Original Research Article

A Geomorphological Survey and Landscape Analysis of Anambra State Southeast Nigeria

ABSTRACT

This paper Geomorphological Survey and Landscape Analysis of Anambra State Southeast Nigeria looks at the terrain and Landforms in Anambra State. The research used both primary and secondary data. Primary data used are measurements and direct field observations. Secondary data are from Satellite imageries of the State obtained and analyzed using ArcGIS to show the variations in the terrain and landforms of the study area, and other literatures. The geology, topography and soil types of the State were identified, analyzed and mapped. The result shows among other things the relationship between soil type and settlement vis-à-vis population. The slope analysis was also carried out in order to identify areas with steep slopes that limit accessibility and other economic activities. The paper concludes that there is strong influence of the physical environment particularly, the geomorphological factor in determining the spatial pattern of socio-economic activity and development in Anambra State. A disproportionately high percentage of population (71.98%) and development structures are found on the higher grounds, on the smaller sand – sandstone formations covering 36.42% of the State, leaving a very small percentage of population (28.02%) and development structures on the larger flood and other low plains covering 63.58% of the area. This observed distribution raises the issues of the need for the government and people of the State to employ science and technology to overcome the limitations on the lower surfaces. The lowlands have their developmental potentials which still remain untapped because of the low level of scientific development in those areas.

Keywords: Geomorphological Survey; Landscape Analysis; physical environment; socio-economic; developmental potentials.

1. INTRODUCTION

1.1 Background of the study

Geomorphology is the study of the origin, characteristics and distribution of landform and their relationship to man (Getis et al. 2011). It emphasizes the study of the various processes that create landscape; the position and location of those landforms and man's use of the landforms and landscapes so created (Getis et al. 2011). Thus whenever man makes a choice of what facet of the landscape he would place his settlements upon or route his pathways or cultivate to obtain food, he is practicing geomorphology (Mozie 2015). This, very many authors and researchers have shown that man's use of his land resource is not random but guided by innate and intimate knowledge of the landscape (Grant, 2000). For example in parts of Igboland, features are named according to their peculiarities. The present day Anambra River is called *"Omambala"* because of its yearly wide spread floods. Landslides which happen by dull explosive noise are called "*Ala-Mbize"*. Man is intimately related to his environment and must use it sensibly as was advocated by (Ofomata 2001). It is science that provides the basis for sensible and sustainable use of resources. The application of science to the global environment is vast and includes the sciences of the land which include soil science, engineering, geology, geomorphology, agricultural science among others. Today, farmlands are scientifically assessed before they are used as plantation. Housing estates are generally established after the land has been scientifically evaluated (Ndulue 2018).

Land is an area of the earth's surface, the characteristics of which embrace all reasonably stable, or periodically cyclic attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and the underlying geology, the hydrology, the plant and animal population and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man (Ayadiuno 2014; Akanazu 2016).

Land is very critical in human existence and development (Briassoulis 2000). Since the appearance of homo-sapiens on earth, land and its resources has been their means of subsistence. Land produces their food and clothing, provides for their shelter among others (Briassoulis 2000). Land is the specified geographical tract of the earth's surface which comprises its flora and fauna, geology, hydrology, topography, soils, superficial deposits, and the recorded and unrecorded past and present features as well as all natural and anthropogenic activities attributed to it, that has significantly influence its present and future use (Whittow 1984; Ndulue 2018; Ayadiuno et al. 2021). Land, landscape, landform, plains, topography, uplands, lowlands, high lands, hills, mountains, terrain among others are nomenclatures used interchangeably and is attributed to the solid surface of the earth. (Stewart 1968; High 1972; Townshend 1981; Ayadiuno et al. 2021), though practitioners in the land resources are aware of the differences and what they conceive them to mean (Ayadiuno et al. 2021; Ayadiuno et al. 2021)

Every human activity (primary, secondary, tertiary and quaternary) is being carried out on land which is the only source of all the material resources needed for this conduct. Human needs for the use of land resources give rise to the type of land use which varies with the purpose other than it is meant to naturally serve over time and space. The use, to which a tract of land is put to, is sacrosanct on two broad set of forces, which are human needs, and the environmental feature and processes. None of these forces is static rather in a continuous constant state of flux (Olaleye et al. 2009; Ayadiuno et al. 2021).

This paper therefore looks at the geomorphology and the landscape of Anambra State and its attraction to various land uses and subsequent population densities of the components of the State

1.2 Basic Concepts

Geomorphology developed from geology first as the geomorphogeny of William Morris Davis (Davis 1899) and later as geomorphology as first used by Baron Von Richtofen (Ofomata 2001; 2009). In line with the principles and methods of geomorphological description (Schumm 1977; Ndulue 2018), it is necessary to define the geomorphological system or surface thus: GS = (g, c, v, m, t). That is to say that the state of any geomorpohological surface is a function of the geologic substrates on which it is developed; climate over the geomorphological surface; vegetation cover; man and time over which it has evolved under the natural and anthropic events on it. Time in this paper is not conceived in line with the Davisian concept but a factor in which the natural processes can operate in either direction of equilibrium. This framework will aid in the understanding of the evolution of the land surface in Anambra State.

2. MATERIALS AND METHODS

2.1 Location

The geological and geomorphological maps of Anambra State in figures 2*a*, 2*b* and beyond portray the State which has an area of 4844 km^2. The State is located between Latitude 5º 40'N to 6º 46'N, and Longitude 6º 35'E to 7º 21'E. It lies wholly within Koppen's Af climate region (Ndulue and Ayadiuno 2021). Mean annual temperatures are around 27ºC with a mean rainfall of 1870 mm per year. The southwest through to the western part of the State are warmer and wit high humidity while the central through to the north and northeast part of the State are relatively colder and drier due to elevation and distance from water bodies (Obetta et al. 2011). The tropical humid climatic conditions influence the natural denudational processes in the State. The rainy season lasts from mid April to late October each year. The recent trend of increased rainfall in amount and distribution explained in the context of climate change appears to be eliminating the occurrence of the little dry season – August Break for which the area is known. The dry season starts from late October and ends in late March or early April. The harmattan (a kind of tropical disturbances witnessed in this part of the world) starts from late November through to February (Anyadike 2002; Ndulue and Ayadiuno 2021).

2.2 Research Design

Following from the foregoing paragraphs, the objective of this paper report is to present an account of the evolution and characteristic features of the land surface in Anambra State. A geomorphological account by the tradition set out by the earlier geomorphologists consists of information about the landscape of a demarcated region obtained by the examination of extant literature about the area and field observations within the area in quote (Offodile 1976; Ofomata 2009). Data were collected and analyzed on the geologic substrate in the area and the landscape developed upon the geologic substrate by the agents of denudation (Umeji 2002). The character of the landscape forms the basis for:

a. Explaining the distribution of the features of human landscape on the surface, or
b. Suggesting likely directional patterns for the location and emplacement of the structures and socio-economic activities and development in the study area (Nwokocha 2009).

This report consists of geomorphological map renditions, written elaborations and statistical analysis.

2.3 Hypothesis

There is no significant relationship between the geomorphological surfaces and population density as well as settlement pattern in Anambra State.

2.4 Data Collection

Data were collected from constant visit and re-visit of areas already studied in detail by the head author and his co-authors over the years for a re-confirmation of the landscape. The field visits were carried out with the aid of the 1: 50,000 topographical map sheets covering Onitsha Southeast, Onitsha Northwest, Ilushi Southeast and Udi Northeast for reasons of coverage of the entire Anambra State. The satellite imagery of Anambra State was obtained from EARTHDATA Alaska Satellite Facility, UAF, [01 May, 2020] and processed using ArcGIS 10.2 by the authors to produced the various maps used for the study. These graphical materials enabled proper identification of the features of the landscape and an appreciation of their distribution and inter-relationships through which they influence the pattern of human activities. Student t-Test of two samples assuming unequal variance was applied using Microsoft Excel to test for the hypothesis. A preliminary geomorphological map was drawn from these graphical tools and together with the provisional map of the field visits undertaken in five phases that covered Ayamelum, Anambra East, Awka North and Njikoka Local Government Areas (Phase 1). Awka South, Anaocha, Orumba North and Orumba South Local Government Areas (Phase 2). Idemili North, Idemili South, Oyi, Onitsha North and Onitsha South Local Government Areas (Phase 3). Nnewi North, Nnewi South and Ekwusigo Local Government Areas (Phase 4) and Ihiala Local Govewrnment Area (Phase 5). The combined contribution of the topographical surface and the two or three dimensional digital elevation models proved to be of great values as they offered high fidelity images of the land surface in the study area.

Data obtained from these exercises comprised the Morphographic, Morphometric, Morpholithological, Morphohydrologic data and a confirmation of the peculiar control of these groups above on the habitability and pattern of socio – economic development of Anambra State.

Morphographic data was obtained by the inspection of the satellite imagery and confirmed during field visit and observation; Morphometric data such as drainage basin density (Horton 1945) (Eqn 1), and elevation, mean slope angle on typical slopes were determined using the method suggested by Monkhouse and Wilkinson (1971) and having been used by a string of other scholars notably Olofin (1972); Mozie (1992); Eze (2009); Ayadiuno (2014); Ayadiuno et al. (2020). Except for Olofin (1972), all the other users applied the method in various parts of tropical humid Southeastern Nigeria. Morpholithologic and morphohydrologic data were assayed from the works of Mozie (1992) and Ayadiuno (2014). The field visits therefore involved re-confirmation and ground truth verification of some of the existing results. It is based on the literature search and the field investigation that the geomorphological surface of Anambra State is portrayed.

Drainage Basin Density

$Dd = \frac{C_t}{A}$ - - - - - - - - - - - -(Eqn 1)

Where

C_t = Total Length of Stream

A = Area (Horton 1945).

3. RESULTS ANALYSIS AND DISCUSSIONS

3.1 Geologic Surface

Anambra State consist of cretaceous sedimentary rocks, Shale formations underlie the State and are exposed in the Mamu basin, the Anambra basin and the Niger basin (Umeji 2002; Igwe and Egbueri 2018). On the shale are the deposits of the Eocene – Miocene consisting of the Bende-Ameke, Nanka Sands, Ebenebe Sandstones, etc. The sands and sandstones appear to be a later mantle that was broken by the faults of the Maastrichtian and have continued to be worn down and wide by the streams that issued from these aquiferous sands and sandstones from where the streams in the State take their sources (Offodile 2002; Okoyeh et al. 2014). Thus the surface of the State consists of a broken topography of streams established on the relatively impermeable shale bounded by scarps of sand and sandstones with various degree of resistance to weathering and loses by water – based denudation processes (Ofomata 1981).

The spatial pattern of distribution of the sands to sandstones and the exposed shale formations, initial coverage of the State by the sand to sandstone mantle which overtime became rifted and flexed in diverse degrees as demonstrated by the profile of the landscape from the Niger River plains across the south to central area of Anambra plains reveals a type of landscape as posited by Schumm (1977) (Figure 1).

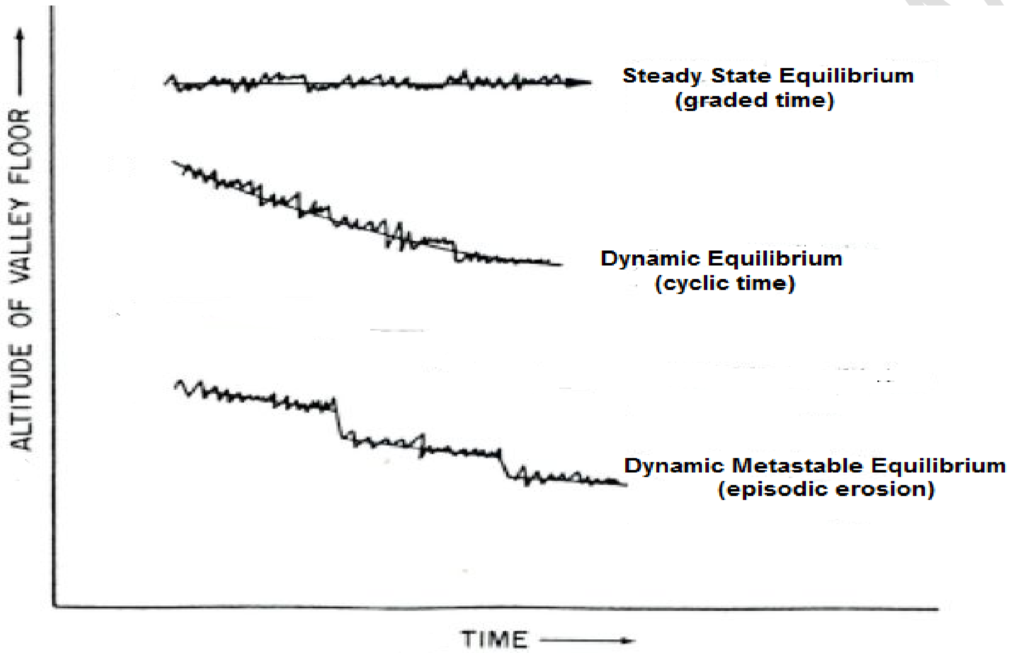

Fig 1: Dynamic Metastable Equilibrium
Source: Schumm (1977). Modified by the Authors, (2021)

The earth movement of the Gondwana Orogeny was responsible for the fissures that enabled the depositions of the materials during a series of marine transgression and regression (Umeji 2002). The subsequent laterization occurred leading to the creation of lateritic crusts which still remain at the high points in the Umuchu (*Ikpa Okwute*) Field of rocks, Agulu area and parts of the Umunya – Ogbunike – Nkwelle Ezunanka axis. The riftings and incisions by rivers and streams into the earth through the laterized sands and sandstones substrate together, account for the scarps of various heights and steepness in the State. The process of valley widening by slope retreat and headstream elongation provides a full explanation for the presence of the south to central sand/sandstone plateau and other outlying high grounds in the State and the lowlands underlain by shale in the eastern, northern and southwestern parts of the State. The worrisome landslides that keep advancing and eating up the high grounds constitute a natural phenomenon of landscape degradation in the State (Igbozurike 1993).

An inspection of figures 2*a* and 2*b*, the surface pattern of slopes in the State shows a direct association of the steep slopes to stream incision at the sandstones to shale interfaces along stream channels with the mass of the south to central sand/sandstone cuesta, particularly in the Nkisi – Nakweze and Obele Oyi basins in Oyi, Onitsha North and Anambra East Local Government Areas. Scarps occur along the entire length of the Idemili River channel, the Ulasi (Orashi) River channel in Nnewi North, Nnewi South and Ihiala Local Government Areas and along the slopes of the Mamu River in Aguata, Orumba North, Orumba South, Anaocha, Awka South and Awka North Local Government Areas. In Ayamelum Local Government Area, the scarp and slope retreat along the Anambra Bluff which actually is a fault line, is yet slow due to the presence of the protection offered by a sheet of hard lateritic capstones along the fault line and the near absence of high human presence in the area that would have usually accelerated the rate of the retreat.

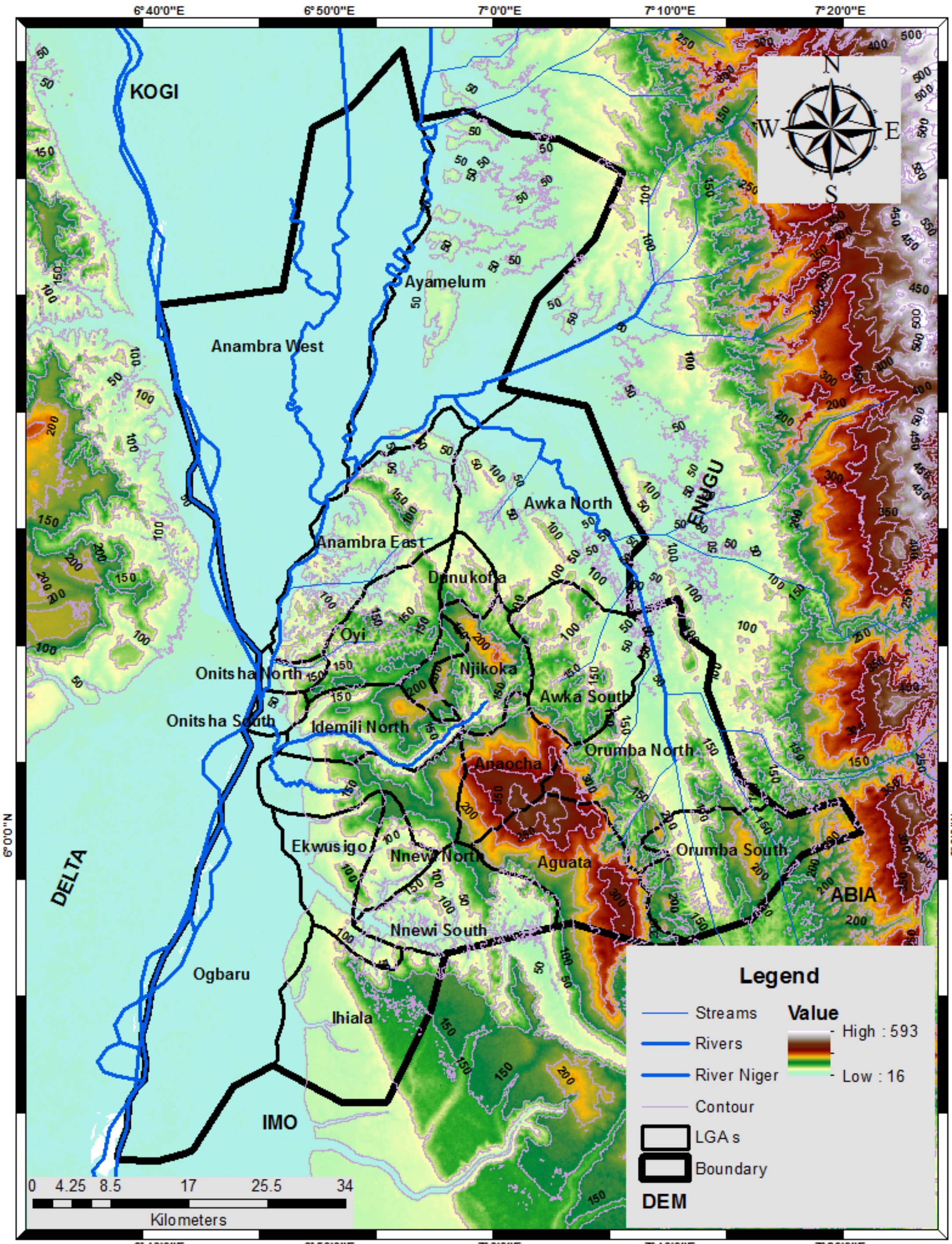

Fig 2*a*: Dem of Anambra State with Contour Lines
Source: Alaska Satellite Facility, UAF, Modified by the Authors, (2020)..

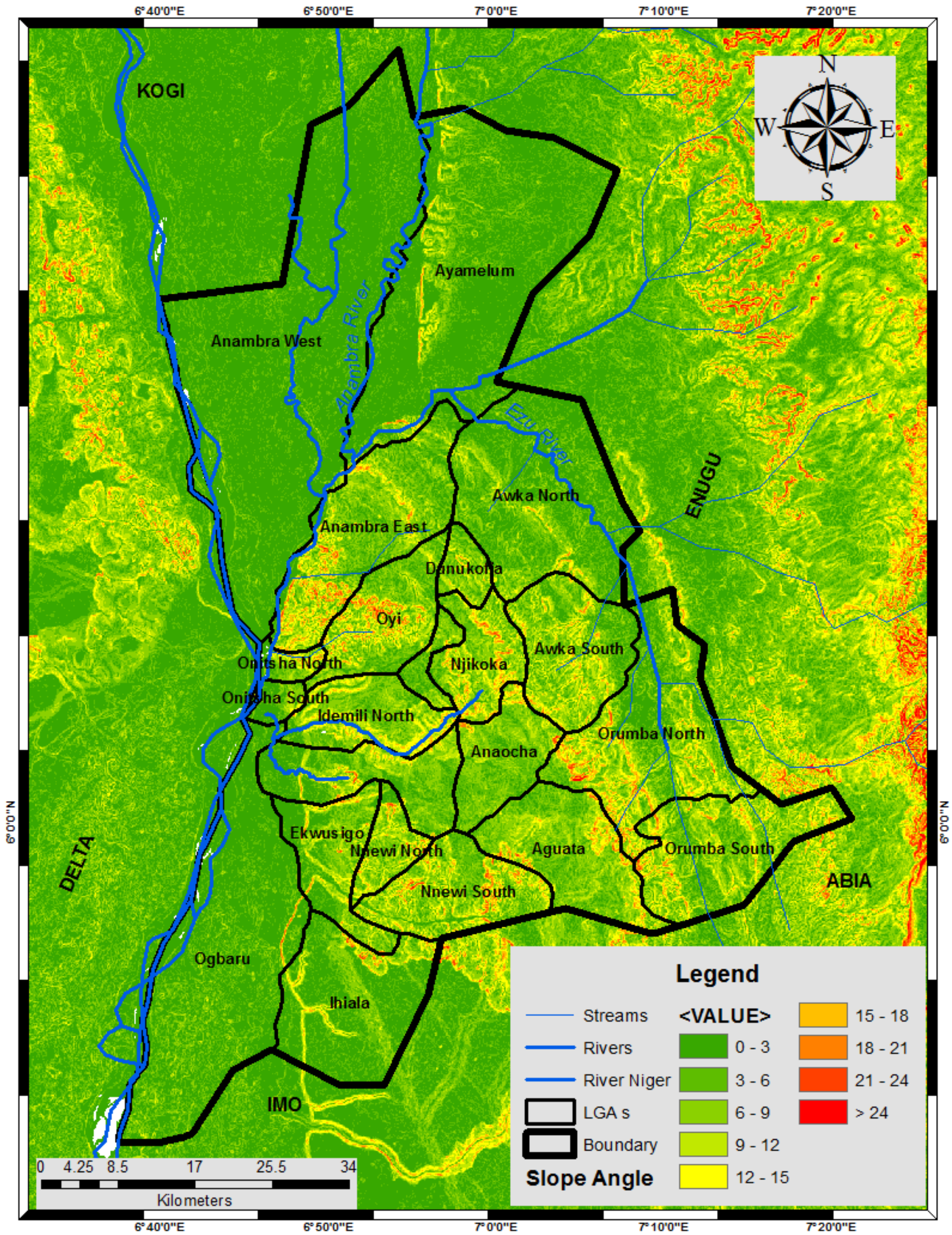

Fig 2*b*: Slope Angle and Drainage Model of Anambra State
Source: Alaska Satellite Facility, UAF, Modified by the Authors, (2020).

Within Anambra State the general slope facets are evident:

I. The low and flat to near flat land facet lying generally below 60 metres above sea level. This facet is developed on shale and in the Niger – Anambra plains are covered by riverine alluvium. The soils is grayish in colour with a slope angle of below 5º, and is found in Ayamelum, Anambra West, Awka North, Onitsha North, Onitsha South and Ogbaru Local Government Areas (Plate A).

Plate A: Niger – Anambra Plain Covered with Riverine Alluvium in Anambra West L.G.A.
Source: Authors' Fieldwork, (2020)

II. Above the flats exist the restricted and limited strips of brown soils which are the down-ward washing of the talus from the well defined slope. This soil – slope unit merges into the talus slope and is best classified as part of the talus slope. Its slope angle is between 5º and 15º, elevation of between 60 and 120 metres above sea level, and is found in Anambra East, Idemili South, Oyi, Dunukofia, Awka South, Nnewi North and Nnewi South Local Government Areas (Plate B).

Plate B: Middle Slope of the Study Area in Oyi Local Government Area
Source: Authors' Fieldwork, (2020)

III. The talus slope is followed by upward elevations of between 120 and 230 metres above sea level. They are found in Anaocha, Aguta, Orumba North, Orumba South and Awka South Local Government Areas from the higher grounds as one looks towards the Mamu basin. The scarps are also appreciated as separating the higher grounds and the River Niger flood and other low plains in Idemili South, Ekwusigo and Ihiala Local Government Areas (Plate C).

Plate C: The Scarp Separating the Higher Grounds and the River Niger Flood Plains in Idemili South Local Government Area
Source: Authors' Fieldwork, (2020)

IV. The highest grounds lie from 230 metres up to 315 metres above sea level. The surface of this highest ground is undulating consisting of wide – topped elevation and long gentle valleys. The topography between Nnobi and Alor (Idemili South L.G.A) provides a good example of this surface. Also the long slope from Isuofia, Ezira to Achina and Umuchu to Akpo (Aguata L.G.A) belongs to this type of topography. Other examples abound around Isulo, Owerre Ezukala, Ihitte, Umunze and Ogboji communities (Orumba South L.G.A).

The long steep slopes favour the accumulation of relatively large volume of surface runoff which as they flow towards the edge of this land facet triggers gully initiation, incision and expansion on the face of the scarps by valley elongation (Plate D).

Plate D: The Surface of the Highest Undulating Ground, Consisting of Wide – topped Elevation and Long Gentle Valleys in Aguata Local Government Area
Source: Authors' Fieldwork, (2020)

A few geomorphological indices that are of interest and importance are the elevation, flow direction, geology and patterns of soil distribution which are shown in figures 3*a*, 3*b* and 4.

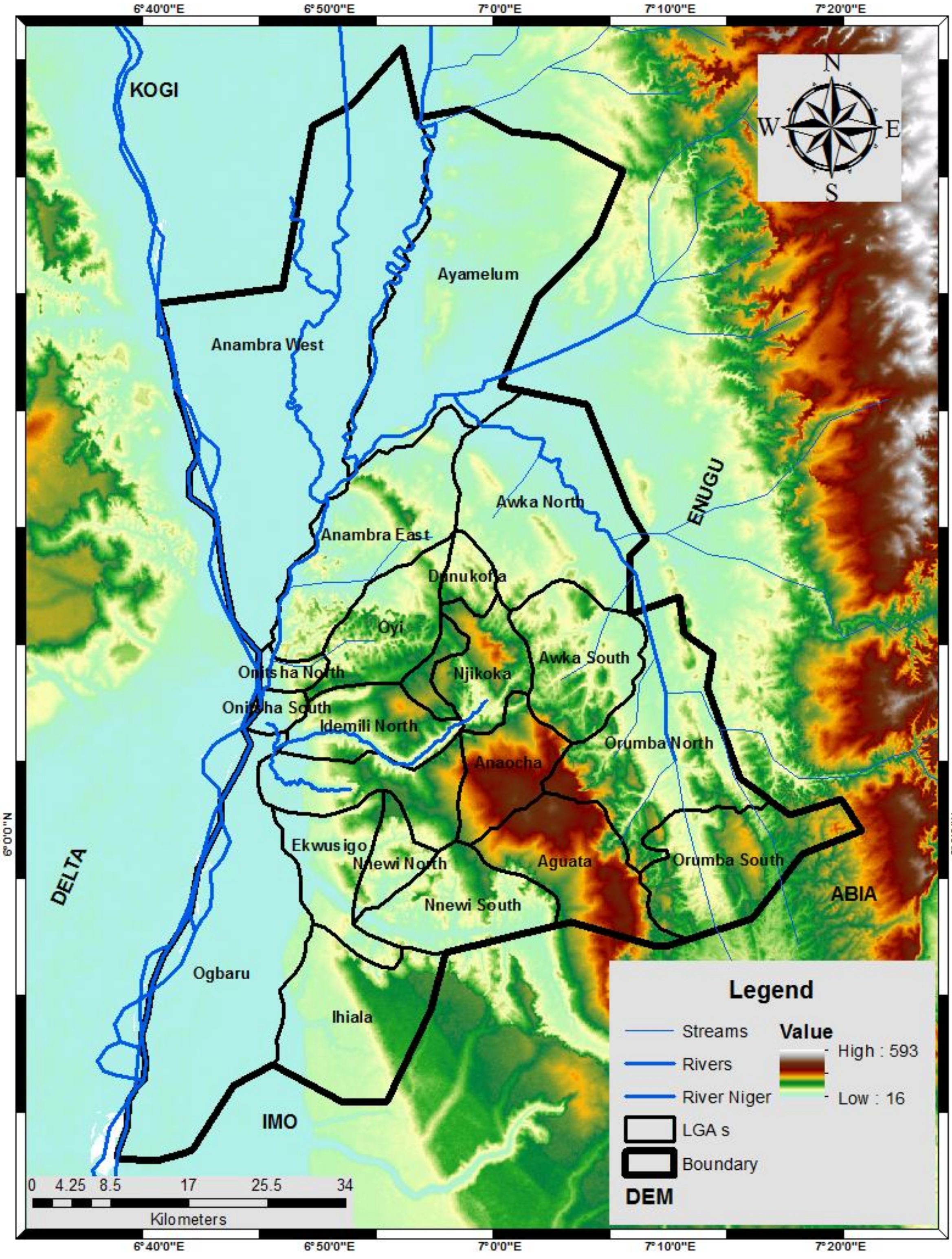

Fig 3*a*: Dem of Anambra State
Source: Alaska Satellite Facility, UAF, Modified by the Authors, (2020).

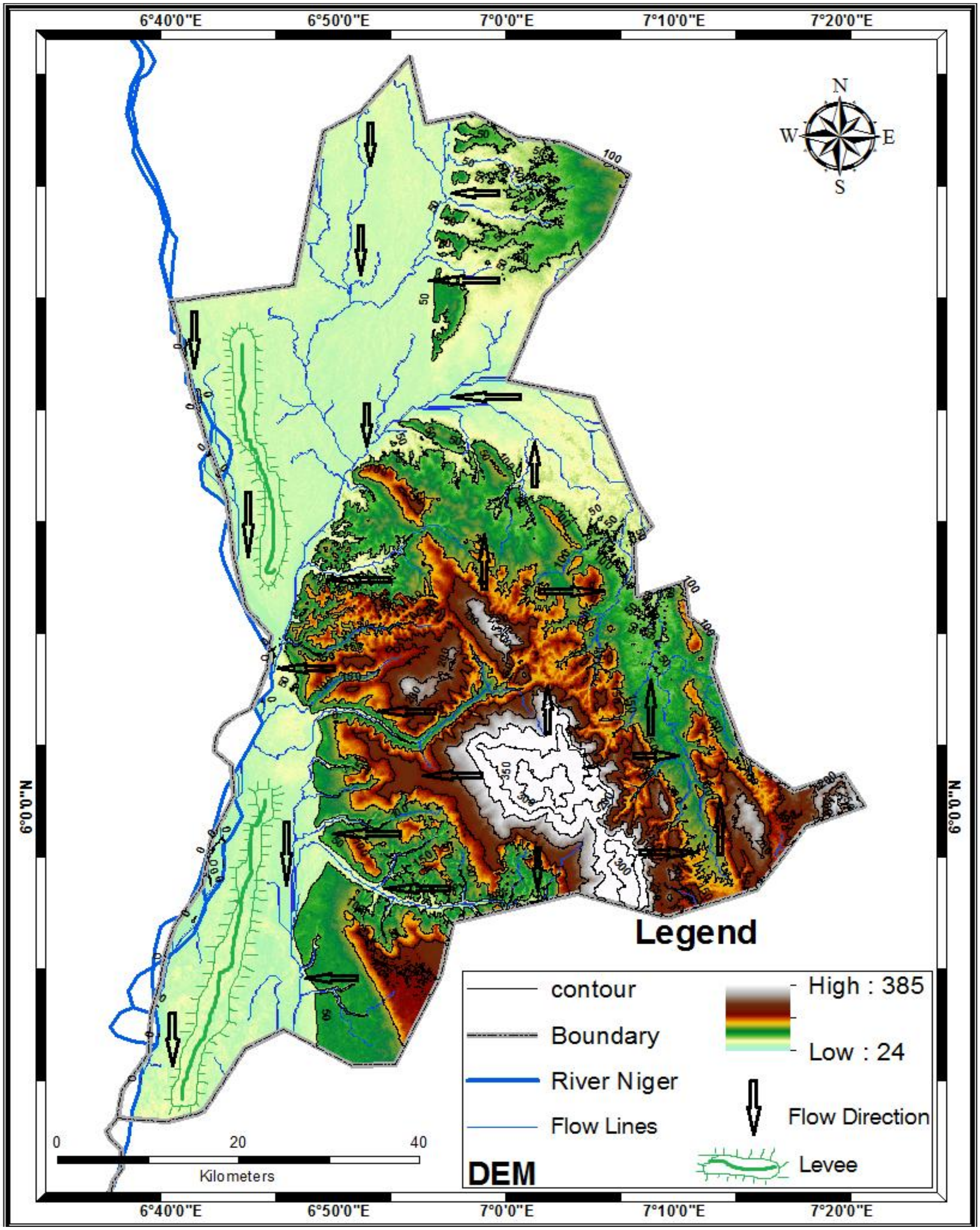

Fig 3*b*: D.E.M and Flow Direction of Anambra State
Source: Alaska Satellite Facility, UAF, Modified by the Authors, (2020).

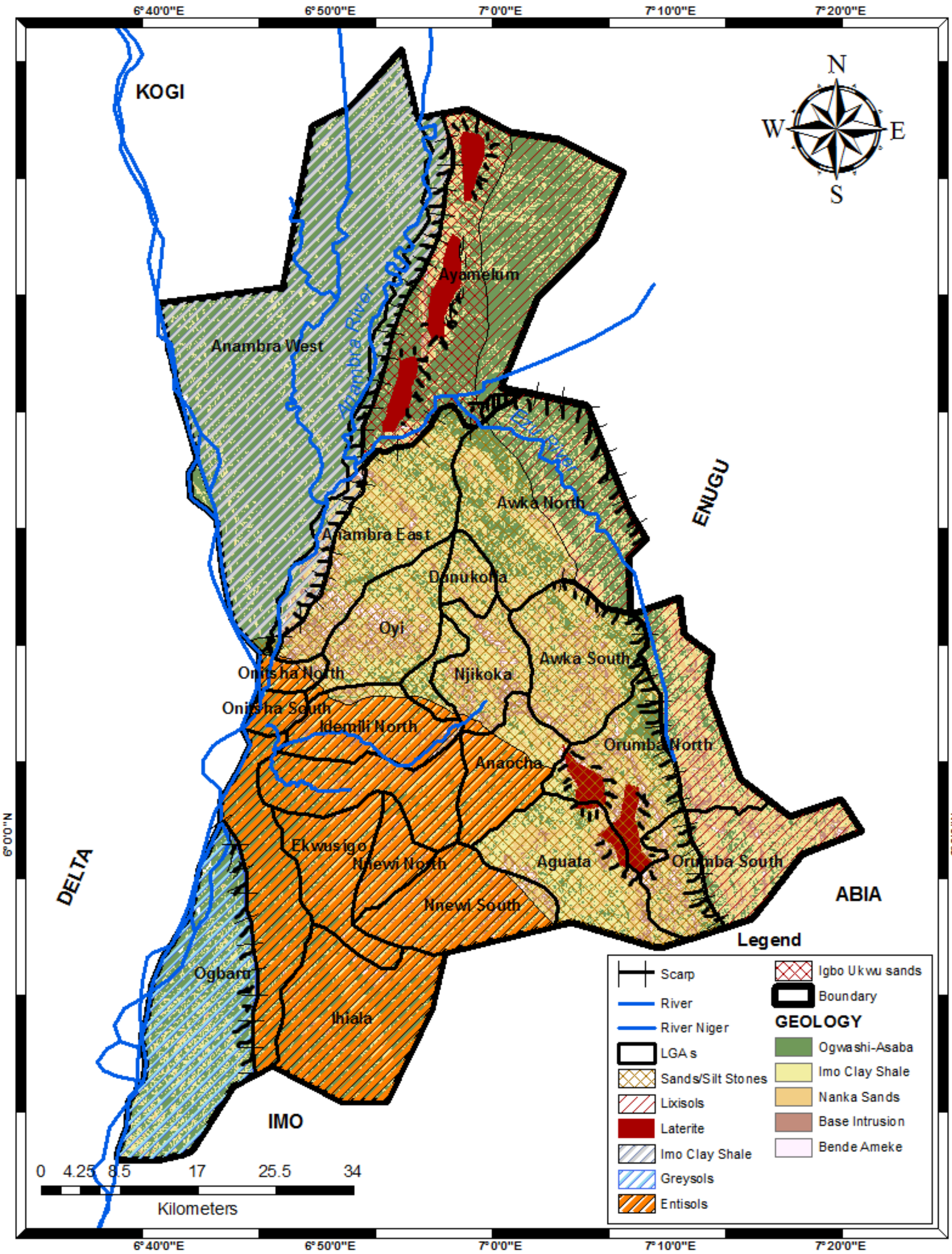

Fig 4: Geology and Soil of Anambra State
Source: Alaska Satellite Facility, UAF, Modified by the Authors, (2020).

The soils fall into two major groups:

a. Soils associated with low wet topography are found in the Anambra plains towards the North, the Niger flood plains in the Southwest and the narrow strip of the Mamu basin in the East of the study area.
b. The other soil groups are those formed on sands and sandstones in the Central and the Southern part of the State.

The geological substrates and the consequent geomorphological surface that developed in Anambra State exert control over the spatial pattern of population distribution and economic activities carried out in the State. The table below (Table 1) shows the population data distribution and density of Anambra State as influenced by the geological substrates and the consequent geomorphological surfaces. The population data of Anambra State was mapped for better comparison of population density with geological substrates and geomorphological surfaces (Figure 5). The population data is presented in the charts below (Figures 6 and 7).

Table 1: Population Data of Anambra State, 2006

	Distribution by LGAs	**Population**	**% of Pop**	**Area (Km²)**	**% of Area**	**Pop. Density (/km²)**
1	Aguta	369,972	8.86	189.25	3.91	1954.94
2	Anambra East*	152,149	3.64	633.57	13.08	240.15
3	Anambra West*	167,303	4	600.65	12.4	278.54
4	Anaocha	284,215	6.8	116.22	2.4	2445.5
5	Awka North*	112,192	2.68	356.9	7.37	314.31
6	Awka South	189,654	4.54	168.68	3.48	1124.34
7	Ayamelum*	158,152	3.79	553.34	11.42	285.81
8	Dunukofia	96,517	2.31	77.34	1.6	1247.96
9	Ekwusigo	158,429	3.79	135.76	2.8	1166.98
10	Idemili North	431,005	10.32	150.16	3.1	2870.31
11	Idemili South	206,816	4.95	105.94	2.19	1952.2
12	Ihiala	302,277	7.24	309.58	6.39	976.41
13	Njikoka	148,394	3.55	86.81	1.79	1709.18
14	Nnewi North	155,443	3.72	55.23	1.14	2814.47
15	Nnewi South	233,362	5.59	185.13	3.82	1260.53
16	Ogbaru*	223,317	5.35	399.06	8.24	559.61
17	Onitsha North	125,918	3	29.52	0.61	4265.52
18	Onitsha South	137,191	3.28	11.01	0.23	12460.58
19	Orumba North*	172,773	4.14	330.15	6.82	523.32
20	Orumba South*	184,548	4.42	205.7	4.25	897.17
21	Oyi	168,201	4.03	144	2.97	1168.06
Total		**4,177,828**	**100**	**4,844**	**100**	**862.47**
High Density Area		**3,007,394**	**71.98**	**1,765**	**36.42**	**1704**
Low Density Area*		**1,170,434**	**28.02**	**3,079**	**63.58**	**380**

Source: NPC, (2006), Compiled by the Authors (2020)

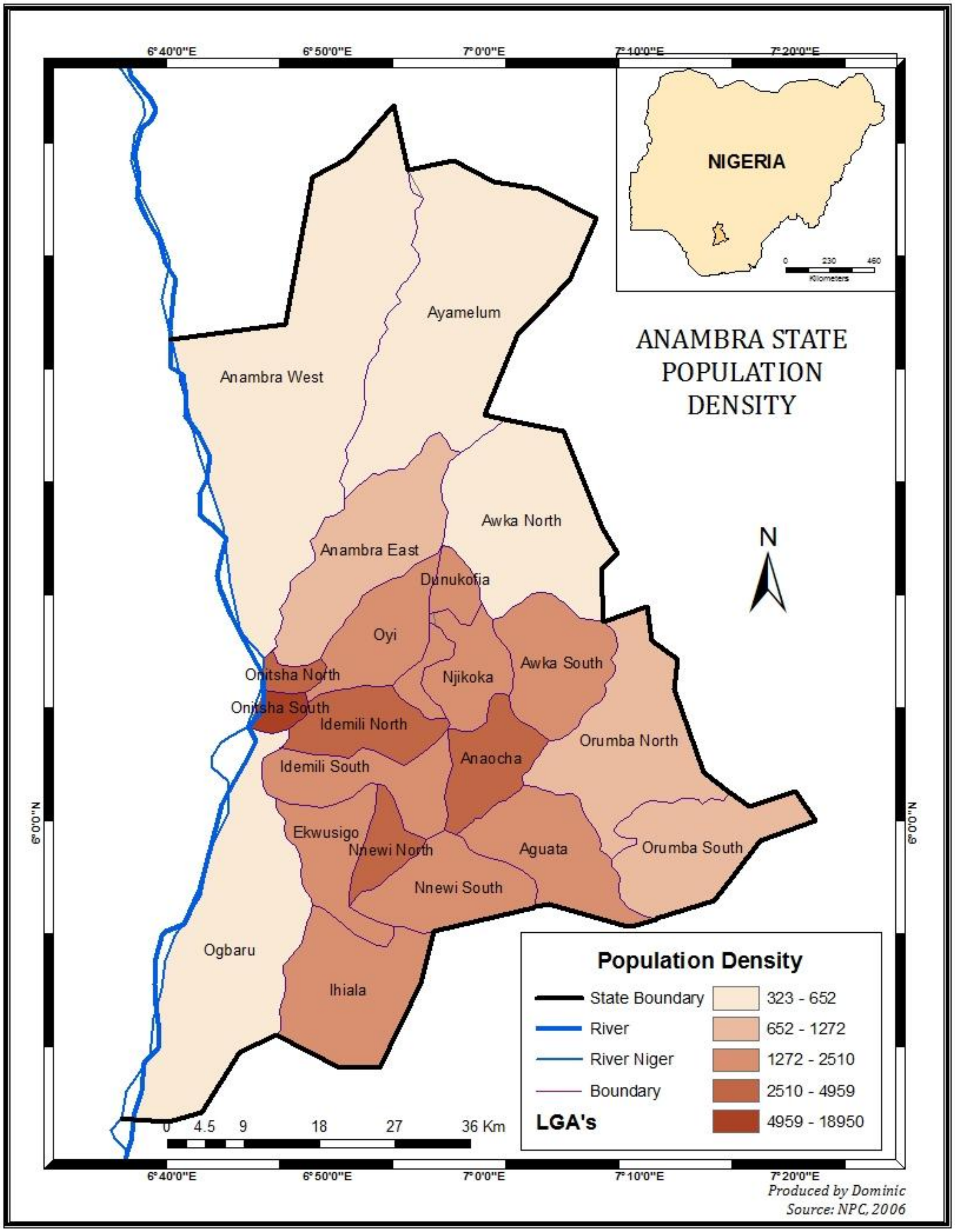

Fig 5: Anambra State Population Density
Source: NPC, (2006) and Ndulue and Ayadiuno, (2021)

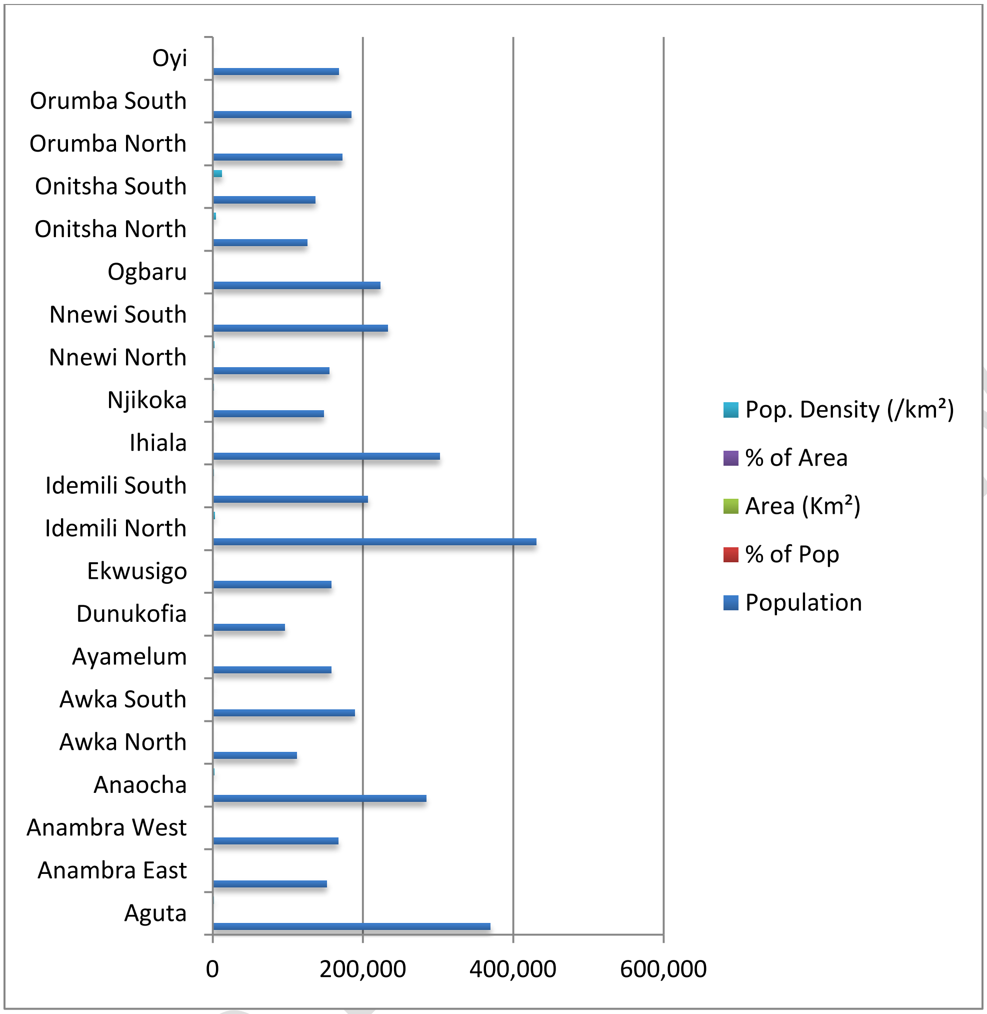

Fig 6: Population Data Distribution of Anambra State
Source: Authors Computation (Microsoft Excel) (2020)

Figure 7 below shows that a disproportionately high percentage population of 71.98%, and population density of 81.77%, are found on the higher grounds, that is on the smaller sand – sandstone formations covering about 36.42% of the study area, leaving a very small percentage population of 28.02%, and population density of 18.23%, on the larger flood and other lower plains (*flats*) covering about 63.58% of the study area.

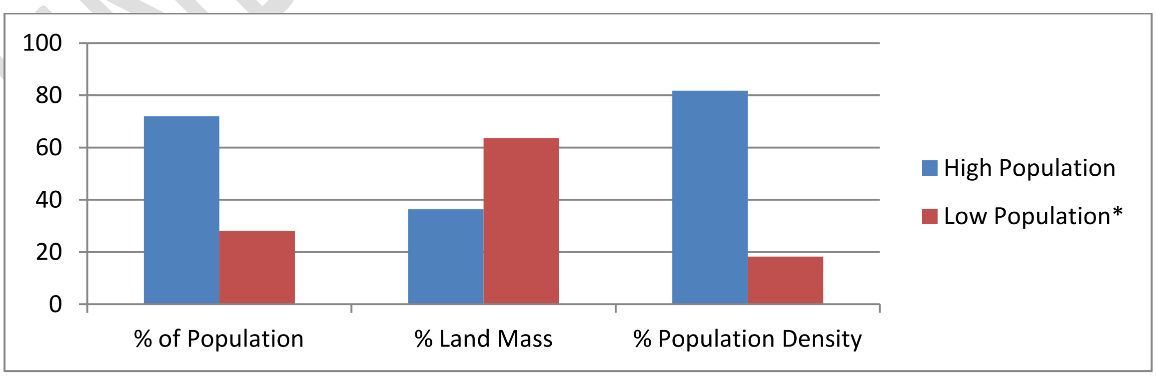

Fig 7: Percentage of Population Data Distribution and Density of Anambra State
Source: Authors Computation (Microsoft Excel) (2020)

It is worthy to note that the higher grounds in the study area is made up of 14 local government areas with a land mass of about 1,765 km^2 (36.42%), while the flood and other low plains are made up of 7 local government areas with a land mass of about 3,079 km^2 (63.58%).

3.2 Test of Hypothesis

The hypothesis raised for this research is tested using Student t-test in Microsoft Excel to test if there is a relationship between geomorphological space and population density and the result is presented in the table below:

Table 2: Student t-Test for the Study Hypothesis

t-Test: Two-Sample Assuming Unequal Variances		
	Pop. Density (/km²) at Higher Ground	*Pop. Density (/km²) at Low Plains*
Mean	2672.639854	442.7059688
Variance	8787936.948	55962.45051
Observations	14	7
Hypothesized Mean Difference	0	
df	13	
t Stat	2.79681907	
P(T<=t) one-tail	0.007560753	
t Critical one-tail	1.770933383	
P(T<=t) two-tail	0.015121507	
t Critical two-tail	2.160368652	

Source: Microsoft Excel Output, (2021)

The table above shows the outcome of hypothesis test for the statistical significant relationship between the population density at the higher ground and the flood, and other low plains (*flats*).
The model has a P-value of less than .05 at approximate 0.02, indicating that the model is significant. The P-value 0.02 shows that there is a 98% level of confidence that both mean of the model are different. The table statistics is 2.80 and a critical value is 2.16 respectively. Since critical value of 2.16 is less that table statistics of 2.80, null hypothesis is reject which states that, *there is no significant relationship between the geomorphological surfaces and population density as well as settlement pattern in Anambra State at 0.05 level of significance* and the alternate hypothesis is accepted.

3.3 Summary of the Surface Characteristics, Geology, Lithology, Structure and Topography and Drainage Basin Density in Anambra State as Observed, and Findings during the study

The summary of the geomorphological surface is contained in the map and table below; Five basins covered the surface of Anambra State and are as follows: Anambra; Mamu; Nkisi – Nakweze; Idemili and Ulasi (Orashi) basins. The Anambra basin lies on Shale substrate. The Nkisi – Nakweze basin lies on the Nanka sands. The Idemili basin lie on the Bende-Ameke sandstones and the Ulasi (Orashi) basin lies on the Entisol and the Deltaic sands of the Southwestern part of the State adjoining the Niger (Figure 8; Table 3).

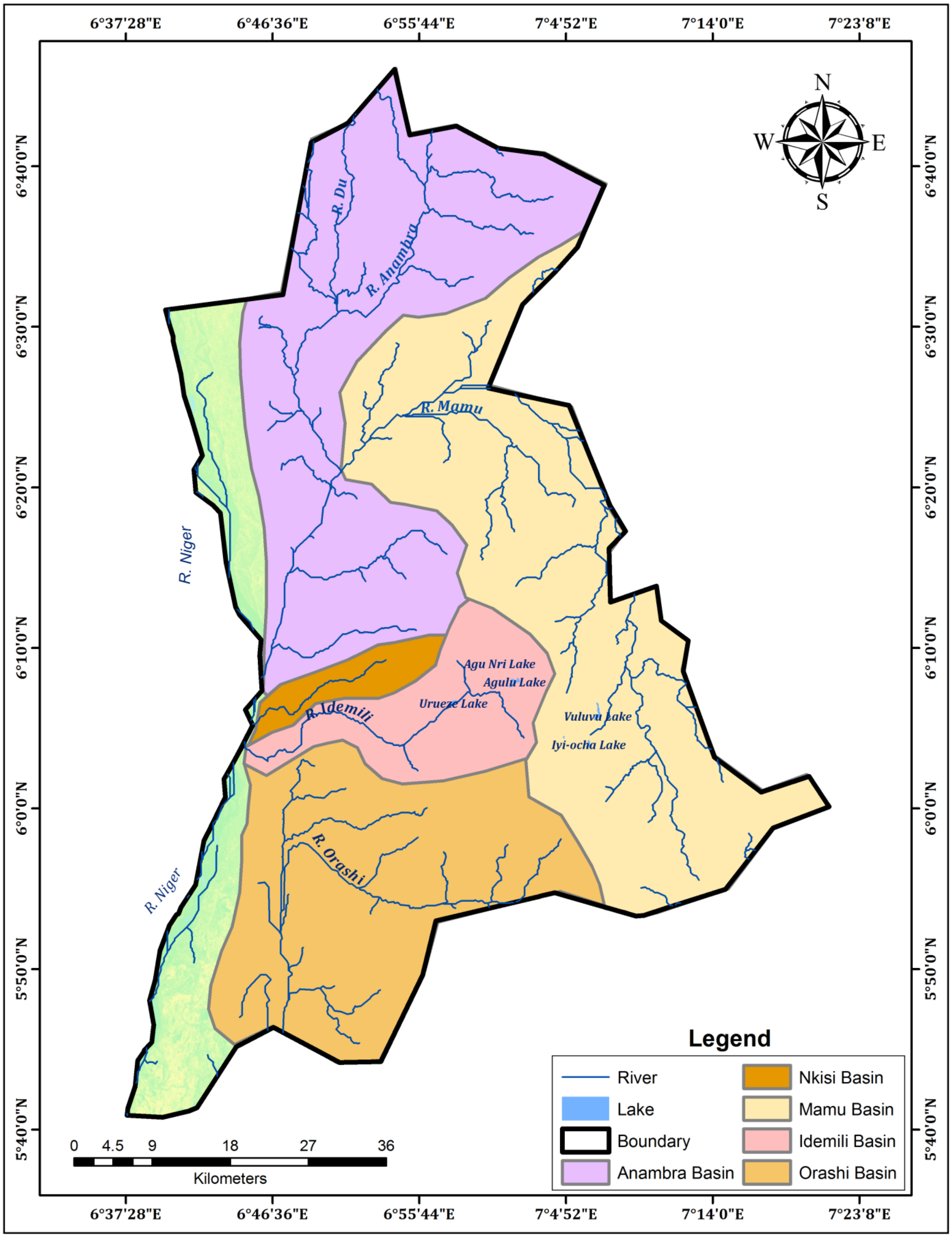

Fig 8: Drainage Basins in Anambra State
Source: Alaska Satellite Facility, UAF, Modified by the Authors, (2021).

Table 3: Summary of the Surface Characteristics, Geology, Lithology, Structure and Topography and Drainage Basin Density in Anambra State as Observed, and Findings during the study

Period	**Basin Unit**	**Lithology**	**Structure**	**Topography**	**Drainage Basin Density**	**Relative Relief**	**Vegetation**	**Dominant Economic Activity**
Cretaceous - lower Paleocene	Anambra Basin (Shale Substrate)	Clay – Shale Fine Soil Fraction	Gentle dip to Southwest 1^0 - 3^0	Low, Mean elevation below 30m. restricted dry points	2.11 Km/km^2	7 m	Gallery forests along river courses, grass land	Farming, fishing and trading.
Tertiary, Upper – middle Eocene	Nkisi – Nakweze, Obele Oyi basins. (Nanka Sands)	Gravelly Coarse – medium grained sands. False bedded Sandstones, Carbonaceous Shales.	Gentle dip to the West and South 3^0 - 4^0	Low domey, round – topped residuals, and dry valleys. Low cliffs, dormant slopes, 4^0 - 9^0	1.23 Km/km^2	137 m	Oil palm bush, built-up areas >45% of surface	Subsistence farming, trading and tertiary economic activities
Miocene - Eocene	Idemili Basin (Bende-Ameke Sands)	Medium to Fine Sands, porous with high transivity, Coarse grained, poorly consolidated calcareous	Gentle dip to the south and west, Elevation of 250m above sea level	Broad ridges with fairly broad summits. Presence of relict lateritic crust. (Agulu, Isu Ofia, Umuchu), etc	0.66 Km/Km^2	335m	Oil palm bush, grasses.	Subsistence Farming, Tertiary economic activity.
Lower Maastrichtian	Mamu (Imo Clay)	Clay – Shale and some Sands/Sandstones predominated by fines.	Gentle dip, Southwards 2^0 – 3^0, Elevation 230 m	Broad Sandstones ridge (Ebenebe), Flat Swamps	2.01 Km/Km^2	285m	Raffia Palm and other Hydrophytes (Ugwuoba) Organic Soils	Farming And Fishing, Trading, etc
Holocene Quatenary	Orashi (Entisol and the Deltaic sands)	Recent Alluvium and Deltaic Sands	Gentle Slope towards Southern Delta	Flat Swamps and little porous sands.	0.13 Km/Km^2	20m	Raffia Palm, Hydrophytes.	Farming, Farming/aquaculture, Trading, Oil Exploration
All these Basins Drain ultimately into the River Niger which is the Regional Base Level.								

Source: Nwachukwu (1975); Mozie (1992); Ofomata (2002); Umeji (2002); Authors Analysis and Compilation (2020).

4. CONCLUSION

This paper has attempted to give a scientific description of the geological substrate and geomorphological landscape of Anambra State. The authors in this paper had undertaken their studies in Anambra State at various times and their works have enabled the conflation of facts to which other relevant facts have been added in order to obtain a complete picture that is presented in this paper.

In the course of the fieldwork over the years, the authors found that there is strong influence and relationship between the physical environments particularly, the geomorphological factor in determining the spatial pattern of socio-economic activities and development in Anambra State. A disproportionately high percentage population of 71.98%, population density of 81.77%, and development structures are found on the higher grounds on the smaller sand – sandstone formations covering about 36.42% of the study area, leaving a very small percentage population of 28.02%, population density of 18.23%, and development structures on the larger flood and other low plains (*flats*) covering about 63.58% of the study area

This observed distribution raises the issues of the need for the government and people of the State to employ science and technology to overcome the limitations on the lower surfaces. The lowlands have their developmental potentials which still remain untapped because of the low level of scientific development in those areas.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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