

Drainage Morphology of Imo Basin in the Anambra – Imo River Basin Area, of Imo State, Southern Nigeria

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

This study involved the delineation of all the river sub-basins in the Imo Basin of the Anambra-Imo River basin area. It the area drained by measuring all the tributaries and their stream order. This study found out that there are basically five sub-basins in Imo State, viz. Imo River, Upper Orashi, Njaba/Lower Orashi, Otamiri, and Ogechie River sub-basins. All of these rivers and their tributaries cover approximately 5, 493.45 km² in Imo State. The Imo River is one of the largest river basin covering (1,322.82 km²) and drained through northeast tilted topographic slope and disappears into the Atlantic Ocean near Opobo estuary; while Orashi and Njaba flows northwest and down south to the Bight of Bonny in the Gulf of Guinea - (is a part of the tropical Atlantic Ocean).

Keywords: River basin; catchment; watershed; otamiri; Imo river; stream order; tributaries.

1. INTRODUCTION

Conventionally river basin is the portion of land drained by a river and its tributaries. It encompasses the entire land surface dissected and drained by many streams and creeks that

flow downhill into one another, and eventually into the Ocean. Essentially it acts as a funnel, collecting water and shunting it into the ocean or into inland lakes and seas. A river basin can be relatively small, or quite large, and in all cases, they are interconnected systems. Political or

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administrative boundaries do not determine the direction and flow of rivers, it thus requires the co-operations of States/Countries within the natural hydrological unit of the river basin in protecting and managing the system bringing together all interests upstream and downstream, this is so because drainage basins are a very important part of the world's ecology.

Management of river basins can be extremely challenging because they cross regional and national boundaries and especially so when neighboring nations have differing views about the best way to manage the system. Following the 1972-74 drought in Nigeria which many describe as the worst ever experienced in Nigeria, the Supreme Military Council promulgated decree 25 of 1976, as a swift move towards the development of Nigeria's water resources. Accordingly twelve river basin development authorities, (RBDAs), were created to harness the nation's water resources and optimize its agricultural resources for food sufficiency. The RBDAs include; Upper Benue Basin, the Lake Chad Basin, Benin-Owena Basin, Sokoto-Rima Basin, Sokoto; Hadejia-Jema'are Basin, Kano; the Lower Benue Basin, Makurdi and the Cross River Basin, Calabar. The others are; Oshun-Ogun Basin, Abeokuta; Anambra-Imo Basin, Owerri; the Upper Niger Basin, Ilorin; Lower Niger River Basin and Niger Delta Basin, Port Harcourt. One way of managing this resource optimally is to have an accurate knowledge of the character of the total drainage systems in a particular river Basin; this may include the area extent, the underlying geology, the total number of streams/rivers and their stream order, bifurcation ratio, time of concentration, discharge etc.

The Anambra – Imo River Basin is one of the river basins in Nigeria covering the rivers in Anambra, Imo and Abia States. It has been discovered in literature that knowledge of the rivers and streams in Imo State which make up part of the Anambra – Imo River Basin is sketchy and sometimes faulty. Onweremadu [1] asserted that Otamiri sub-basin is 10,000 km² and on an elevation of 152m. Many other authors hold this same view [2-5]. Some of these authors (e.g. 4, 5]also assert that Otamiri flow into the Atlantic Ocean; that Okitankwo River is an offshoot of Imo River, the basis for these conclusions were not well defined. Furthermore, Okoro et al. [5] delineated the rivers in the Imo Basin into five watersheds namely Okigwe watershed, Mbaise/Mbano watershed, Orlu watershed,

Oguta watershed and Owerri watershed. The basis for this categorization was not also explained and is misleading. The objectives of this paper therefore include:

1. Delineation of the sub-basins of Imo State drainage systems.
2. Identification of major rivers and their stream orders.
3. As well as discuss the features of some of the major rivers in this basin to ease effective planning and management. With the hope that this work can serve as a baseline study for further research in the management of water resources as well as the control of flood and erosion

2. STUDY AREA

The study area (Imo State) Fig. 1 is located in the Southeastern region of Nigeria and is one of the 36 States of the Federation, with Owerri as its capital and largest city. It lies between latitude 4°45'N and 5°50'N, longitude 6°35'E and 7°30'E, and covers approximately 5,529.17 km² area with a Population of 2,938,708 [6]. The State derives its name from Imo River, which takes its course from the Okigwe/Awka upland. Imo State is located between the lower River Niger and the upper and middle Imo River in the Southeastern part of the country.

The climate of Imo State is humid, semi-hot equatorial type. The State experiences heavy rainfall, with an average annual rainfall of 2000-2400 mm/yr and an average number of 152 rain/days particularly during the rainy seasons (April–October) the superficial rainfall distribution is bimodal, with peaks in July and September and a two weeks break in August. The rainy season begins in March and lasts till October or early November. Rainfall is often at its maximum at night and during the early morning hours. The higher annual rainfall depths and rainfall days encourages large volumes of runoff. However, variations occur in rainfall amount from year to year, usually between 1,990 mm and 2,200 mm [7]. Relative humidity oscillates between 75% and 90% between the Dry and Rainy seasons. Temperatures are similar all over the State; the hottest months are January to March, with the mean annual temperature above 20°C.

Imo State is underlain majorly by the sedimentary sequences of the Benin Formation (Miocene to recent), and the Bende-Ameki Formation (Eocene). The Benin Formation is

made up of friable sands with minor intercalations of clay. The sand units are mostly coarse –grained, pebbly, poorly sorted, and contain lenses of fine grained sands. In some areas like Okigwe, impermeable layers of clay occur near the surface, while in other areas, the soil consists of lateritic material under a superficial layer of fine grained sand. The thickness of the Benin Formation in this area is about 800 m [8,9].

In terms of relief, Imo State is characterized by three main landform regions: a highland region of elevation of 340 m in the northern sections covering Orlu, Ideato, Okigwe and Ihitte-Uboma local government areas; a moderate elevation of about 175 m which covers midway between the north and the southern sections of the State as well as the river valleys of the streams that rises in the highland regions of the State and the lowland regions in the Southern areas of the State Figs. 2,3,4.

3. MATERIALS AND METHODS

The following maps were acquired to serve as base maps these include Administrative map of Imo State (scale 1:1000, 000) from the Imo State Ministry of Land and Survey; Geological Map of Imo State, Dominant Soil Map of Nigeria, Provisional Soil map of Nigeria (simplified) 1952 edition, Soil Map of Eastern Nigeria, Scale 1:1,000,000 and Soil Map of Nigeria Scale 1:5,000,000, Topographic and relief map of Imo State from the Anambra – Imo River Basin Development Authority. From the Regional Centre for Training in Aerospace Survey (RECTAS) Ile Ife, Osun State; SPOT 5 satellite images of Imo State with a resolution of 10 m and Shuttle Radar Topography Mission (SRTM) data with a resolution of 30 m were acquired. The base maps (which were in analogue form) were scanned and converted into raster image and imputed into ArcGIS version 9.3 environment, geo-referenced to a universal transverse Mercator (UTM) grid to allow compatibility and comparison with other data sets to enable the extraction of Imo State from the rest of Nigeria. Various data enhancement techniques such as linear enhancement and image enhancement operations were carried out for better visual interpretation, to reduce noise distortion in the image prior to a multi-band image classification and to detect line features in the satellite image to aid structural interpretation. The watercourses were traced from their source to their mouth (discharge point) including all the

tributaries within a given contour elevation (drainage divide) between two adjacent or opposite contours. Lengths and area measurement was done using the Dot Grid method and compared with on screen measurement on the GIS interface.

4. RESULTS AND DISCUSSION

The results generated in the course of this exercise are presented as maps and tables.

4.1 Sub-Basins in Imo State

From the output of the GIS, five sub-drainage basins were effectively delineated in Imo State that constitutes the Imo Basin of the Anambra-Imo River Basin Area namely Upper Orashi, Njaba/Lower Orashi, Otamiri, Ogechie and Upper Imo. These five river sub-basins are comprised of about fifty one rivers, and three lakes (Fig. 4 & Table 1). They drain an average area of about 5,493.768 km² of Imo State. Each of these watersheds is of different shape and drainage composition. The largest in terms of area drained is Otamiri, although the number of streams in this watershed is few compared with Imo River. Imo River is an oval shaped watershed; it has more tributaries in Imo State, though the area it drains in Imo State is not as large as Otamiri. The Drainage Density (D_d) of the study area can best be described as medium drainage density (or medium texture) with a D_d of 0.21, while the stream frequency is 0.02 and the drainage intensity is 2.00 (Fig. 5).

4.1.1 Imo river sub-basin (Fig. 6)

Imo River drains three States, namely Imo State, Abia State and Rivers State. In Imo State, is the largest (in terms of size and length). It takes its course from the Okigwe/Awka upland and runs through the area underlain by the Imo Shale and the coastal plain sands down to the coast in Rivers State. The source area/tributaries form a trellis pattern. For the purpose of this work, the river was divided into the Upper reaches, middle reaches and lower reaches. The upper and middle reaches are found in Imo State while the lower segment is in Abia and Rivers States. Several first order streams (Iyode stream, Ore River, Abuba River, Ikwe River, Amovi River, Ibu River, Iyechare River, Law-Law river, Izeh River and Akum) and second order streams (such as Efuro River, Ahumum, Awkwu river) form the major tributaries of Imo river in this segment. The total area drained by Imo River and its tributaries

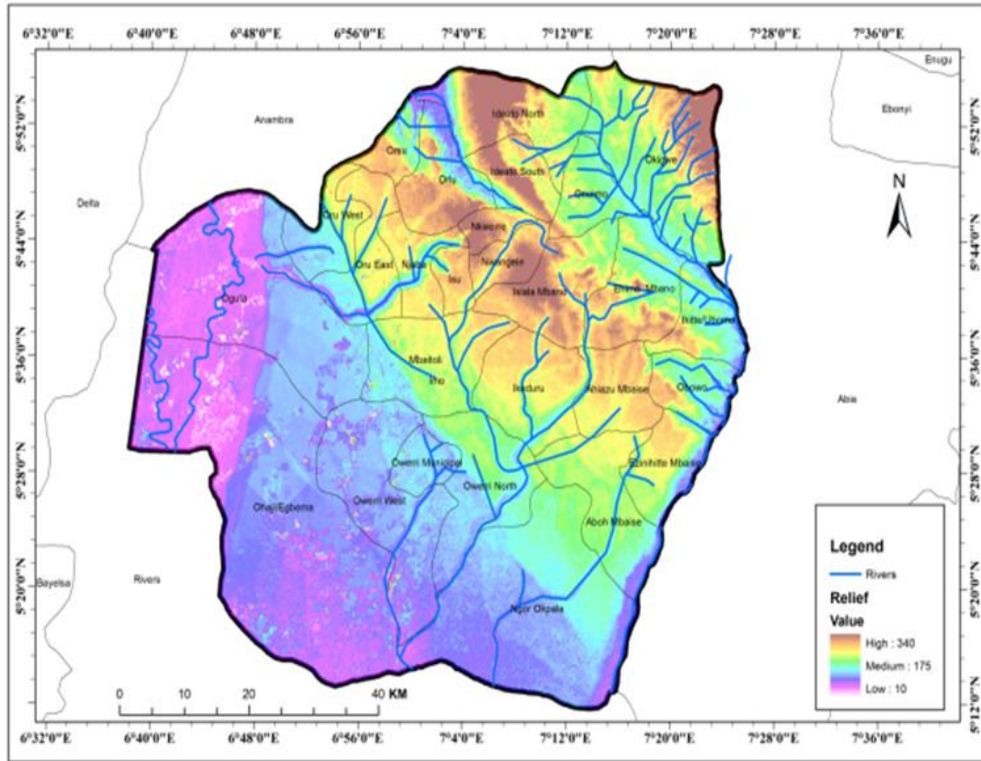


Fig. 3. Relief map of Imo State

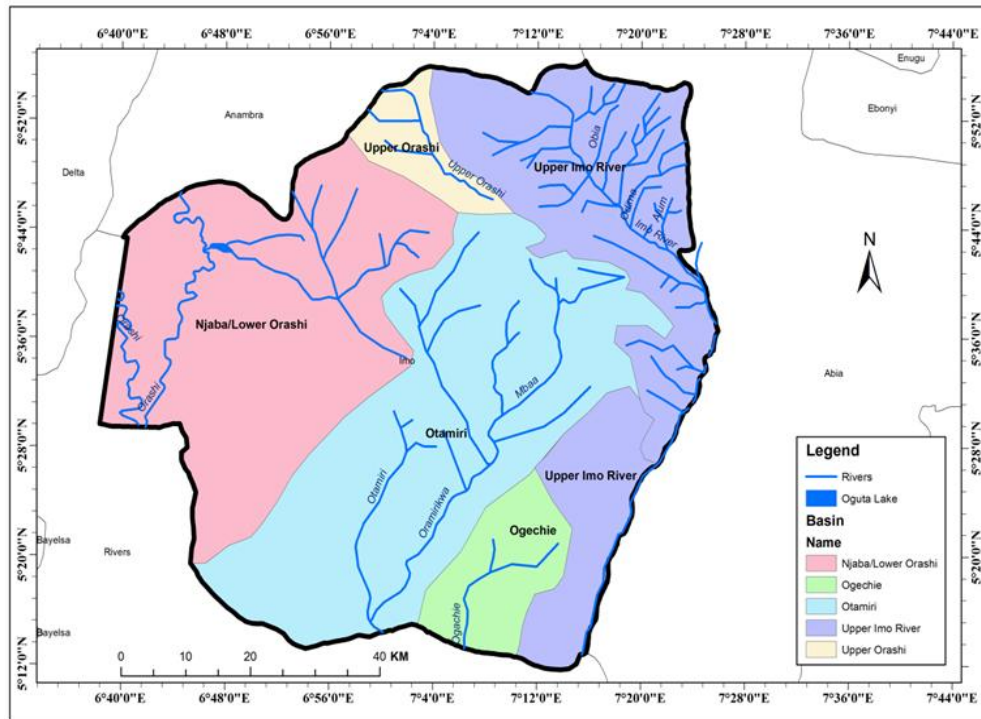


Fig. 4. The five major sub-basins in Imo State

Table 1. The five sub-basins and their tributaries in Imo State

S/No	Sub-Basins	Area drains	Tributaries	Source Area	Flows into	Stream order
1	Imo	1,322.83	Imo Rv	Ideato	Atlantic Ocean	5 th
2			Ibi	Okigwe	Law-law	2 nd
3			Ibu	Nneafor	Law-law	1 st
4			Efuru	Okigwe	Imo River	2 nd
5			Ikwo	Okigwe	Law-law	2 nd
6			Abuba	Okigwe-Ideato	Imo River	1 st
7			Iyoba	Okigwe-Ideato	Imo River	1 st
8			Idiu	Okigwe-Ideato	Imo River	1 st
9			Ibu	Okigwe-Ideato	Imo River	1 st
10			Nterere	Okigwe-Ideato	Imo River	2 nd
11			Ife	Okigwe-Ideato	Imo River	2 nd
12			Izah	Okigwe-Ideato	Imo River	1 st
13			Ndimma	Okigwe-Ideato	Imo River	1 st
14			Alum	Okigwe-Ideato	Imo River	2 nd
15			Uyiri	Okigwe-Ideato	Imo River	2 nd
16			Iyeoachara	Okigwe-Ideato	Imo River	2 nd
17			Ohia	Okigwe-Ideato	Imo River	2 nd
18			Lawlaw	Okigwe-Ideato	Imo River	2 nd
19			Ugbi	Okigwe-Ideato	Imo River	2 nd
20			Onyimbo	Umunumo	Imo River	3 rd
21			Biyi	IkpaOkoto	Imo River	2 nd
22			Upo	Afugiri	Imo River	2 nd
23			Eme	Afugiri	Imo River	2 nd
24			Obiyi	IkpaOkoto	Imo River	2 nd
25			Nfro	Ihitte-Uboma	Imo River	2 nd
26			Onuiyiri	Obowo	Imo River	1 st
27			Asa	Nsu	Imo River	2 nd
28			Okuimiri	Aroundizeogu	Imo River	1 st
29			Akworo	Osina	Imo River	2 nd
30			Ahamun	Akokwa	Imo River	2 nd
31			Ore	Ntueke	Imo River	1 st
32			Iyodo	Akokwa	Imo River	2 nd
33			Awkwa	Ntueke	Imo River	1 st
34			Abadaba Lake	Ihitte-Uboma		Lake
35	Upper Orashi	181.012	EzezeAsa			1 st
36			Orashi	Dikenafai	Oguta Lake	1 st
37			EzezeAsa	Oguta		1 st
38	Njaba/Lower Orashi	1,600.84	Njaba	Nkwerre		3 rd
39			Awbana	Mgbidi	Oguta Lake	
40			Eyin	Oguta	Orashi	1 st
41			Utu		Oguta	1 st
42			Oguta Lake	Oguta Lake	Orashi	Lake
43	Otamiri	1,719.25	Otamiri	Egbu	Imo River	4 th
44			Okitankwo	Umudi	Oramiriukwa	1 st
45			Oramiriukwa	Abba	Okitankwo	1 st
46			Mbaa	Isu(Nwangele)	Oramiriukwa	1 st
47			Nwaorie	Ohii/Egbeada	Otamiri	1 st
48	Ogechie	669.521	Ogechi	Umuneke-Ngor	Otamiri	1 st
Total		5,493.45				

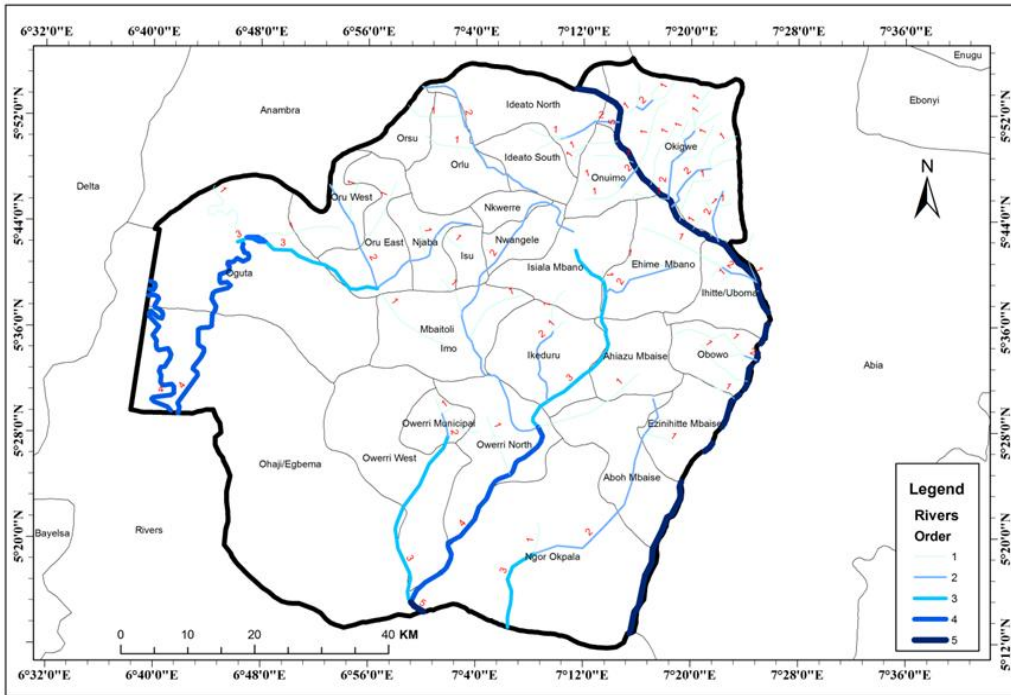


Fig. 5. Drainage map of Imo State

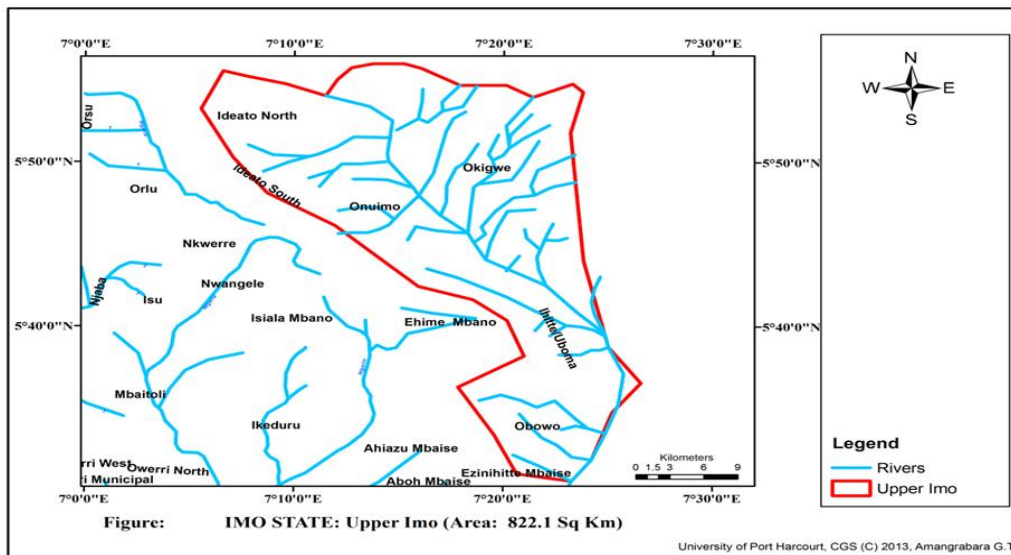


Fig. 6. Imo River Sub-Basin

The Abadaba Lake is one of the hydrological units in this sub-basin, found at Nkumeato settlement in the Ihitte/Uboma Local Government Area of Imo State. The lake surface area covers 4 hectares of land with a shoreline spanning 6 kilometers. Two streams from Nkumeato and Odenkume communities drain into it and

discharging into Omoruyi Stream on the eastern side. The Onuiyi and Aham streams empty into Imo River at the Obowo-Umuahia boundary, about eight kilometers from the lake.

The reach between Oyigbo and the Akwete Bridge in Rivers State is strongly meandering;

downstream of the Imo River Bridge the character of the river is gradually affected by the tide with the vegetation changing from freshwater into the saline mangrove and Nypa palms. The river from the bridge (boundary between Abia and Rivers States) down to the Atlantic coast is seemingly straight with one conspicuous bend off Obete where the course of the river changes from almost east towards a southerly direction. The river width gradually widens from 60m off Oyigbo to over 1,000 m at the estuary. The tidal impact on the discharge of the river can be observed during the rainy season up to 10 km upstream of Obete where the magnitude of the flow varies with the tide; 10 km downstream of Obete the flow is of tidal reversal in nature. Downstream of Ikot Abasi the tidal basin of the Imo River is characterized by mud flats and tidal creeks. Finally, the river discharges the waters of the drainage basin into the Opobo channel, Bight of Bonny (Gulf of Guinea,) off Down-Below fishing village of Opobo Town, about 107 km from Oyigbo.

4.1.2 Upper orashi river sub-basin

The area drained by Orashi before it enters Anambra State is regarded as the Upper Orashi River basin. The shape of the basin is like a triangle from the source area to the point it

entered Anambra State, covering an area of 152.4 km². The river has three segments. A two first order stream and a one second order stream comprising a total length of 40,191 m (40.5 km). It has a drainage density of 0.27, stream frequency of 0.02, drainage Intensity of 0.052 from its source in a spring from the mountainous area of Ezeama community in Dikenafai, Ideato-South LGA; The River stretches to Ideato North, terminating in Oguido (the blue lake and Urashi River) and flows northward to Ozubulu in Anambra State, it becomes braided in Anambra State and a part of it turns round in a wide loop and heads Southward into Imo State in the Oguta alluvial/floodplains before heading towards the Bight of Bonny via the Orashi region in Rivers State.

The area drained by this river form part of the Awka-Orlu cuesta. According to Nwajide [10], the crest of the cuesta stands at over 340 m and at Isuofia attains a height of 378 m. The dominant geological formation is the Eocene Ameki Sands which is a sequence of unconsolidated or poorly consolidated sand, 305 m thick, underlain by the thick Imo Shale formation of Palaeocene age, and overlain by the lignite-clay seams of the OligoceneOgwashi-Asaba formation. The Ameki

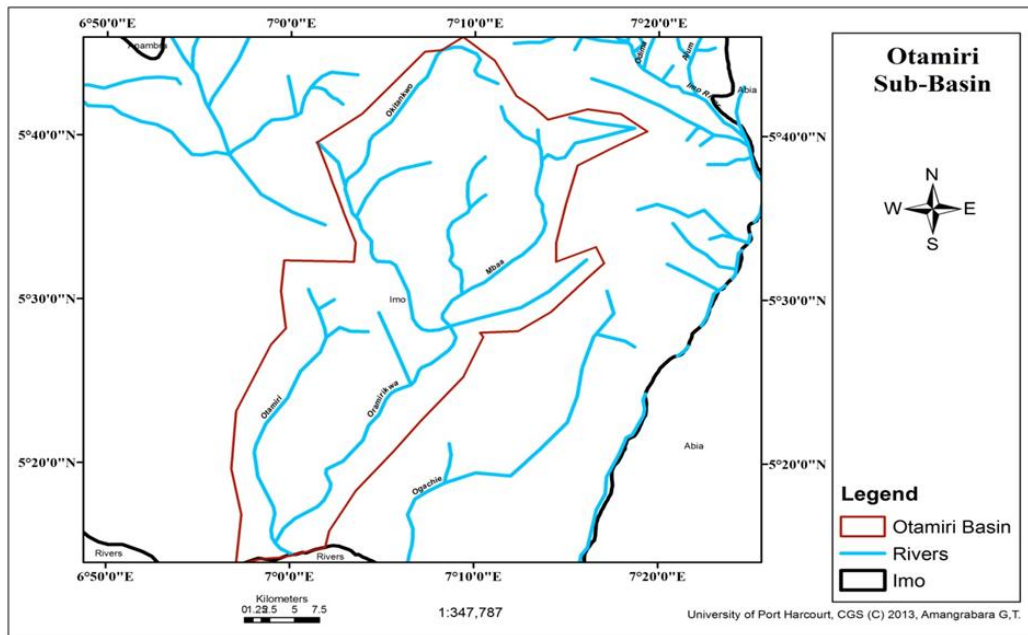


Fig. 7. Otamiri sub-basin

Sands are predominantly sandy with thin claystone and siltstone bands, lenses and laminations. The sand is poorly-sorted, cross-bedded and medium to coarse grained. These units, separated by shale-siltstone-fine sand layers, may be as thick as 30m in some places. The deposits also exhibit well developed patterns of alternating cross-bedded sands. The unconsolidated sands are loose, friable and poorly cemented with thin shale layers. The sands are very permeable while the shales are not. Below the water table, these sands and shales are saturated with water which affects their strength. Generally, the topography is undulating making stream flow/surface runoff irregular. The Orashi River is visualized as following a major fracture, trending North-South with elevated ground on both side.

4.1.3 Njaba/lower orashi river sub-basin

This watershed has a shape of a clover leaf and it's comprised of two major sections. The upper region which comprised of Njaba River and River Awbana can be described as the upper course while the lower section which is comprised of Utu Stream, Oguta Lake and the braided section of Orashi River can be described as the floodplain or alluvial section. The total area of the watershed is about 1,600.84 km² Njaba River is a 35km long tributary of Orashi River and rises at Ihitte located at Isunjaba in Isu Local Government Area of Imo State. It forms a dendritic pattern as it drains the entire Isu and Njaba Local Government Areas, Eziana and Amucha to the North, Amaigbo to the West, Umudugba, Amandugba and Ekwe, Okwudo, Umuaka and Awo-Omama to the South and runs through the rolling hills in a meandering flow and empties into Oguta Lake. As it approaches Oguta Lake it becomes braided. The lake in question is a major hydrological formation, the largest natural lake in Imo State formed from a natural depression. During the dry season the surface area of the lake is about 1.8 km² while during the rainy season it is about 2.5 km². The maximum depth is about 8.0 m with a mean depth of 5.5 m. The average total length of the shoreline is 10 km. The floodplain is occupied by the lower reaches of Orashi River as it flows in from Anambra State. In this section, it is highly braided and the drainage pattern is trellis. The morphometric characteristics of this watershed reflect the nature of the relief of the area. There are about seven first order stream, one second order stream and two each of third and fourth order streams. Drainage density (D_d) is 0.15

Drainage Intensity (D_i) is 0.001 while the stream frequency in this watershed is 0.01. The bifurcation ratio is 2.84. Studies of many stream networks confirm the principle that in a region of uniform climate, rock type and stage of development, the bifurcation ratio tends to remain constant from one order to the next. The closeness of 2.84 to 3 is indicative of the characteristics of streams that have two major sections.

4.1.4 Otamiri river sub-basin

The Otamiri watershed (Fig. 7) covers an approximate area of 1,719.25 km². The major rivers/stream in this watershed includes Otamiri, Oraminiukwa, Okitankwo, Mbaa, Nwaorie and Efuru etc. The total length of the rivers in the watershed is about 228.3 km. There are in all about eleven first order streams, three second order streams, two third order streams, and one each of fourth and fifth order streams with Bifurcation ratio of 2.04, drainage density of 0.20, stream frequency of 0.02 and drainage intensity of 0.003. It is underlain by the Benin Formation (Coastal Plain sands) which is generally coarse and poorly consolidated with little cement. The Okitankwo River a major stream in this sub-basin is a first order stream that rises from the highlands of the central part of Imo State in Nkwerre flowing down south in a single thread system and joins Inyishi/Mbaa River. The Inyishi/Mbaa River is an ephemeral river system with its source in Ikeduru Local Government Area of Imo State. It is a first order stream, it flows as a single thread channel 7.5 km southwards and joins Okitankwo and flows as Oraminiukwa River. River Oraminiukwa runs approximately a 32km course from its headwaters in Abba Isu (Nwangele LGA) to its discharge into Otamiri River, it starts as a first order stream from its source near Abba Isu in Nwangele local government area of Imo State and flows southwards for about 3.75 km to receive Mbaa, after about 4.1 km from the confluence with Mbaa, Oraminiukwa is joined by the seasonal Okitankwo River at Eziala Emii in Owerri North LGA of Imo State, From Eziala, Oraminiukwa flows southwards for about 5.8 km before discharging into Otamiri River near Nihi (Fig. 8).

The Otamiri River itself starts as a first order stream at its source at Egbu and captures Nwaorie river and flows for about 30 km to confluence with the Oraminiukwa River at Emeabiam. It is a major river that washes through the Ihiagwa autonomous community, in the Owerri West Local Government Area of Imo

State. This river runs from Egbu where it has its source, through to Nekede, Eziobodo, OlokwuUmuisi, Mbirichi, Umuagwo, and finally to Chokocho, Umuanyaga and Ozuzu in Etche LGA of Rivers State. At Nihi in Etche Local Government Area of Rivers State, it conflues with Ogechie River and continued as Otamiri River up to Umuebulu before Oyigbo where it finally joins the Imo River and flows to into the Opobo channel, Bight of Bonny (Gulf of Guinea/Atlantic Ocean). The Otamiri River has maximum average flow of 10.7 m³/s in the rainy season (September - October) and a minimum average flow of about 3.4 m³/s in the dry season (November - February). The total annual discharge of the Otamiri is about 1.7 x 10⁸ m³, and 22 percent of this (3.74 x 10⁷ m³) comes from direct runoff from rainwater and constitutes the safe yield of the river [11].

range from 50.0 mg/l to 115.42 mg/l in the Otamiri River, and 100.5 mg/l to 107.5 mg/l in the Nworie River. Magnesium ion concentration ranges from 4.23 mg/l in the Nworie River to 10.21 mg/l in the Otamiri River. The impact of city growth on the Otamiri and Nwaorie water quality is reflected in the values of certain constituents (nitrates, magnesium and iron). Nitrate was 8.3 mg/l in the Otamiri River (damsite) in 1984 but by 1997 it has risen to 50.1 mg/l. The Nwaorie River ranges from 49.3 mg/l upstream to 65.1 mg/l downstream. Generally, it is observed that the concentration of nitrates is on the increase as urbanization increases. This increase is attributed to surface water flowing from the farmlands, recreation areas, industrial effluent and the indiscriminate disposal of solid wastes into the rivers.

4.1.5 Ogechie Sub-basin

Nwaorie River is another major river in this sub-basin. It is a first order stream which has its source in Ohii in Mbatoli L.G.A of Imo State. It flows from the north to the south in a single thread unbraided nearly straight channel. The course of this first order stream is about 5km across Owerri metropolis, flowing through the Federal Medical Centre (FMC) Owerri, AlvanIkoku Federal College of Education (AIFCE), Owerri and Holy Ghost College Owerri before emptying into the Otamiri River at Egbu. The river lies in moderate slope. The total length of Nwaorie River is about 5.2 km. The major ion chemistry of both Otamiri River and Nwaorie Rivers varies greatly. The total dissolved solids

The major stream in this watershed is the Ogechie River underlain by the Benin Formation. It rises at Umuneke in Ngor/Okpala Local Government Area of Imo State and joins the Otamiri at Nihi in Etche LGA of Rivers State. The river is short within in Imo State draining an approximate area of about 669.53 km². It is a nearly straight slow flowing channel during the dry season while during the rainy season the flow is increased usually overflowing its banks and flooding the adjoining plains. In-stream sand mining and burrow pits excavation of laterite are major anthropogenic economic activity in this watershed.

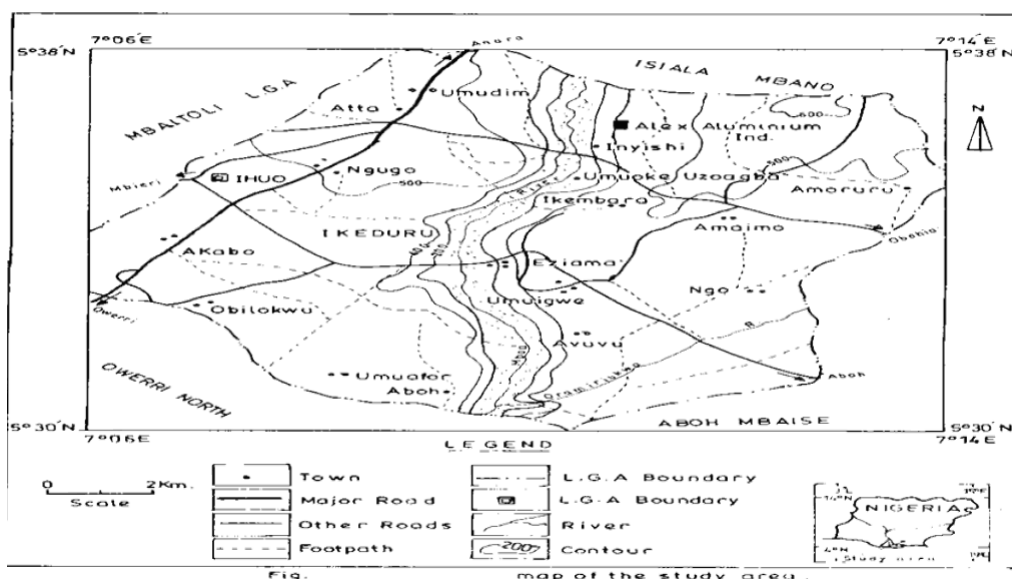


Fig. 8. Map of Imo central showing the Rivers Mbaa and Oraminiukwa [12]

5. CONCLUSION

Going by the definitions of watershed, drainage basin or catchment area, this study delineated five sub-basins in Imo State, namely Imo River sub-basin, Upper Orashi sub-basin, Njaba/Lower Orashi sub-basin, Otamiri sub-basin and Ogechie River sub-basin. All of these rivers and their tributaries drain 5,493.45 km² of Imo State; the delineation adopted by Okoro et al. [5] is faulty as it was not based on the definitions stated above. Furthermore, this study found out that the area drained by Otamiri is 1,719.25 km² contrary to the 10,000 km² usually stated in literature; obviously, the figures cited are guess works. No doubt there could be some marginal errors in the measurement carried out by this study; however we believe that the approach adopted in this study towards establishing the various hydrological units and the areas drained by them will help in the planning and the development of the Anambra-Imo River Basin water resources.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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