Density (Km/Km^2), Lμ = Total Stream Length Of All Orders and A = Area of the basin (Km^2)	Singh & Singh (1997)
8	Drainage Frequency	F_s	F_s = Nμ/A, Where, F_s = Drainage frequency, Nμ = Total no. of streams of all orders and A = Area of the basin (Km^2)	Singh & Singh (1997)
9	Drainage Intensity	Di	Di =Dd/Df Where Di=Drainage Intensity, Dd=Drainage Density(Km/Km^2) Df= Drainage frequency	Singh & Singh (1997)
			Relief Aspect	
10	Basin Relief	H	H = Z – z, Where, Z = Maximum elevation of the basin (m) and z = Minimum elevation of the basin (m)	Rudraiah , Govindaiah & Vittala (2008)
11	Relief Ratio	Rr	$R_r = H / L_b$, Where, H = basin relief (m) and L_b = Basin length (m)	Schumn (1956)
12	Basin Slope	S_b	Sw = H / L_b, Where H and L_b= given above	Miller (1953)

Figure 1, 2 and 3 show that the Nyaba and Oji basins exhibit dendritic type of drainage network which indicate the homogeneity in texture and lack of structural control in the study area. Tables 2, 3 and 4 represent values pertaining to linear, areal and relief aspects of drainage morphometry in Nyaba and Oji drainage basins. Horton's contribution of quantitative technique of assessing the drainage basins was adopted for this research instead of qualitative descriptions. The morphometric parameters determined include the basins shape, basin length, area, stream order, number of stream segments, bifurcation ratio, drainage density, intensity, and frequency, relief ratio, basin relief, basin slope. Form factor, infiltration number, length of overland flow, circulatory ratio and elongation ratio. These parameters have previously been developed and used in previous studies of geomorphology and surface- water hydrology, such as flood characteristics, sediment yield, and evolution of basin morphology (Jolly, 1982; Ogunkoya, Adejuwon, & Jeje, 1984).

Linear Aspects/Properties of the Drainage Basins

The morphometric investigation of the linear parameters of the basin calculated includes stream order (Sμ), stream number (Nμ), bifurcation ratio (Rb), stream length (Lμ), basin perimeter (P), basin length (Lb). Some of the important linear aspects have been computed as shown in Tables 2 and 3.

Stream order (Sμ).

The first step in the drainage basin analysis is the designation of stream order(Horton, 1945) As per the Strahler's (1964) ordering scheme, the study basins Nyaba and Oji are 4^{th} and 5^{th} order drainage basin respectively as shown in Figures 2 and 3. Higher stream order is associated with greater discharge. The trunk streams, Nyaba and Oji, through which all discharge of water and sediment passes are therefore the stream segment of highest order.

Stream number (Nμ).

The count of stream channels in a given order is known as stream number (Horton, 1945). Results of the analyses showed that Nyaba stream is having 154 streams linked with 4 orders of streams while Oji has 255 stream linked with 5 orders of streams as shown in Table 2. Since stream frequency decreases as the stream order increases, stream number is directly proportional to size of the contributing basin and to channel dimensions as shown in Table 3. A higher stream number indicates lesser permeability and infiltration.

Infiltration Number (If*)*

The infiltration number of a watershed is defined as the product of drainage density and stream frequency and gives an idea about the infiltration characteristics of the watershed. The higher the infiltration number, the lower will be the infiltration and the higher will be the run-off generated. Nyaba and Oji drainage basins have infiltration number of 0.07 and 0.13 respectively. The implication of this in comparison is that Oji basin will have lower infiltration rate and higher run-off generated and more liable to flooding than Nyaba basin.

Length of overland flow (Lg)

Length of overland flow (Lg) relates to the length of water over the ground before it becomes concentrated into definite stream channels. Length of overland flow is one of the most important independent variables affecting both hydrologic and physiographic development of drainage basins (Horton, 1932). Length of overland flow is considered the most crucial independent variable affecting hydrological and geomorphological development of drainage basins. It affects both runoff and flooding processes. When there is overland flow, the infiltration process takes place for entire basin. In high land areas, lower order streams quickly joins under the influence of slope, hence minimizes Lg and time of concentration. Higher Lg value provides longer concentration time and favourable condition for sheet erosion/infiltration under sparse/dense vegetation cover (Oyatayo et al, 2017). Nyaba and Oji basins have Lg value of 1.19 and 1.02 respectively. Since Nyaba drainage basin has higher length of overland flow, it will provide longer concentration time and a more conducive condition for infiltration within the basin; whereas in Oji basin, where concentration time will be shorter and condition for infiltration will be less.

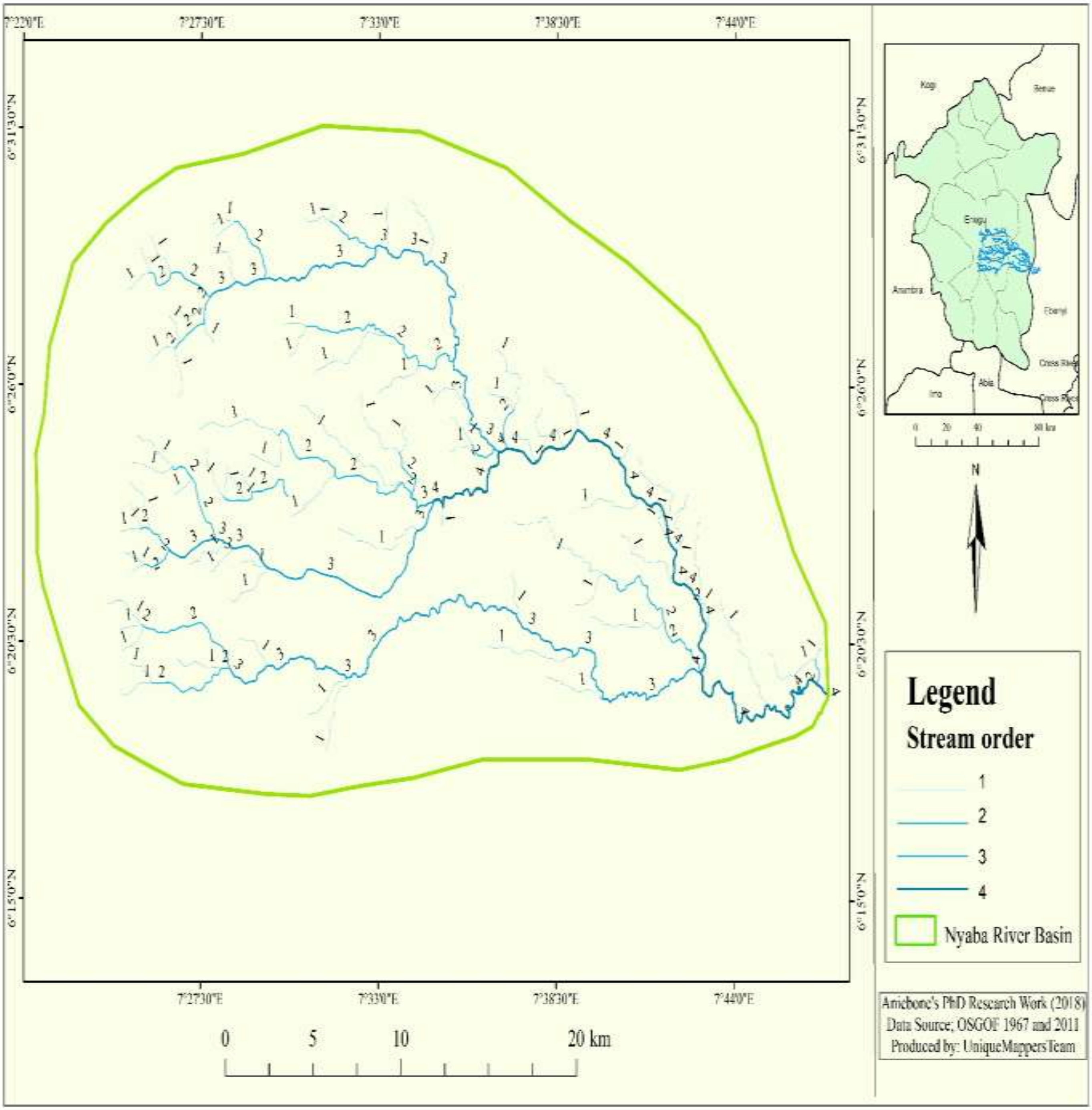

Figure 2: Nyaba River Drainage Pattern/Ordering

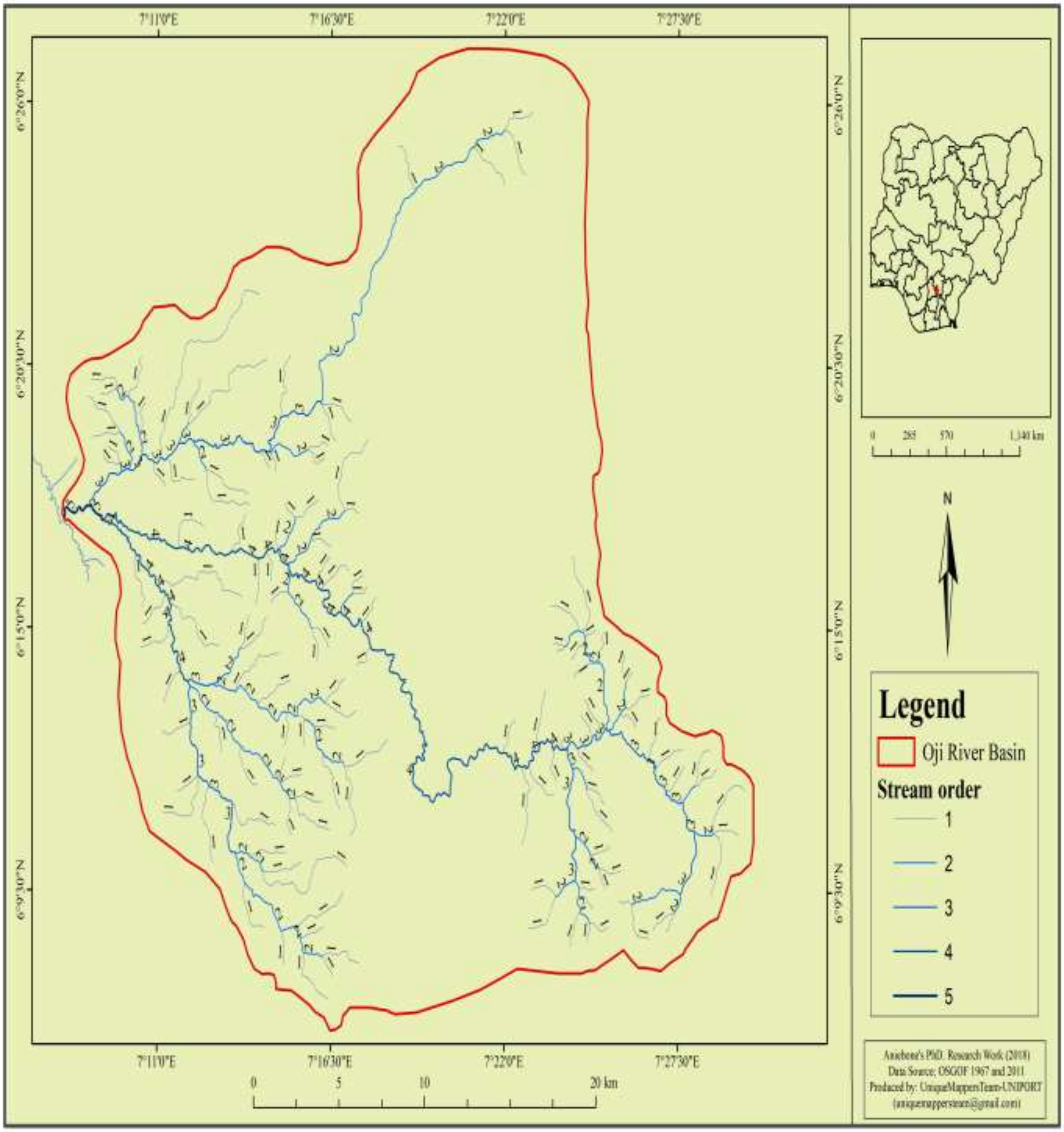

Figure 3: Oji River Drainage Pattern/Ordering

Table 2: Linear Morphometric Parameters of the Nyaba and Oji Drainage Basin Network

Morphometric parameter	Nyaba River Basin	Oji River Basin
1st order (Number of segments)	77	131
2nd order,,	35	63
3rd order,,	23	33
4th order,,	19	26
5th order,,		2
ΣNu	154	255
ΣLu (km)	387.48	454.19
Rb	1.23	3.65
Lb (km)	63.33	63.59
Pb	118.38	135.70
Lg	1.19	1.02

Where; Rb=Bifurcation ratio; Lb= basin length; Pb= Basin perimeter; Nu = total no. of stream segments of order; Lu = the total stream length of order, Lg= Length of overland flow

Table 3: Areal Morphometric Parameters of the Nyaba and Oji Drainage Basin Network

Morphometric parameter	Nyaba River Basin	Oji River Basin
Drainage Area (A)	921 km2	928km2
Drainage Density (Dd)	0.42km-1	0.49km-1
Drainage Frequency (Fs)	0.17km-1	0.27km-1
Drainage Intensity (di)	2.47	1.81
Drainage Texture	0.65	0.97
Infiltration Number (If)	0.07	0.13
Form Factor Ratio (Rf)	0.22	; 0.22
Elongation Ratio (Re)	0.15	0.15
Circularity Ratio (Rc)	0.83	0.63

Table 4: Relief Morphomtric Parameters of the Nyaba and Oji Drainage Basin Network

Morphometric Parameters	Nyaba River Basin	Oji River Basin
Basin Relief (H)	1300 m	900 m
Relief Ratio (Rr)	0.021	0.014
Basin Slope (Sb)	0.021(= 2.1%)	0.014(=1.4%)

Source: Author's fieldwork. 2018

Bifurcation Ratio (Rb)

According to Schumm, (1956), Bifurcation ratio is related to the branching pattern of a drainage network and is defined as the ratio between the total numbers of stream segments of one order to that of the next higher order in a drainage basin. Chorley (1969) had noted that the lower the bifurcation ratio, the higher the risk of flooding, particularly of parts and not the entire basin. The low mean bifurcation ratio of the Nyaba basin of 1.23 is an indication that parts of its segments are liable to flooding. This actually confirmed what is obtained in the field as was discovered during the reconnaissance survey. Oji river basin has a mean bifurcation ratio of 3.65. Bifurcation ratios are controlled by basin physiographic factors especially basin relief and drainage density (Milton, 1966).

Stream Length (Lµ).

Stream length is a revelation of the chronological developments of the stream segments including interlude of tectonic disturbances. The total length of individual stream segments of each order is the stream length of that order. The total stream lengths of the various stream orders in Nyaba and Oji River basins are presented in Table 1 Stream length is one of the most important hydrological features of the basin as it reveals the surface runoff characteristics. When bedrock is of permeable character then only subtle number of relatively longer streams are formed in a well drained basin area. On the other hand, when the bed rock is less permeable then large number of smaller length of streams in the basin are produced. Streams of relatively smaller lengths are characteristics of areas with larger slope and finer textures. Streams with longer lengths are generally the characteristics of flatter surface with low gradients.

Basin Perimeter (P)

Basin perimeter is the outer boundary of the drainage basin that encloses its area. It is measured along the divides between basins and may be used as an indicator of basin size and shape (Schumm, 1956). The basin perimeter of Nyaba and Oji river basins are 118.38 and 135.70 kilometers respectively.

Basin Length (Lb)

Basin length is the longest dimension of a basin to its principal drainage channel. The longer the length of a basin, the lower the chances that such a basin will be flooded when compared with a more compact basin. The Lb is the longest length of the basin, from the catchment to the point of confluence (Gregory, & Walling, 1973). The length of the Nyaba river basin is 63.33 kilometers while that of Oji is 63.59 kilometers

Areal Aspects/Properties of the Drainage Basins

Area of a basin (A) and perimeter (P) are the important parameters in quantitative geo- morphology. Basin area directly affects the size of the storm hydrograph, the magnitudes of peak and mean runoff. The maximum flood discharge per unit area is inversely related to size (Smart, & Surkan, 1967).

Drainage Area (Au)

This is the entire area drained by a stream or system of streams such that all streams flow originating in the area is discharged through a single outlet. The boundary of the drainage area is determined by the ridge separating water flowing in opposite directions. The total area of the Nyaba drainage basin is estimated to be 921 km^2 while that of Oji river basin is about 928km^2. It has been identified as the most important of all the morphometric parameters controlling catchment runoff pattern. This is because, the larger the basin, the greater the volume of rainfall it intercepts, and the higher the peak discharge that result (Morisawa, 1959., Faniran & Ojo, 1980., Patrick, 1994).

Drainage Density (Dd)

Drainage density is regarded as the computation of the total stream length in a given basin area to the total area of the basin (Strahler, 1964). Strahler (1964) distinctly observed that drainage density is directly proportional to basin relief. Dd is the result of interacting factors controlling the surface runoff and in turn influences the output of water and sediment from the drainage basin (Chorley, 1969). Drainage density is known to vary with climate and vegetation, soil and rock properties, relief and landscape evolution processes (Ozdemir &Bird, 2009). Generally, the hydrology of basin changes significantly in response to the changes in the drainage density. A high drainage density indicates weak basin and impermeable subsurface material with sparse vegetation and high relief. Drainage basin with high Dd indicates that a large proportion of the precipitation runs off. Whereas low drainage density manifests weak coarse drainage texture, and indicates that most rainfall infiltrates the ground and few channels are required to carry the runoff. (Roger, 1971). Dd is a measure of the texture of the network, and indicates the balance between the erosive power of overland flow and the resistance of surface soils and rocks.

The factors affecting drainage density include geology and density of vegetation. The vegetation density influences drainage density by binding the surface layer and slows down the rate of overland flow, and stores some of the water for short periods of time. The effect of lithology on drainage density is marked. Permeable rocks with a high infiltration rate reduce overland flow, and consequently drainage density is low. The Drainage densities of the Nyaba and Oji drainage basins are low and are 0.42 km/km^2 and 0.49km/km^2 respectively

Drainage frequency (Fs)
The stream frequency (Fs) or channel frequency or drainage frequency of the Nyaba and Oji river basins are 0.17/km^2 and 0.27km^2 respectively as shown in Table 2. It depends upon the basin lithology and indicates distinctly texture of the drainage network. It is an index of the various stages of landscape evolution. The Stream frequency depends on the rock structure, infiltration capacity, vegetation cover, relief, nature and amount of rainfall and subsurface material permeability. The stream frequency shows positive correlation with the drainage density. Lesser the drainage density and stream frequency in a basin, the runoff is slower, and therefore, flooding is less likely in basins with a low to moderate drainage density and stream frequency (Nag, 1998). Low value of stream frequency exhibits presence of a permeable subsurface material.

Drainage Intensity (Di)
The Drainage intensity of Nyaba drainage basin is 2.47 while that of Oji river basin is 1.81. It is calculated as the value of drainage density divided by the value of drainage or stream frequency

Elongation ratio (Re)
This is defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length (Schumm, 1956). Elongation ratio determines the shape of the basin and can be classified based on these values as circular (0.9 - 1), oval (0.8 – 0.9), less elongated (0.7 – 0.8), elongated (0.5 – 0.7), more elongated (< 0.5). Regions with low elongation ratios are susceptible to more erosion whereas regions with high values correspond to high infiltration capacity and low runoff. The elongation ratios of the Nyaba and Oji drainage basin are 0.15 each which indicates more elongation and more prone to erosion with less infiltration capacity. Runoff discharges are more efficient in the circular drainage basins. They are at greater risk from flood hazard because they have a very short lag time and high peak flows than the elongated basins. Elongated drainage basins have low side flow for shorter duration and high main flow for longer duration and are less susceptible to flood hazard (Oruonye et al 2016).

Circularity ratio (Rc)
This is defined as the ratio of basin area to the area of the circle having same perimeter as the basin. It is used as quantitative measure for the shape of the basin (Strahler, 1964). Lower Rc value indicates elongated shape of drainage basin, while higher values indicates that the basin shapes are circular. Drainage basins with higher circularity ratio are more exposed to flooding incidence because such basins will always experience shorter time lag, shorter time of rise and higher hydrographic peak (Ajibade, et al 2010). Nyaba and Oji basins have circularity ratio of 0.83 and 0.63 respectively. Higher circulatory ratio recorded by Nyaba drainage basin is in conformity with (Ajibade, et al 2010) proposition. The shorter the basin length, the closer to one (1) the circulatory ratio (Oyatayo et al 2017).

Form Factor (Rf)
This is the numerical index commonly used to represent different basin shapes (Horton, 1932). It is an index of drainage shape and is computed as a unit-less dimension of drainage area divided by the square of the basin length (Horton, 1932). The value of form factor would always be less than 0.754 (for a perfectly circular watershed). Smaller the value of form factor (<0.45), more elongated will be the watershed. The watershed with high form factors have high peak flows of shorter duration, whereas elongated watershed with low form factor ranges from 0.42 indicating them to be elongated in shape, hence, will have peak flow for longer duration (Horton, 1932). The Smaller the value of form factor, the more elongated will be the basin. Consequently, the flood flow of this type of basin is easier to manage than the circular basin. The form factor value of the two basins is low, 0.22 that represents elongated shape. So, the two drainage basins have flatter or low peak flows of longer duration that is easier to manage than of the circular basins (Singh, 1998). Hence, low incidences of flooding

Relief Aspects/Properties of the Drainage Basins
The relief aspects of the drainage basins are significantly linked with the study of three dimensional features involving area, volume and altitude of vertical dimension of landforms to analyze different geohydrological characteristics.

Basin Relief (H)

Basin relief is an important factor in understanding the geomorphic/denudational processes and landform characteristics. Relief is the difference between the maximum and minimum elevations in the basin. The total basin relief of the Nyaba and Oji river drainage basin are 1300 and 900 ms. The lowest basin relief is observed in the plains and highest relief is in the mountainous areas. It has been observed that a high degree of correlation exists among relief and drainage frequency and stream channel slopes.

Relief Ratio (Rr)

Relief ratio (Rr) measures the overall steepness of a drainage basin and is an indicator of the intensity of erosional process operating on slope of the basin (Schumm, 1956). It is calculated by dividing the relief (H) of a basin by its length (L). The Rh normally increases with decreasing drainage area and size of sub-watersheds of a given drainage basin (Guttschalk, 1964.,Subodh & Gopal, 2012). The relief ratio of the Nyaba basin is 0.021 while that of Oji river basin is 0.014. The relief ratio of the basins are low, which is characteristics feature of less resistant rocks.

Basin slope (Sb)

Basin Slope (Sb) enables the assessment of runoff generation, direction and volume (Zavoiance, 1985). The Nyaba and Oji river basins have a Sb of 0.021 and 0.014 that reflect the mountainous and plateau nature of the terrain is shown in Table 3 More than 50 percent of the main stream flows through the mountains and plateau and the relatively low values of Sb confirm the same.

CONCLUSION

This study has attempted to examine the morphometric characteristics of Nyaba and Oji Drainage Basins, Enugu, Southeastern Nigeria, with a view to assessing the influence of linear, area, and relief morphometric parameters on the hydrological processes within the basins. The study shows that the drainage network of the two basins is not structurally controlled. Drainage basins characteristics such as size, shape, vegetation cover, geology are important indices for predicting environmental hazards especially erosion and flood. They reveal how fast rainfall reaches a main river, their frequency and the intensity of flooding. The study also shows that Nyaba basin is having shorter bifurcation ratio, basin length, circularity ratio, infiltration number higher length of overland flow, relief ratio, and the same elongation ratio with Oji basin. The results of the findings has revealed that the basin has a low relief, coarse texture, gentle slope and permeable bedrock. The elongated nature of the basins implies a high main flow for longer duration and less susceptibility to flood hazard. The finding from here is that the two drainage basin morphometric variables are likely to cause flatter or low peak flow and concentration time of longer duration. The two basins are less liable to flooding. This study shows how the configuration of drainage basins contributes significantly to environmental hazards occurrence in an area. This research has demonstrated the influence of morphometric parameters on geomorphic and hydrological processes within a drainage basin. However other basin characteristics such as climate, soil characteristics and land use pattern which acts as contributory factors to flooding in drainage basins.

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