

A Geomorphological Survey and Landscape Analysis of Anambra State Southeast Nigeria

ABSTRACT

This paper 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%) as well as developmental activities and 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%) as well also as developmental activities and structures on the larger flood and other low plains covering 63.58% of the area. These disparities in population distribution as a result of geomorphological factors raises the issues of the need for the government and people of the State to employ new developmental ideas in the area of science and technology to overcome the limitations on the lower surfaces in order to attract settlers and balance population distribution in the State.

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 (Ndulue 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 geomorphological 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 2a, 2b and beyond portray the State which has an area of 4844 km². The State is located between Latitude 5° 40'N to 6° 46'N, and Longitude 6° 35'E to 7° 21'E (Figures 2, 3, 4, 5 and 8). It lies wholly within Koppen's Af climate region (Ndulue and Ayadiuno 2021). Mean annual temperatures are around 27°C with a mean rainfall of 1870 mm per year. The southwest through to the western part of the State are warmer and with 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.

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).

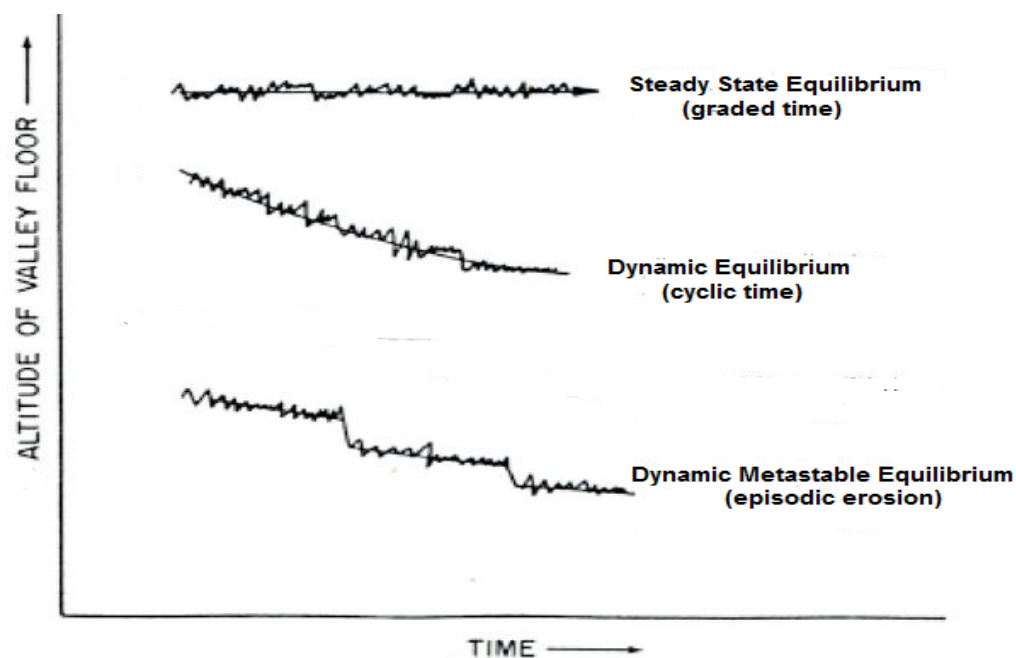


Fig 1: Dynamic Metastable Equilibrium

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 2a and 2b, 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.

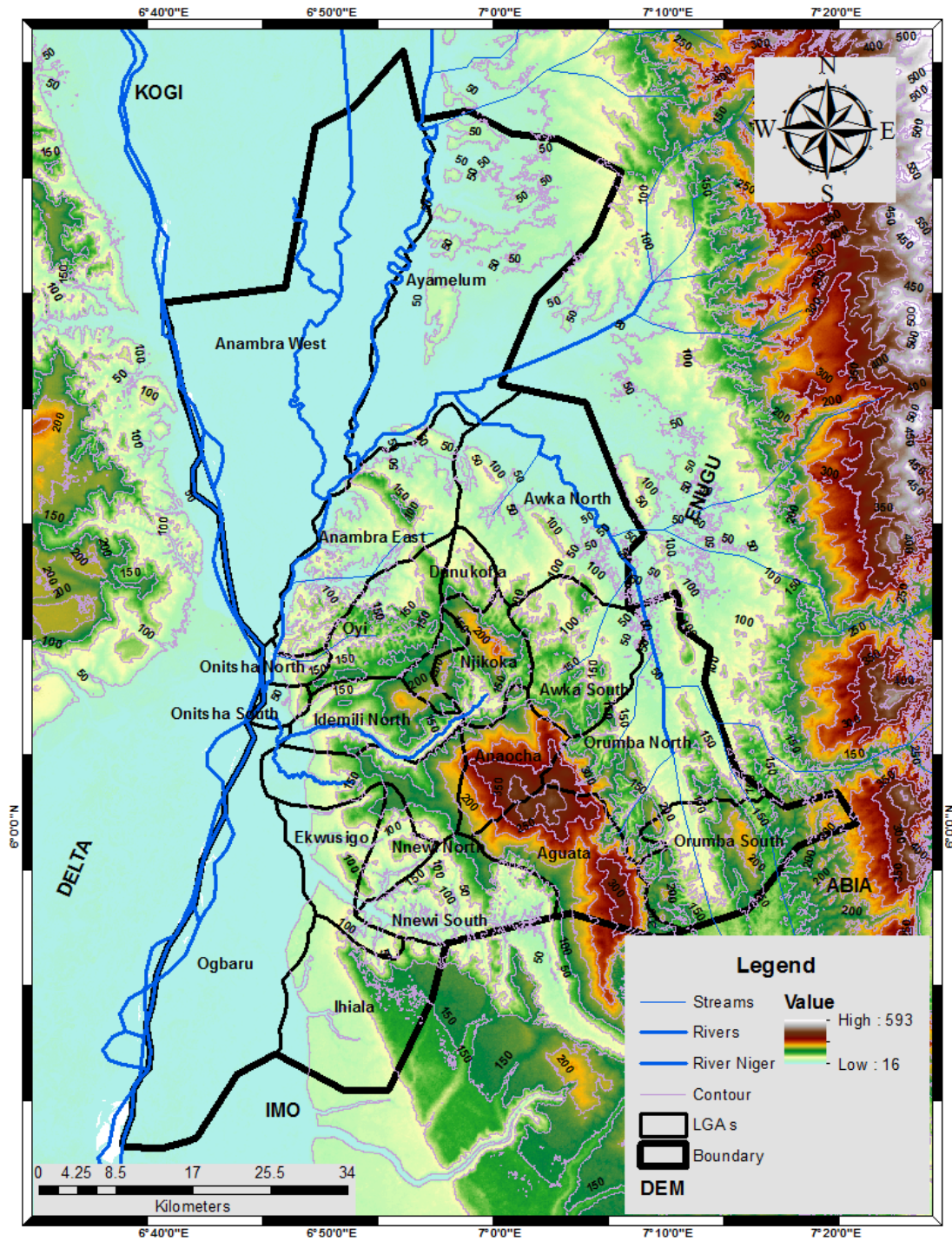


Fig 2a: Digital Elevation Model (DEM) of Anambra State with Contour Lines
Source: Alaska Satellite Facility, UAF, Modified by the Authors, (2020)..

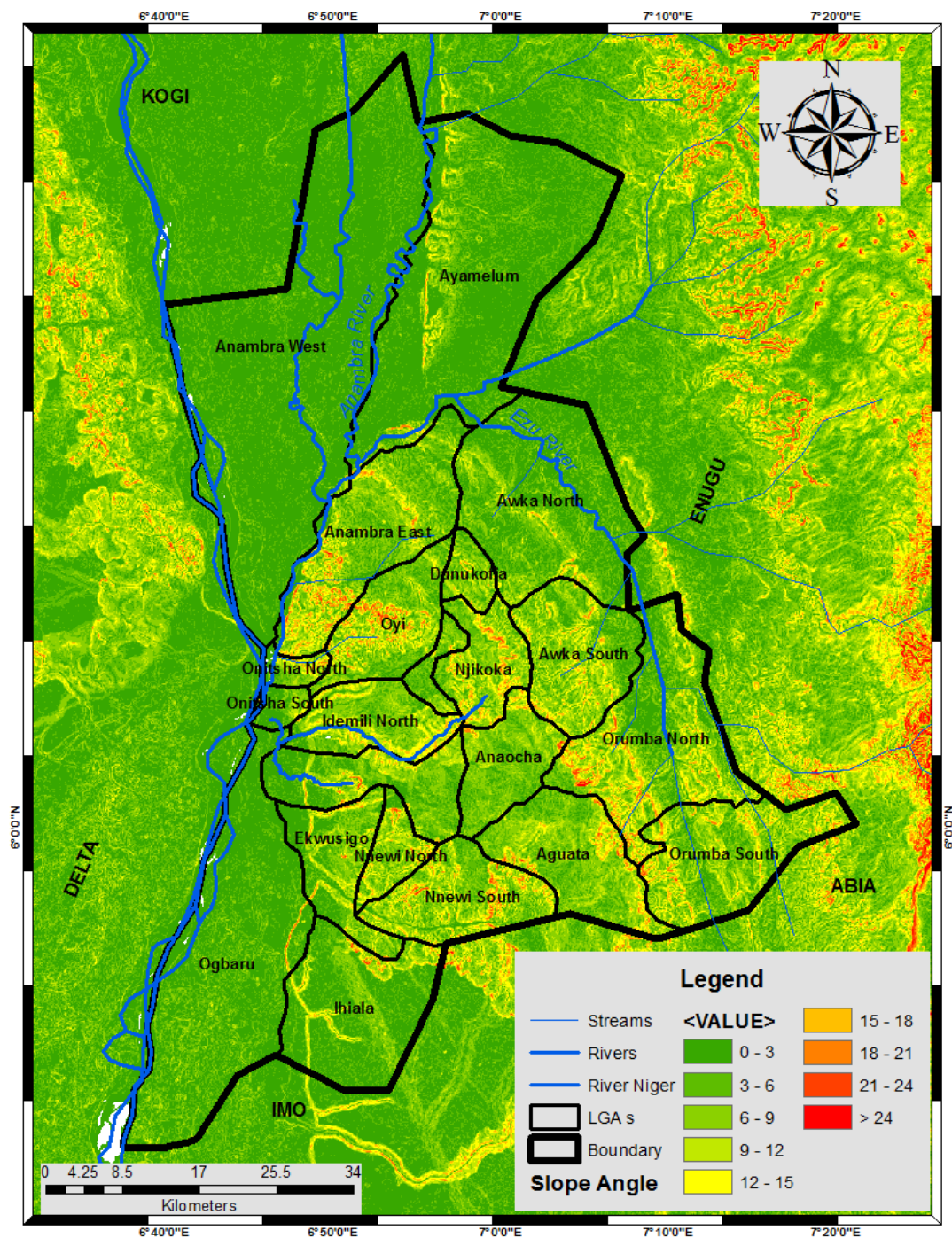


Fig 2b: Slope Angle and Drainage System of Anambra State

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 5°, 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 5° and 15° , 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 3a, 3b and 4.

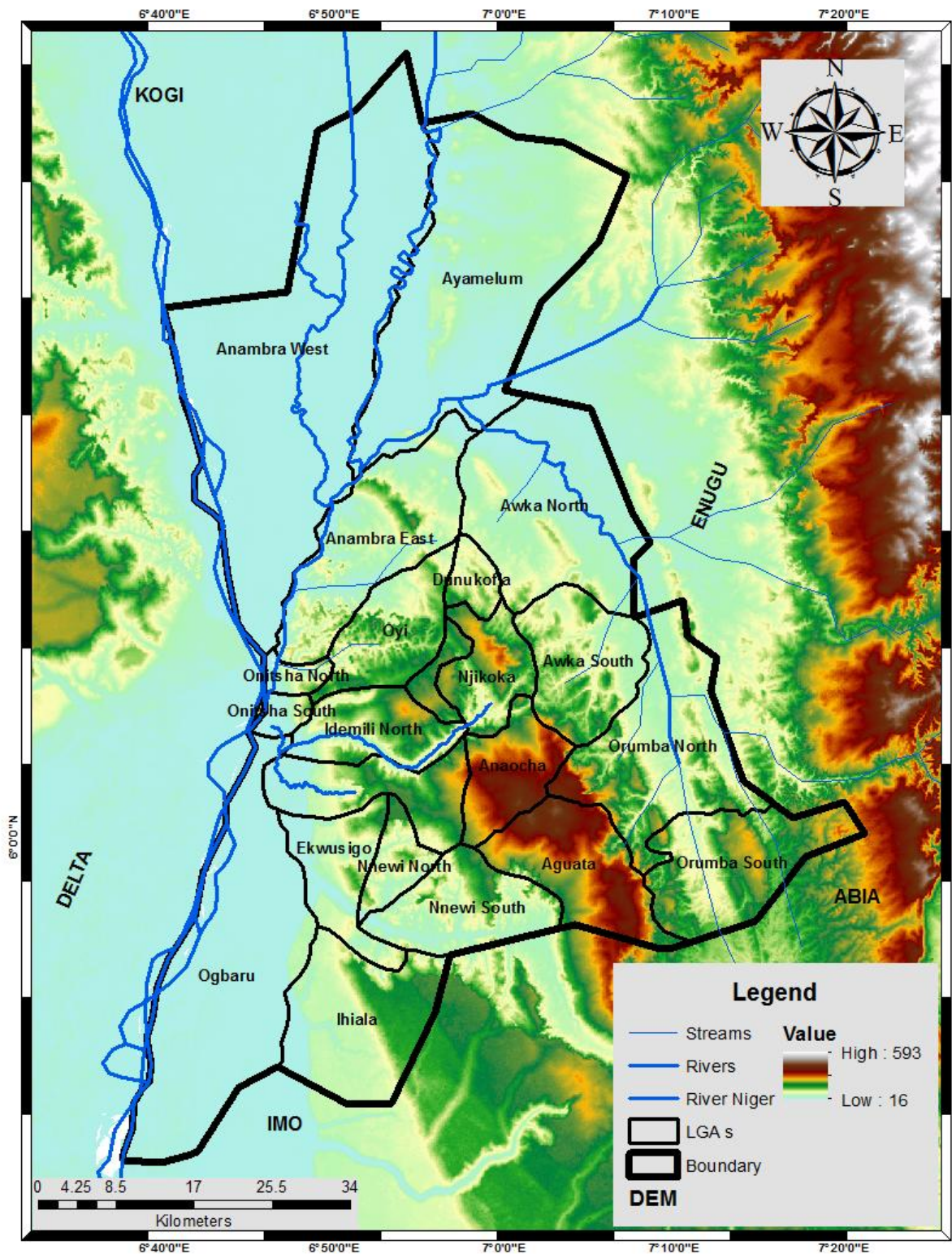


Fig 3a: Digital Elevation Model (DEM) and Drainage System of Anambra State
Source: Alaska Satellite Facility, UAF, Modified by the Authors, (2020).

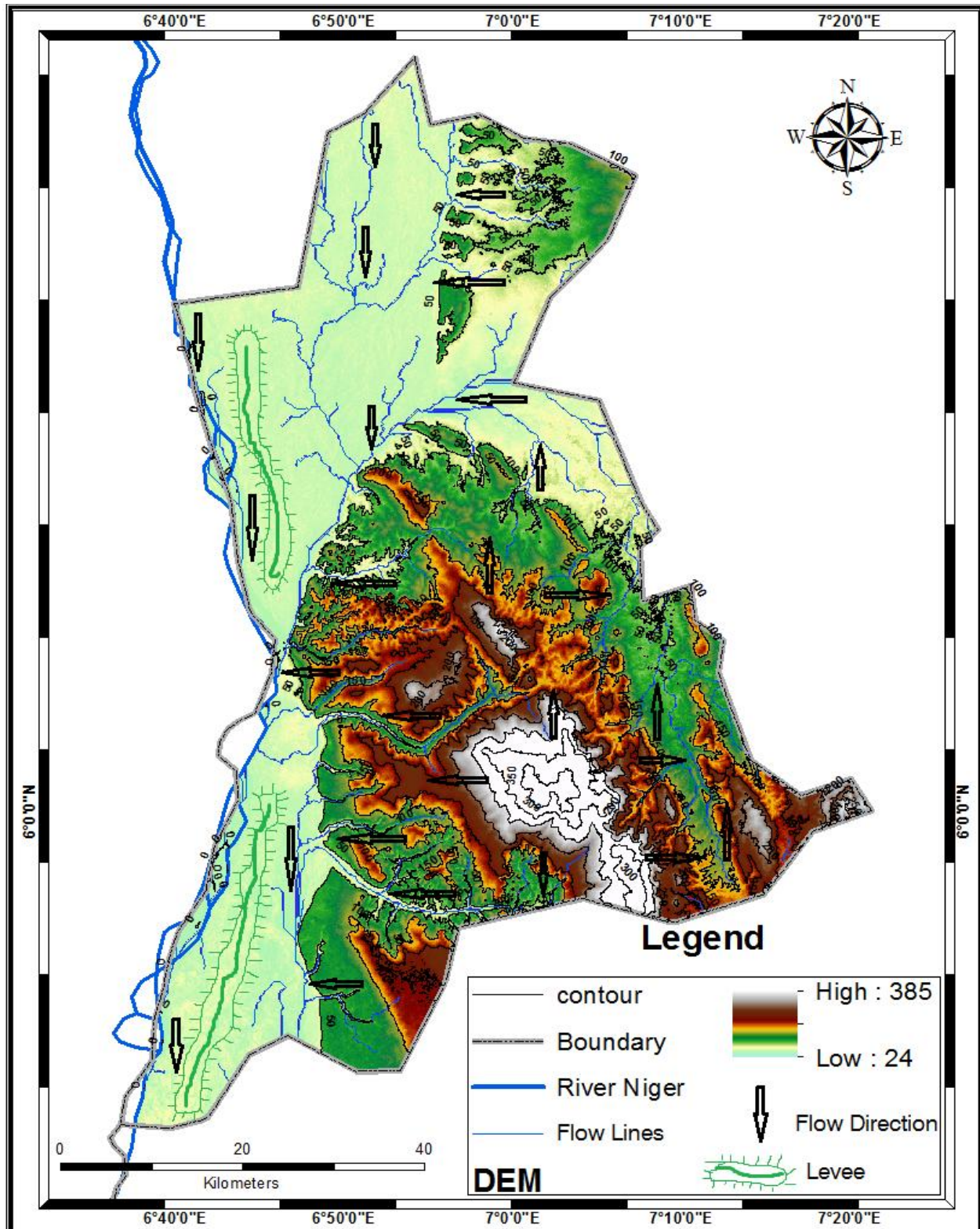


Fig 3b: Digital Elevation Model (DEM) and Flow Direction of Anambra State
Source: Alaska Satellite Facility, UAF, Modified by the Authors, (2020).

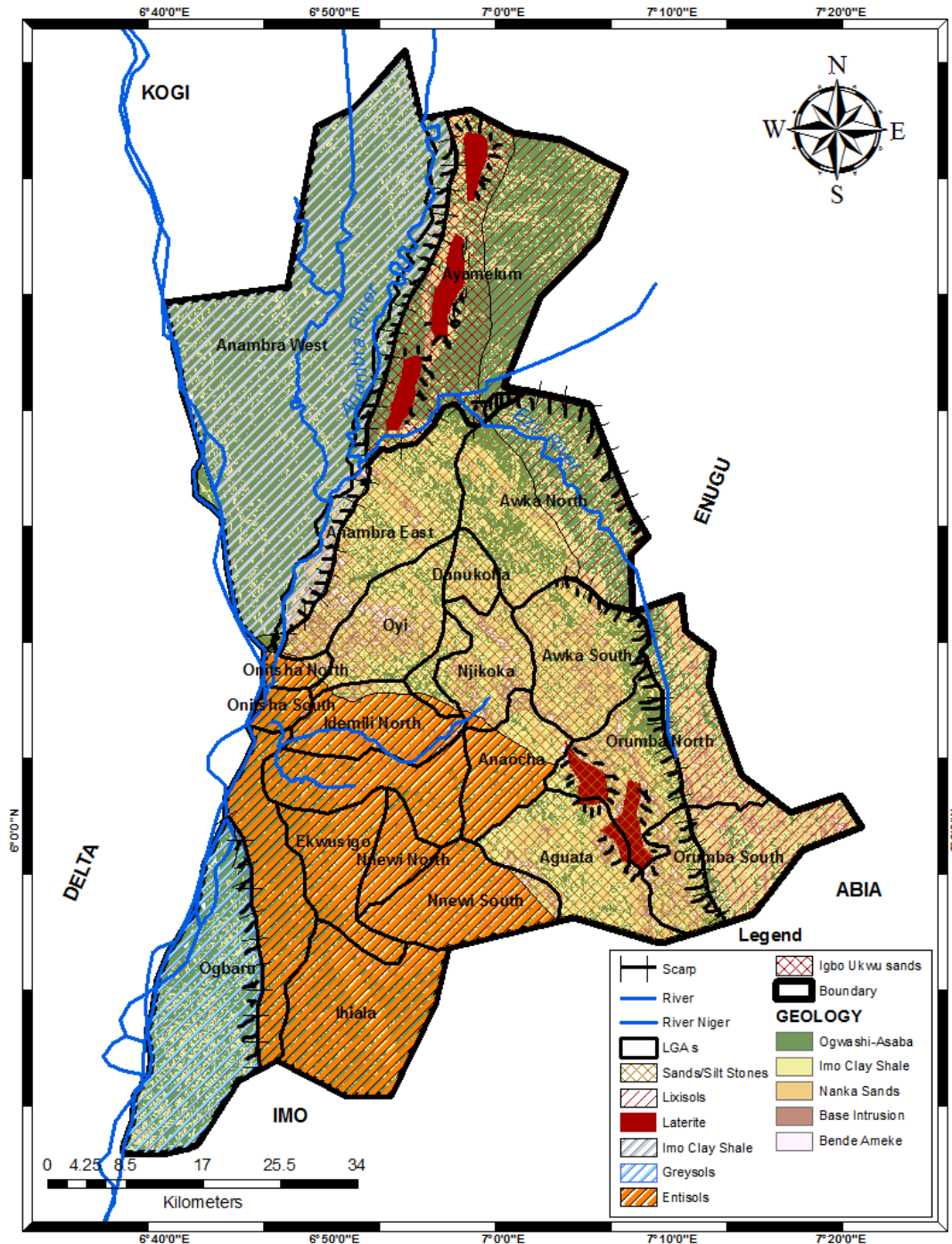


Fig 4: Geology and Soils of Anambra State

Source: Alaska Satellite Facility, UAF, Modified by the Authors, (2020).

The soils fall into two major groups:

- 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.
- 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	1955
2	Anambra East*	152,149	3.64	633.57	13.08	240
3	Anambra West*	167,303	4	600.65	12.4	279
4	Anaocha	284,215	6.8	116.22	2.4	2446
5	Awka North*	112,192	2.68	356.9	7.37	314
6	Awka South	189,654	4.54	168.68	3.48	1124
7	Ayamelum*	158,152	3.79	553.34	11.42	286
8	Dunukofia	96,517	2.31	77.34	1.6	1248
9	Ekwusigo	158,429	3.79	135.76	2.8	1167
10	Idemili North	431,005	10.32	150.16	3.1	2870
11	Idemili South	206,816	4.95	105.94	2.19	1952
12	Ihiala	302,277	7.24	309.58	6.39	976
13	Njikoka	148,394	3.55	86.81	1.79	1709
14	Nnewi North	155,443	3.72	55.23	1.14	2814
15	Nnewi South	233,362	5.59	185.13	3.82	1261
16	Ogbaru*	223,317	5.35	399.06	8.24	560
17	Onitsha North	125,918	3	29.52	0.61	4266
18	Onitsha South	137,191	3.28	11.01	0.23	12461
19	Orumba North*	172,773	4.14	330.15	6.82	523
20	Orumba South*	184,548	4.42	205.7	4.25	897
21	Oyi	168,201	4.03	144	2.97	1168
Total		4,177,828	100	4,844	100	862
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)

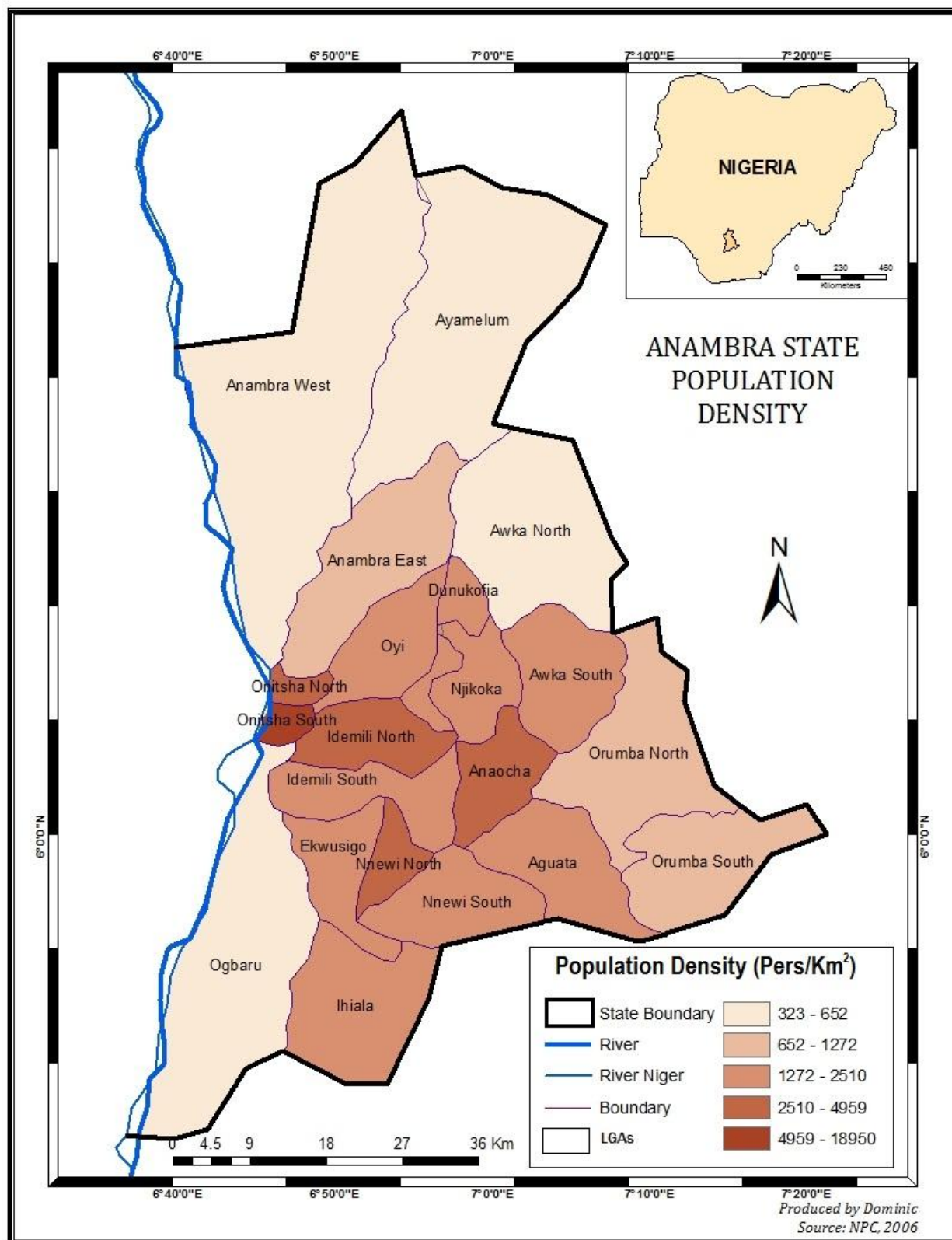


Fig 5: Anambra State Population Density
Source: NPC, (2006) and Ndulue and Ayadiuno, (2021)

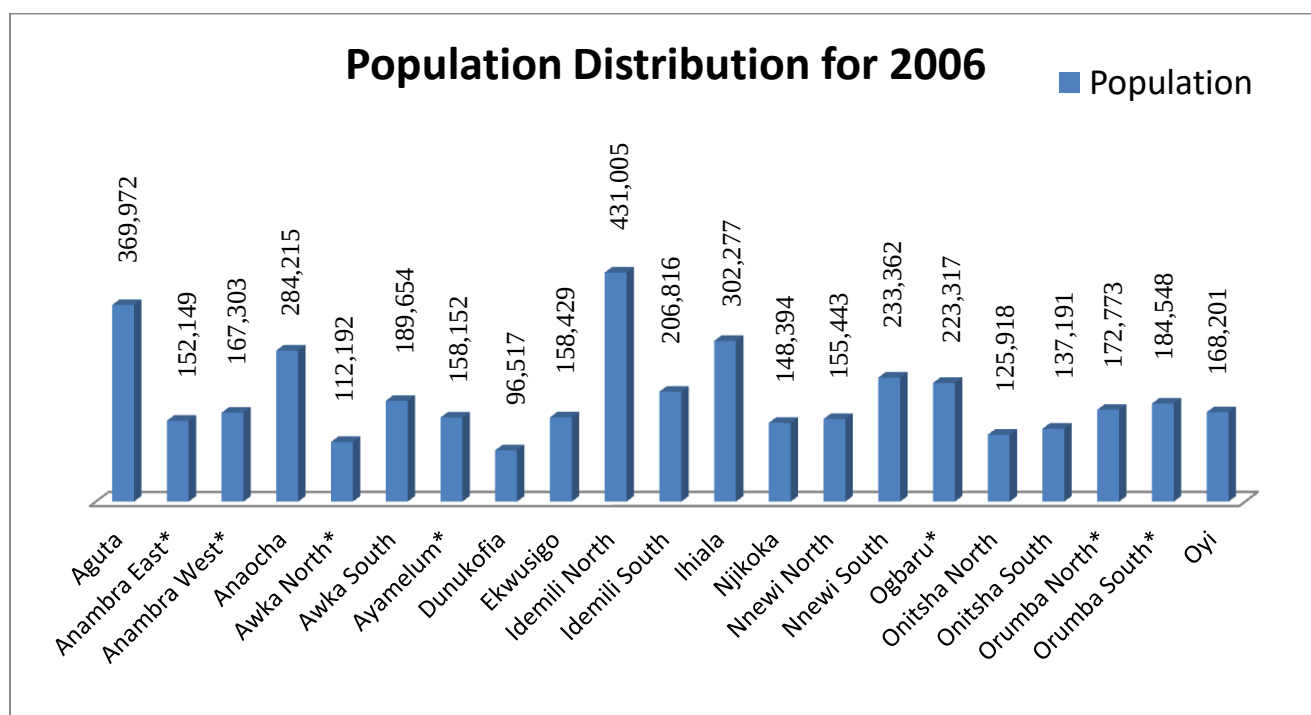


Fig 6a: Population Distribution of Anambra State for 2006

Source: Authors Computation (Microsoft Excel) (2020)

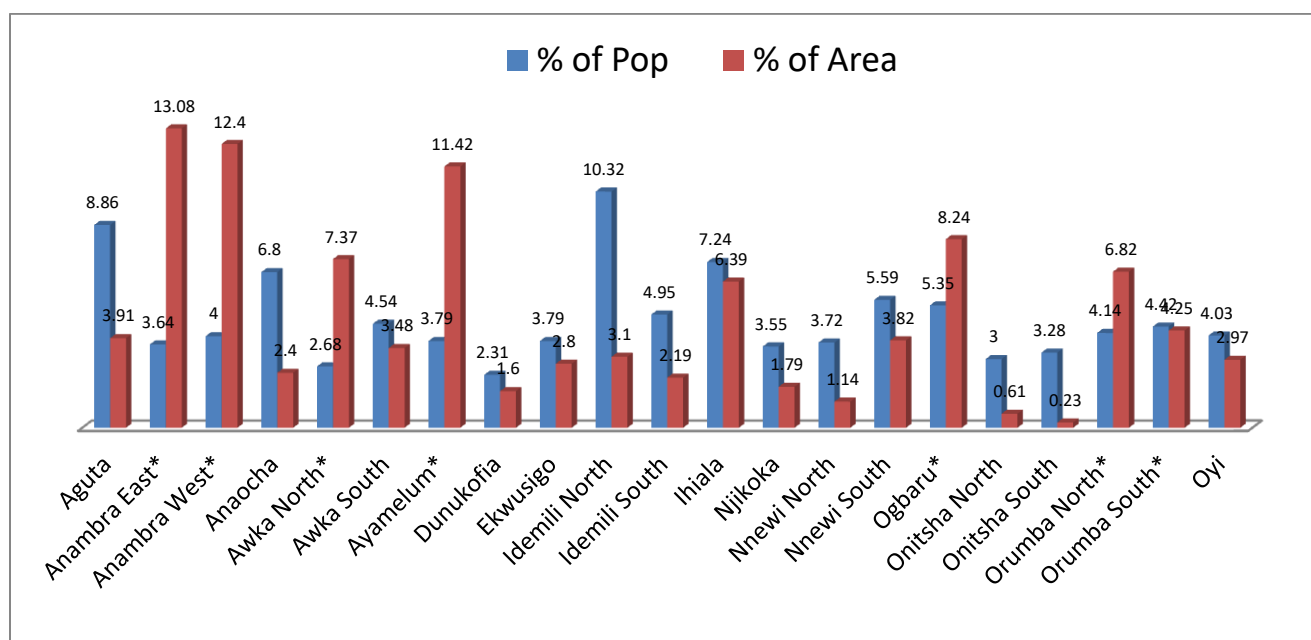


Fig 6b: Percentage Population and the corresponding Percentage Areas in Anambra State

Source: Authors Computation (Microsoft Excel) (2020)

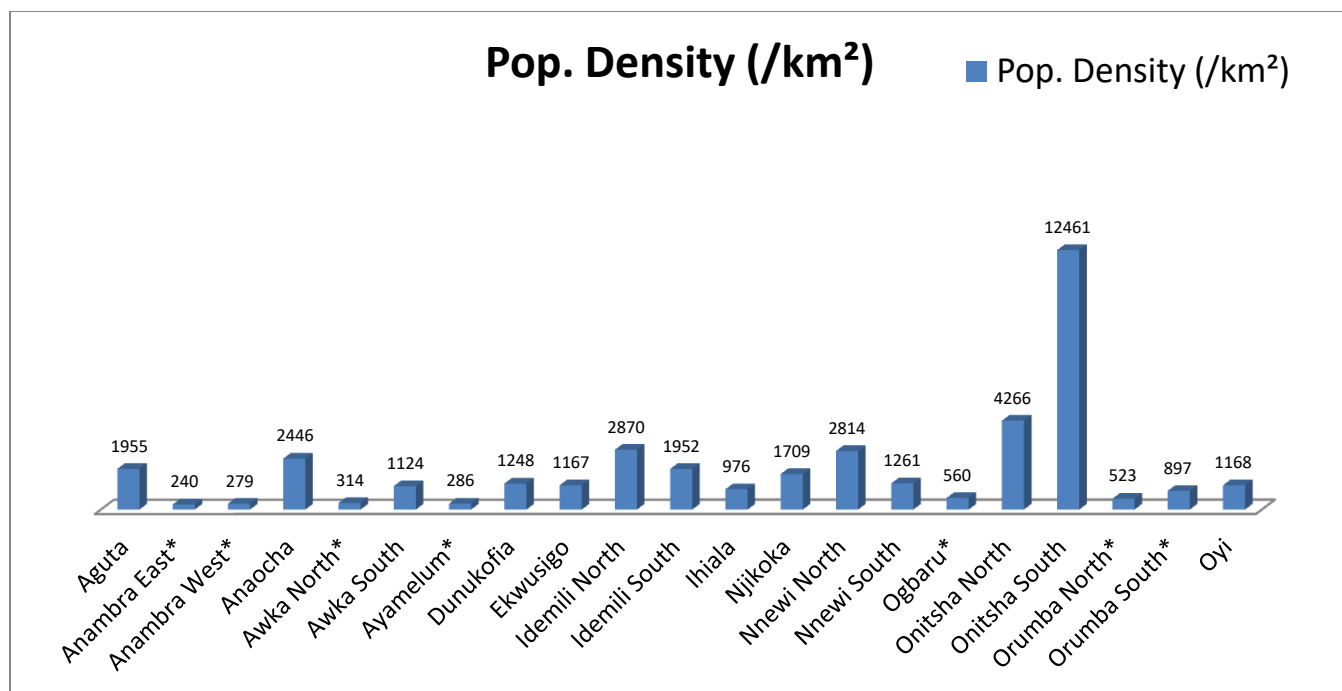


Fig 6: Population Density Distribution of Anambra State

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 36.44% 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 63.56% of the study area. Also, 36.42% of the lowlands have high population while 63.58% of the same areas have low population.

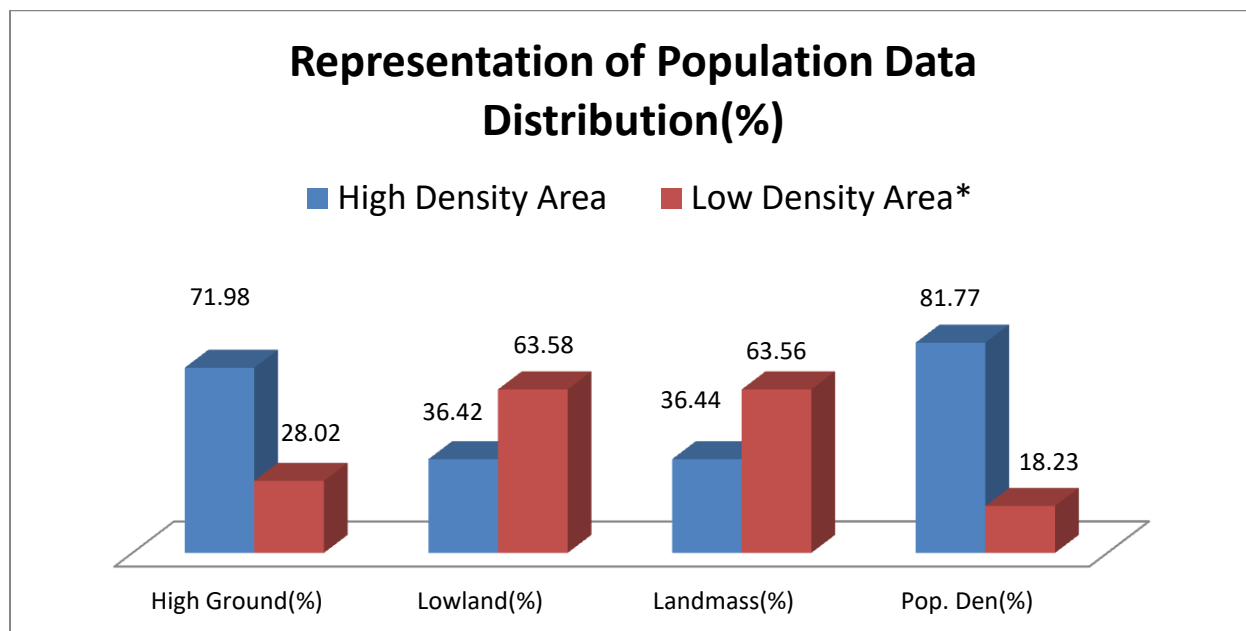


Fig 7: Percentage of Population Distribution and Density of Anambra State

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 km² (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 km² (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		
	<i>Pop. Density (/km²) at Higher Ground</i>	<i>Pop. Density (/km²) at Low Plains</i>
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 than 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. Mamu lies on the Imo clay. The Nkisi – Nakweze basin lies on the Nanka sands. The Idemili basin lies 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 5; Table 3).

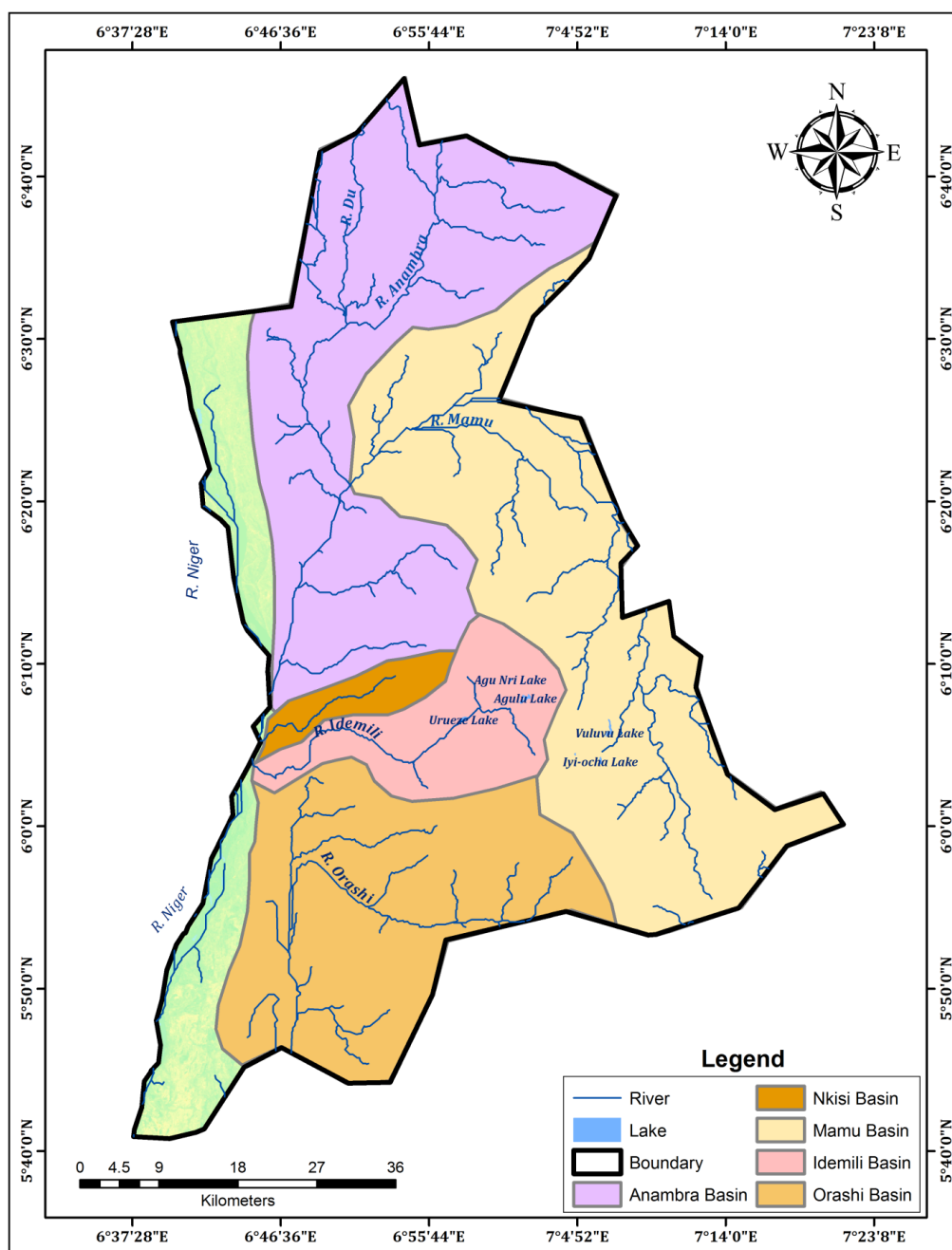


Fig 8: Drainage Basins in Anambra State

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 Activity	Economic
Cretaceous lower Paleocene	- Anambra Basin (Shale Substrate)	Clay – Shale Fine Soil Fraction	Gentle dip to Southwest 1° - 3°	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° - 4°	Low dome, round – topped residuals, and dry valleys. Low cliffs, dormant slopes, 4° - 9°	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 Tertiary activity.	Farming, economic
Lower Maastrichtian	Mamu Basin (Imo Clay)	Clay – Shale and some Sands/Sandstones predominated by fines.	Gentle dip, Southwards 2° – 3° , 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 Quaternary	Orashi Basin (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. The study discovered that the study area is made up of five river basins which are as follows: Anambra; Mamu; Nkisi – Nakweze; Idemili and Ulasi (Orashi) basins. The Anambra basin is of the Cretaceous - Lower Paleocene period, and lies on a Shale substrate. Mamu basin is of the Lower Maastrichtian period, and lies on the Imo clay. The Nkisi – Nakweze basin is of the Tertiary, Upper – middle Eocene period, and lies on the Nanka sands. The Idemili basin is of the Miocene – Eocene period, and lies on the Bende-Ameke sandstones and the Ulasi (Orashi) basin is of the Holocene Quaternary period, and lies on the Entisol and the Deltaic sands of the Southwestern part of the State adjoining River Niger

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. There is an unprecedented attraction of settlers in the study area, who concentrated on the elevated Nanka and Bende-Ameke geologic formation. As a result, disproportionately high percentage of population (71.98%), population density (81.77%), as well as large developmental structures are found on this higher elevated, but smaller (in terms of size) sand – sandstone formations covering about 36.42% of the study area, leaving a very small percentage of population (28.02%), population density (18.23%), and infinitesimal developmental structures on the larger flood and other low plains (*flats*) covering about 63.58% of the study area. In essence, higher population of about 71.98% of the population of the entire study area concentrated on 36.42% land mass of the study area. On the other hand, about 28.02% of the population of the entire study area, occupies about 63.58% land mass of the study area, even though these areas are flat plains and are susceptible to flooding which may be the cause of the low population, there is the need to understand the trait posed by this disparity occasioned by the geomorphological features in the State. The understanding of the terrain and the geologic and geomorphologic features of the study area is the key to deploying suitable and sustainable ideas and innovations toward land and other resources use.

This observed distribution variations raise the issues of the need for the government and people of the State to employ and apply modern knowledge especially in science and technology in order 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 and technological development in those areas. If attention is paid towards eliminating these limitations associated with the lowlands in the study area, the area may become attractive to settlers thereby reducing the high concentration of people on the smaller elevated part of the study area.

Acknowledgements

The authors are grateful to all the members and staff of UD RUA Project Ltd. We are also thankful to the anonymous reviewers and editors for their insightful comments on the original manuscript.

Conflict of Interest: The authors declare no known conflict of interest

Data Availability

All data used in this research can be made available upon reasonable request.

Funding: Funding for this research was borne by the authors.

REFERENCES

- Akanazu, L.A. (2016). *Slope Stability and Habitation Safety on the Eastern Face of Udi Cuesta, Enugu State*. Unpublished B.Sc project, Department of Geography, University of Nigeria, Nsukka.
- Anyadike, R.C.N. (2002). “*Climate and Vegetation*”. In Ofomata G. E. K. (ed), *A survey of Igbo Nation*, African First Publishers Ltd: Onitsha, PP. 56-72.
- Anyadiuno, R.U. (2014). *Geomorphological Analysis of the Terrain between the Du and Anambra River*. Unpublished M.Sc Thesis, Department of Geography, University of Nigeria, Nsukka.

Ayadiuno, R.U; Agbakwuru, G.O and Ndulue, D.C (2021). Assessment and Map Analysis of the Terrain and Landscape for the Siting of Banks Locations in Abaji Area of Abuja Federal Capital Territory, Nigeria. *Journal of Contemporary Issues in Business and Government* | Vol 27, Issue 3, 2021

Ayadiuno, R.U; Mozie, A.T. and Ndulue, D.C. (2020). Mapping the Terrain and Land Use Types in Idemili South Local Government Area of Anambra State South Eastern Nigeria. *International Journal of Sciences and Research*, 76(9)/1: 122–134

Briassoulis, H. (2000): Factor influencing land use and land cover change. Land Use, Land Cover and Soil Sciences – Vol. I. Encyclopedia of Life Support Systems (EOLSS) <https://www.eolss.net/Sample-Chapters/C12/E1-05-01-03.pdf>

Davis, W.M. (1899). The Geographical Cycle. *Geographical Journal* 14: 481-504, Reprinted in: Davis, W.M. (Ed). *Geographical Essays*. Ginn and Company, Boston. 249-278.

Earthdata, (2020). <https://www.asf.alaska.edu>, Alaska Satellite Facility, UAF, accessed on 01 May, 2020.

Eze, C.U. (2009). *Morphometric analysis of Ude and Idemili Basins*. Unpublished B.Sc project, Department of Geography, University of Nigeria, Nsukka.

Getis, A., Getis, J., Bjelland M.D. and Fellman, J.D. (2011). *Introduction to Geography*. McGraw-Hill Companies, Inc: New York.

Grant, W. (2000). *Terrain Evaluation*. John Wiley: New York.

High, C. (1972). "Land Evaluation Studies with Special Reference to Nigeria" In Barbour, K.M. Ed. *Planning for Nigeria: A Geographical Approval*; Ibadan, Heinemann.

Horton, R.E., (1945). Erosional Development of Streams and their Drainage Basins; Hydro-physical Approach to Quantitative Morphology: *Geol. Soc. America Bull.*, 56(3) 275-370.

Igbozurike, U.M. (1993). *Soil Erosion Control and Prevention Manual*: Friedreich Elbert Fdn and NEST Publishers, Lagos and Ibadan

Igwe, O. and Egbueri, J.C. (2018) "The Characteristics and the Erodibility Potentials of Soils from Different Geologic Formations in Anambra State, Southeastern Nigeria", *Journal of the Geological Society of India*. 92, 471–478 (2018). <https://doi.org/10.1007/s12594-018-1044-1>

Monkhouse, F.J and Wilkinson, H.R. (1971). *Maps and Diagrams*, London: Methuen and Co Ltd

Mozie, A. T. (2015). Review of the Development of Geographic Idea and Methodologies. Unpublished Mimeograph, Department of Geography, University of Nigeria Nsukka.

Mozie, A.T. (1992). *Terrain Evaluation for Urban Development Purposes*, Unpublished M.Sc Thesis, Department of Geography, University of Nigeria, Nsukka.

Ndulue, D.C. (2018). *Geomorphological Control of Land Use in Idemili South L. G. A of Anambra State*. Unpublished B.Sc project, Department of Geography, University of Nigeria, Nsukka.

Ndulue, D.C., Ayadiuno, R.U. & Mozie, A.T., (2021). Investigating and Mapping the Terrain, and Analysis of Soil Particles in Awgu Local Government Area of Enugu State, South East Nigeria. *PSYCHOLOGY AND EDUCATION* (2021) 58(1): 5922-5932.

Ndulue, D.C. and Ayadiuno, R.U (2021). Principal Component Analysis of Factors Influencing Mode of Movement in Anambra State, South East Nigeria, *Turkish Journal of Physiotherapy and Rehabilitation*; 32(3) ISSN 2651-4451 | e-ISSN 2651-446X: 3837 - 3837

NPC, (2006). *Population of Anambra State*; Retrieved from www.npc.org.ng, on 20 August, 2020.

Nwachukwu, S.O. (1976). "Approximate geothermal gradients in the Nigeria Delta Sedimentary Basin". *America Assoc Petroleum Geologists Bull.*, Vol. 60 no 7.

Nwokocha, V.C. (2009). *An Investigation into the Factors of Human Occurrence in Nsukka Urban Area*. Unpublished B.Sc project, Department of Geography, University of Nigeria, Nsukka.

Obetta M.C; Anyadike, R.N.C; Mbajiorgu, C.C.; Phil-Eze P.O; Onyekwelu, C.A; Ochege, F.U & Ezech, C.U. (2011). *Diagnosis, prioritization and costing of gully erosion Management Strategies*. NEWMAP Technical Report.

Offodile, M.E. (1976). *The Geology of the Middle Benue, Nigeria*. Publication of the Palaontological Institution, University of Uppsala Special Volume 4,

Offodile, M.E. (2002). *Groundwater Study and Development in Nigeria* 2nd Edition published by Mecon Geology and Engineering Service Limited, Jos, Nigeria.

Ofomata, G.E.K.(1981). "*Land Resource of South-Eastern Nigeria: A Need for Conservation*". In Igbozurike, U.M. (Ed). *A Land Use and Conservation in Nigeria*. Nsukka: University of Nigeria Press.

Ofomata, G. E. K. (2001). *Geographic Thought*. Enugu: Jameo Publishers.

Ofomata, G.E.K (2009). *Basic Geomorphology for West Africa*. Enugu: Jameo Publishers.

Okoyeh, E.I., Akpan, A.E., Egboka, B.C.E. and Okeke, H.I. (2014). An Assessment of the influences of surface and subsurface Water Level Dynamics in the Development of Gullies in Anambra State, Southeastern Nigeria. *Earth Interactions*, Vol. 18, paper No 4.

Olaleye, J.B., Oludayo, A.E. and Igbokwe, Q.N (2009): *Land Use Change Detection and Analysis of Remotely Sensed Data in Lekki Peninsula Area of Lagos Nigeria*.

Olofin, E.A. (1972). *Erosion, Transport and Déposition Processes* (Proceedings of the Jerusalem Workshop, March-April 1987). *IAHS Publ.* no. 189, 1990. The dynamics of gully head recession in a savanna environment

Schumm, S.A. (1977). *The Fluvial System*. New York: John Wiley & Sons.

Stewart, C.A. (1968). *Land Evaluation*: Melbourne. Macmillan.

Townsend, N. (1981): *Terrain Analysis and Remotes sensing*. George Allen and Unwin Ltd London.

Umeji, A.C. (2002). "*The Geology and Mineral Resources of Igboiland*". In Ofomata G. E. K. (ed), *A survey of Igbo Nation*, African First Publishers Ltd: Onitsha. Pp 56-72

Umeji, O.P. (2002). Mid-Tertiary (Late Eocene-Early Miocene) Lignites from MPU Formation, Abakaliki Basin, Southeastern Nigeria February 2002 *Journal of Mining and Geology* 38(2) DOI: [10.4314/jmg.v38i2.18781](https://doi.org/10.4314/jmg.v38i2.18781)

Whittow, J. (1984). *Dictionary of Physical Geography*. Penguin; London.