Investigating and Mapping the Terrain, and Analysis of Soil Particles in Awgu Local Government Area of Enugu State, South East Nigeria

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ABSTRACT

This paper studies the nature of the terrain and analyzes soil particles in Awgu Local Government Area, Enugu State South East Nigeria. Awgu Local Government Area is made up of eighteen (18) communities which are Agbogugu, Isu-Awa, Ituku, Ihe, Ogbaku Ndiagu, Owelle, Ogugu, Agbudu, Amaowelle, Mmaku, Ugbo, Obiagu, Mgbidi, Ugwueme, Ugwuokpara, Awgu, Awgunta and Mgbowo. This study was carried out using geographical information system (GIS) analysis and principal component analysis (PCA) to map and analyze the terrain and soil particles respectively. The study area was classified using the concept of land capability and suitability classification of Klingebiel and Montgomery (1961). The slope angles of the four major slope segments were measured and determined in the field. Soil samples were collected within each of the four slope zones and were analyzed for their particle sizes, texture, organic matter, Cation-exchange capacity, N, Na+, KCl, Ca+, C, Mg+, among others. The soils vary within the scarp slope and slope segments. The dominant crops within the slope-soil zones were identified. The study showed that elevation, slope angle, soil characteristics influences land related socio – economic activities in the study area. Recommendations and remedial measures were suggested for optimal utility of lands, for effective and efficient land use planning in the study area and other similar areas of same undulating highlands and lowlands. Constructions should be in alignment with the slopes. Unsupervised excavation and mining should be discouraged. Community participation is very essential and should be encouraged in a bid to conserve the environment.

Keywords
terrain, soil particles, land capability, socio – economic, planning, mapping, Awgu

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Introduction

Background of the study

The character of the earth's surface influences the uses to which it is put by mankind (Norton, 2010). The first attribute of the earth's surface is its relief - elevation and slopes. Elevation refers to heights of places above sea level (Mozie, 2011). Elevation influences human activities, from the perspective of the relationship between height, slope aspect and temperature. Unequivocally, the basic needs of man are ameliorated through the various uses to which land is put. Land is the most valuable resource endowed to man by nature. Every landscape has specific topographic, soil and climatic attributes which enhance or deter the use of that land. The utilization of any piece of land depends greatly on the nature of the topography which determines moisture content, temperature and soil-rock complex on that piece of land (Klingebiel and Montgomery, 1961; Ayadiuno; Mozie and Ndulue, 2020). The amount of sun's energy also influences the rate of rock decaying or weathering, soil formation, soil depth etc. making such energy receiving slopes to be more favorable for agriculture than the areas shielded from the sun's rays and energy. South-facing slopes in the northern hemisphere are warmer than north facing slopes because they receive a greater amount of heat energy for longer periods than north facing slopes. Also north-facing slopes in the southern hemisphere are warmer than south-facing slopes for reason already stated (Holland and Steyn, 1975; Maren, et al. 2015).).

Elevation is correlated to slope angles by way of high areas having a preponderance of steep slopes (Young 1972; Mozie, 2011). Slope angles determine the rate of soil erosion and slope stability. In the relationship between slope angles and slope stability, most steep slopes are unstable except they are made of hard rocks, and in most cases cliffs (Ayadiuno; Mozie and Ndulue, 2020). The stability of slopes influences the uses to which it can be put (Akanazu 2016). Slopes have been modelled by King (1953) and Nwokocha (2009). The steepness of slopes influences the amount of land that is available for farming, road networks, building construction and influences the size of usable land, the design and distribution of land on the slope face (Njoku, 2013).

Ohamobi (2010) classified the terrain in the Sokoto-Rima basin in terms of suitability for road construction. The term terrain analysis or classifications is:

"The interpretation of landforms, mainly by air-photo interpretation for purposes of land planning, landscape architecture and similar projects.

The advances in satellite surveillance technology has virtually rendered air- photo obsolete so satellite photographs are now relied upon more than air photos.

In this work we adopt Stewart (1968), Townshend (1981); Grant (2000) and Ohamobi (2010) in using the term *"Land and Terrain"* interchangeably. The land is the fundamental interest of geomorphology and geomorphologists. Geomorphologists describe the land both in qualitative and quantitative terms. Although there is no such term as qualitative geomorphology, the expression of the nature of the earth's surface in figures has come to be called quantitative geomorphology or geomorphometry (Evans, 1998).

Quantitative geomorphology started with Strahler (1950, 1952) dynamic geomorphology which was based on quantitative analysis of the terrain. Since that year, geomorphology has acquired the full characteristics of a science and has been able to adopt any method of science including the use of the products of computer science and space technology. These borrowing from the pure sciences in turn, form the basis of terrain analysis which is an aspect of quantitative geomorphology (Stewart, 1968). The quantitative paradigm has allowed for terrain to be studied scientifically.

Beckett and Webster (1965) developed a computer-compatible system for the storage and collation of information on terrain which they followed up with the development of a terrain classification system for military purposes.

Landscape composition and configuration is a critical factor in route ways construction and motility studies for military vehicles. In the same way, the choice of settlements by the initial settler groups have been shown to be largely influenced by the geomorphology of the area in question (Mozie,1992, 2011) while further expansion of cities area is also similarly influenced by the geomorphology of the area (Umeuduji, 1989; Nwokocha, 2009; Ochege, 2009; Ayadiuno, Mozie and Ndulue, 2020). Ndulue (2018) has shown the role of geomorphology in controlling the expansion of cities in Nigeria.

Aitchison and Grant (1967) showed like other similar works, that geomorphology provides the physical conditions within which engineering practice is carried out. Moore (2012) showed the application of geomorphology and aerial photographic techniques in landscape studies and the identification of reserves of lateritic soils. Evans (1998) integrated that system of terrain analysis and slope mapping is one aspect of the new tool of spatial analysis consisting of geographical information system (GIS) -compatible algorithms for automated landscape study and analysis. Wilson and Gallant (2000) also provide insights on the quantitative study of landscape by way of automated extraction of data and analysis of data on geomorphic surfaces within GIS environments using digital image analysis. The truth that emerges from the mentioning of this small fraction of available literature is that the landscape of the earth constitutes a surface on which the widest possible range of methods and models has been applied.

The problems confronted by researchers in quantitative geomorphological studies often relate primarily to the scale of the study. The levels of study and degree of accuracy determine the intensity of field sampling and other observational activities (Ezeaku, 2011, Prayfull et.al. 2013; Zodec, Buddock and Pelt, 2013). The slope angle-soil stability relationship was described by Bunting (1965). This relationship is the very basic factor that dictates the favorable places where human activities can be done. The scheme does not claim that any position of the land is “*useless*”. It requires the evaluation of the land to identify the area favorable for certain activities such as farming and settlement on the terrain in which they are carried out (Ayadiuno, et, al, 2020). This is observed in the study area as local knowledge of the terrain is applied in using the land as seen in plate 1 below, house built in alignment with the slope for stability.

Plate 1: Building in Alignment with the Slope for Stability
Source: Authors Fieldwork, (2020)

Study Area

Location and Climate

The study area is Awgu Local Government Area of Enugu State, Southeastern Nigeria. It is located between latitudes 6^0 00’ and 06^0 19’N and longitudes 07^0 23’ and 07^0 35’E. It is bound in the north by Enugu North, in the west by Oji, in the east by Aniri Local Government Areas all in Enugu State and in the south by Okigwe Local Government Area, in Imo State. Awgu Local Governments is made up of eighteen (18) communities which are Agbogugu, Isu-Awa, Ituku, Ihe, Ogbaku Ndiagu, Owelle, Ogugu, Agbudu, Amaowelle, Mmaku, Ugbo, Obiagu, Mgbidi, Ugwueme, Ugwuokpara, Awgu, Awgunta and Mgbowo (Mozie, 2011; Nwankwo, 2014).

The study area falls within the ‘Am’ climate of the Koppen’s classification. It receives an annual rainfall of 1750mm- 2000mm. The study area annual temperature range of $27^0 – 28^0$ C. as a result of latitudinal position of the study area, the angle of the sun’s ray is almost vertical all through the year and so, there is high intensity of solar radiation. The hours of day light are also long because of long duration of solar radiation all through the year. Therefore, the average monthly hour’s day light is almost constant. There are other factors that modify the actual amount of solar radiation received in the study area at different times of the year. Absorption aside, selective scattering and diffuse reflection by the earth’s atmosphere, the effect of cloud cover, rainfall and harmattan haze also help to modify the actual amount if insulation received. The sensible temperature (temperature as it affects human body) is very uncomfortable because the high temperature of over 21^0C is accompanied by high humidity of over 65 percent all the year round. This implies that there is comparatively little evaporation of perspiration from the body, consequently people feel uncomfortable (Monanu, 1975). See figures 1 and 2 below.

In January, when the temperature is high, relative humidity is low because the wind affecting the study area at this time is the dry continental Air mass. As from April, temperature decreases steadily while relative humidity reaches its maximum. Between June and September; relative humidity reaches a minimum at the same period. The relative humidity is due to the influence of humid Maritime Air Mass. In the climate regions classification, Awgu has three (3) dry months with less than 6cm rainfall a month (Inyang, 1975). Awgu which belongs to the fourth region has three months instead of four, a probability of 33 per cent and more rain days (118) than Okigwe and Afikpo respectively. This modification seems to be as the result of favorable Orographic influence on Awgu which is on the windward slope of the Awgu escarpment.

Geology, Relief and Drainage

The study area is underlain by the Awgu –Ndeaboh shales formed during the Senonian stage consisting of three sub-divisions, namely: Coniacian, Santonian and Campanian (Umeji, 2002). The coniancian sediments exhibit rapid face changes and the primary unit is typified by the Awgu shales. There is no unconformity between the Eze-Aku shales (Turonian) and the Awgu shales (Umeji, 2002). These shales constitute of the plains which are part of the Cross River plains. The Awgu sandstone constitutes the cuesta structure. They are layered and fractured by tectonism.

The study area is also marked by extensive hills especially in the western flank and lowland in the eastern side; these hills have steep slopes and could attain an altitude of about 350–400 meters above sea level with mean slope angle of 15^0 and a modal class of 11^0 (Mozie, 2011; Nwankwo, 2014). It is drained mainly by seasonal finger-like springs and streams. They dry up during the dry season (November to March) and yield more water in the wet season (April to October). Most of the streams obtain their source from top of the hills and flow downhill. In the rainy season runoffs are collected by the streams thereby increasing their volume and velocity. Due to the muddy nature of the streams channels, the water is usually colored after heavy downpour. The streams carry a lot of debris as they flow from their source (hill top) to the settlement areas downhill (lower course). The stream load (debris) makes the water dirty therefore not suitable for domestic use. Many people that reside at the very lower course of the streams are affected and they have to trek up to the middle course (foot of the hills) to collect water (Nwankwo, 2014; Obeta and Nwankwo, 2015).

Soils and Vegetation

Shallow lithosol soils dominate the highlands whose parent material is of sandstone. On the escarpment, the soil exhibit sandy loam characteristics. On the plains, the two dominant soil types are alluvial and deep clayey soils because; it is the zone of maximum deposition (Nwankwo, 2014). The study area is a transition zone between the guinea savanna and the rainforest. The dominant grass species are *Hyparrhenium spp*, *Ctenium spp*, *Hyparrhenia barteri* and *Andropogon spp*. Forest are ribbons along depressions and valleys. Common tree species found are *Isoberlina doka*, *Anona senegalensis* etc. Grasses envelop the depression in the study area due to favorable soil and ground water conditions (Nwankwo, 2014; Authors Fieldwork, 2020). Evidences are shown in the plates below.

Plate 2*a*: Vegetation, Mixture of the Guinea Savanna and the Rainforest
Source: Authors Fieldwork in Rainy Season, (2020)

Plate 2*b*: Vegetation, Mixture of the Guinea Savanna and the Rainforest
Source: Authors Fieldwork in Dry Season, (2020)

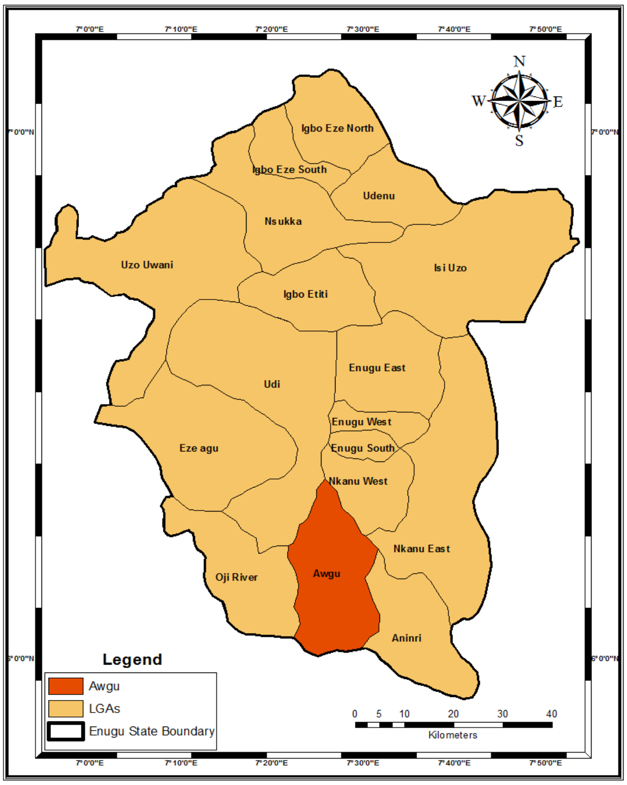

Fig 1: Enugu State Showing the Study Area
Source: Google Earth, produced by the Authors, (2020).

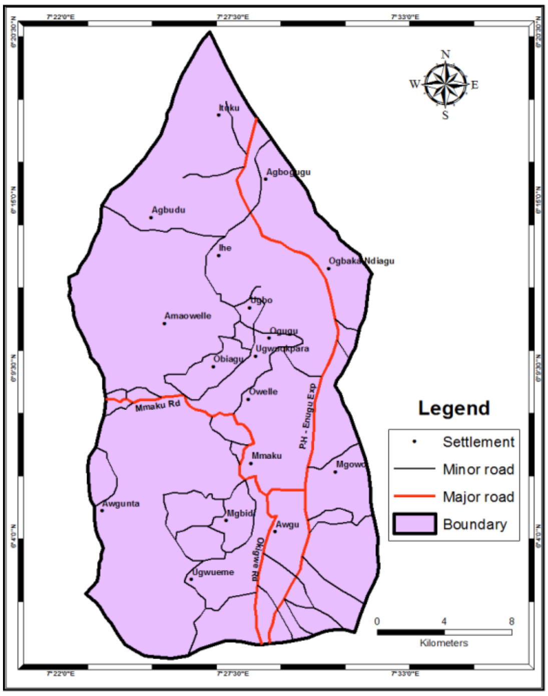

Fig 2: Study Area
Source: Google Earth, Produced by the Authors, (2020).

Materials And Methods

Research Design

Research design is a description of the major steps the researcher took to achieve the aim and objectives of the research.

In this study, reliance was put on empirical study of the study area to physically view the topography, determine the elevation, slope angle, soil types and particles. Mixed method was adopted in this research. Primary and Secondary data were sourced and used. Primary data was obtained during a field visit of the study area and include oral interviews carried out in selected communities to assess the effect of topography on land related socio – economic activities in the study area. Key informant interview was used to collaborate or counter the views of others interviewed in the study area. Photographs were taken for illustrations and evidences. Sources of secondary data also include textbook, journals, reports, unpublished researches, satellite imageries etc. Satellite imagery of the area helped in determining the nature of land and how it affects the activities of man.

Soil samples were extracted at various locations and analyzed in order to determine their particle sizes, texture, organic matter, Cation-exchange capacity, N, Na^+, KCl, Ca^+, C, Mg^+, among others, class and suitability using field sampling methods. The soil samples data were analyzed in the soil laboratories of Civil Engineering Department, University of Nigeria, Nsukka and their relationships determined with Statistical Package for the Social Sciences (SPSS) version 25 software.

Data Collection

In the terrain study of the area, satellite imagery was obtained from the Google Earth map library and Esri web map. This helped the authors to have a preview of the study area and to also adopt the transect/transverse terrain method for Terrain - Soil investigation and mapping. There are 18 communities in Awgu Local Government area, the study area was divided into separate sampling area. King's (1953) model was applied in the slope zonation of the study area. The sample area involves the different slope zones in the study area: the cuesta top, the scarp, talus slope and toe slope.

The communities were selected at random from each slope zone. Digital Elevation Model and geologic map of the study area were used to show the different terrain or slope zones of the study area which help to extract the Land suitability map of the study area. Field visit and observation was undertaken in order to review and ascertain the existing situation of the study area and its physical characteristics. Visual observation through transect walks were made along selected routes on each zones for identification of surface features and for ground truth verification of mapped features. Spot heights were identified as to further explain the different relief and slope zones. This was done with the help of Global Positioning System (GPS). Coordinates were picked for geo-referencing the satellite image and to verify the accuracy of the classified satellite images. The sampled communities in the different slope zones are as follows:

Mmaku and Ugwueme communities are located at the top slope; followed by the scarp slope zone which is too steep for any settlement and not suitable for land related socio – economic activities. Ihe and Awgu are communities located at the middle or talus slope, while Isu-Awa and Mgbowo are located at the toe slope (the plains).

In studying the soil types distribution, soil characteristics for agriculture in the study area, soil samples were collected at deliberately and regularly spaced designated points from soil trenches or soil pits within the depth of 30cm from the top which is the soil rooting zone for crops such as cassava, maize, vegetables etc. In an attempt to achieve a comprehensive result, the soil samples were collected from different sample areas of the slope zones. The soil samples were taken on the same day to the laboratory for analysis. The soil sample points were geo-referenced and mapped as seen in figure 3 below.

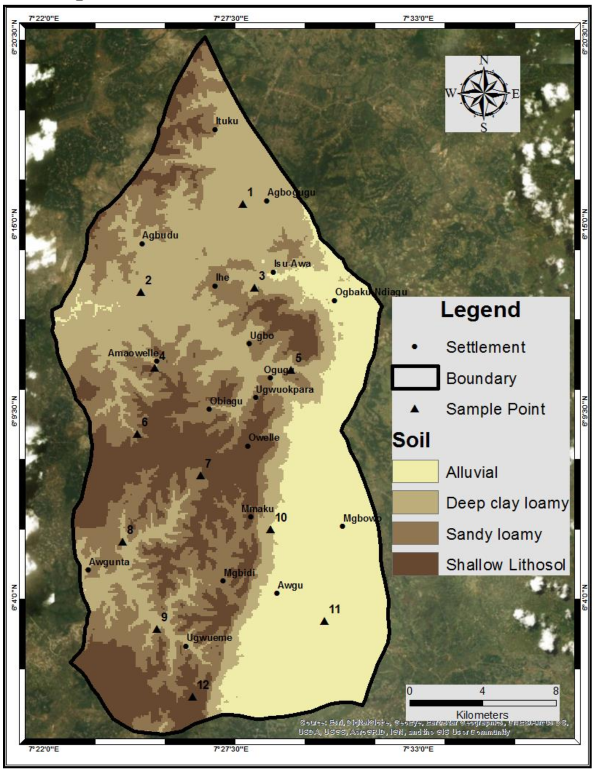

Fig 3: Soil Sampled Points of the Study Area
Source: Google Earth, Produced by the Authors, (2020).

In studying the relationship between elevation, slope angles and land related socio – economic activities in the study area. Elevation readings were taken within the slope segments' using GPS and GIS was applied in mapping the slopes using ArcGIS 10.2 software.

Data Analysis And Discussions

Data Analysis

In this research, the analysis of data began with the analysis of the terrain using the profile from the satellite imagery, cross checked by physical inspection and the profile drawn from topographical map. Using the digital elevation model, the terrain was further analyzed which provided a three-dimensional image of the study and its cross-profile. The slope zones in the study area were quantified in degrees of slope which enabled the inference of the processes taking place in each of the slope segments and quantitative analysis.

Topographic Analysis and Distribution of Soil Types and Particles in the Study Area

The study area has undulating topography with elevation that varies between 350 - 400 meters above sea level (Nwankwo, 2014). Topography is analyzed by verifying the measurement, shape and form of land surfaces. It entails the quantitative representation of landscape. This is important because topography is the first factor that determines land use. Topography controls uses through its steepness, soil cover and gravity (Ohmori, 2003). See figure 4 and 5 below.

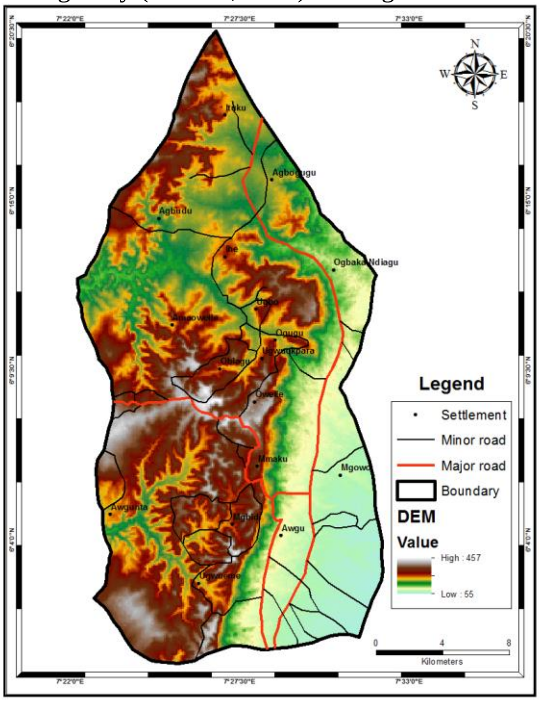

Fig 4: Digital Elevation Model (DEM) of the Study Area
Source: Google Earth, Produced by the Authors, (2020).

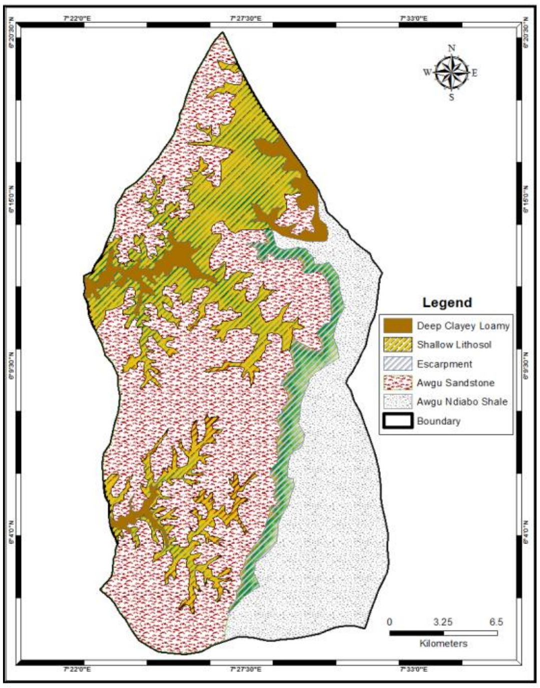

Fig 5: Geology and Soils of the Study Area
Source: Google Earth, produced by the authors, (2020).

Technically the slope angles and topographical surfaces in King's (1953) model were matched with Klingebiel and Montgomery's slope classes in the land classification model as shown in figures 4*a* and *b* below, the DEM of the study area were fitted with the slope zones and are described as follows:

a) Top slope – The dominant slopes in this zone are 2^0 - 4^0.

b) Scarp face – The dominant slope in this zone are greater than 35^0.

c) Talus slope - The dominant slopes in this zone are 7^0 - 10^0.

d) Toe slope - The dominant slopes in this zone are less than 5^0.

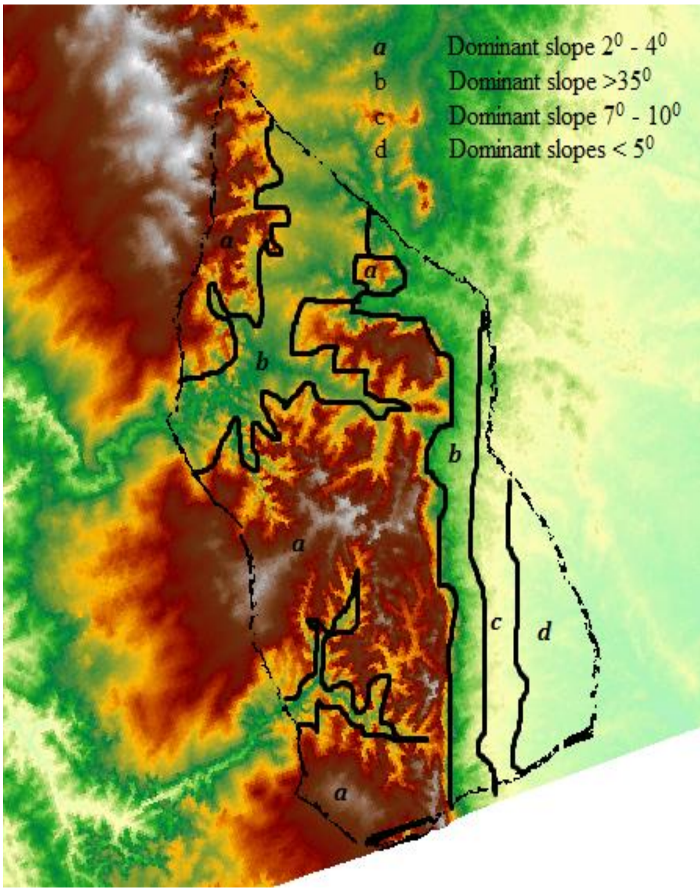

Fig 4*a*: Digital Elevation Model Showing Slope Zones of the Study Area

Source: Google Earth, Produced by the Authors, (2020).

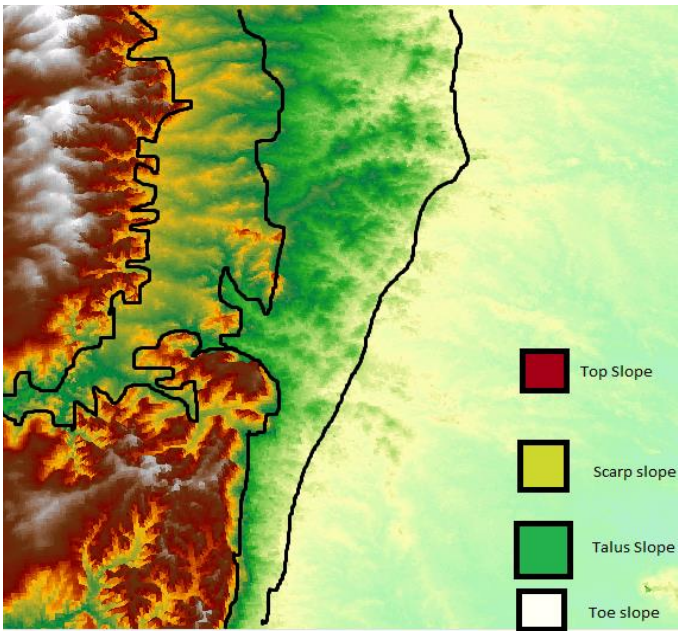

Fig 4*b*: Digital Elevation Model Showing Slope Zones of the Study Area

Source: Google Earth, Produced by the Authors, (2020)

The digital elevation model (DEM) above depicts the various terrain zones in the study area. These zones agree with the various terrain classes as classified by Klingebiel and Montgomery (1961).

Terrain class II: Good cultivable land which needs protection from erosion, drainage improvement and conservation of irrigation water. This class is found at the top slope zone and can support both agricultural and engineering purposes. The zone covers about 45% of the study area and is found in parts of the southwest through the centre of the study area. It is the zone with the most settlements in the study area; structures are erected on them without modifying the residuals on which this class of terrain is found. These are remnants of the sand stone formation which have partly been eroded to expose the underling shale (Ayadiuno, et. al., 2020). They are characterized by relatively gentle slope between 2^0 to 4^o. The communities found in this zone are Isu-Awa, Ihe, Owelle, Ogugu, Amaowelle, Mmaku, Ugbo, Obiagu, Mgbidi, Ugwueme, Ugwuokpara and Awgunta.

Terrain class VIII: Suited only for wildlife, recreational facilities and protection of water supplies. This zone lies immediately around and near class II unit and is the zone of steep slope (scarp face). This zone covers about 25% of the study area and is found at the east facing side and the northeast of the cuesta. They are however the zones of the source of springs that formed the streams in the area. The zone is characterized by a steep slope of about 35^0 and above, some area in this zone have outward extrusion that makes it prone to landslide and it consist of laterites and shales which expands and shrinks depending on the season and are susceptible to breaking up. Their gradient does not support good construction and load bearing capacity is low. They are not suitable for the development of any engineering structure.

Terrain class III: Moderately good cultivable land where special attention has to be paid to erosion control, conservation of irrigation water, intensive drainage to prevent flooding and this class is found on the middle or talus slope zone. The zone is of sand stone origin, the deposits of weathered materials from the preceding zone; it is covered by cap stones that are mined by the locals. The zone is of the marginal unit and covers about 10% of the study area. The zone is characterized by a slope of about 7^0 – 10^0. The communities found there are Ituku, Agbudu and Agbogugu.

Terrain class I: Very good cultivable land with no specific difficulty in farming and found at the toe slope zone; it is basically a deposition zone in the study area. The zone is characterized by a relatively gentle slope of about less than 5^0. It is the zone with the highest number of roads in the study area and it comprises of communities like Ogbaku Ndiagu, Mgbowo and Awgu. Engineering structures are springing up because of accessibility occasioned by the roads built across the zone. The zone covers about 20% of the study area, it is a zone of colluviation and seasonal moisture variation, and are found on the valley floors underlain by shale. This zone is endowed with fertile soil and supports massive farming.

Soil Analysis

Soil analysis was carried out for the following parameters: particle size, pH, organic matter, moisture content, calcium, potassium, sodium and magnesium, these are agricultural indices supporting production of crops. The soil analysis result was presented in tabular form showing the quantities of the aforementioned parameters extracted from the soil samples in the laboratory. The variations between the variables were verified in respect of the soil properties within and between the slope segments. Principal Component Analysis was used in characterizing the soils (Anyadike 2009).

Twelve soil samples were collected from determined communities in the study area and were analyzed in the laboratory Department of Soil Science University of Nigeria; Nsukka. The soil samples were analyzed for their particle sizes, texture, organic matter, Cation-exchange capacity, N, Na^+, KCl, Ca^+, C, Mg^+, among others. The results of the soil analysis are explained thus:

The twelve soil samples were collected from different locations in eight communities in the study area and they are Agbogugu, Agbudu, Ihe, Amaowelle, Ogugu, Mmaku, Ugwueme and Awgu. The results show that clay content ranges from 11% to 57% and an average of 30.42%; silt, from 9% to 27% and an average of 17.58%; fine sand, from 19% to 57%, and an average of 38.42%; while coarse sand, from 1% to 29%, and an average of 13.58% respectively. This means high percentage of clay and fine sand and moderately percentage of silt and coarse sand which explains high ionic bound and subsequent high percentage of moisture content in the sampled areas. Due to the high percentage of fine sand and moderately percentage of coarse sand, the porosity level is high, which shows that there is moderate infiltration that result in the soil holding much moisture that ensures the recharge of aquifers that consistently supply the springs that serve as source of water supply in the study area. The soil water PH level ranges from 4.6% to 6.1% and an average of 5.51%. The normal range for pH level in surface water systems according to Brian Oram (n.d) is 6.5 to 8.5 and for groundwater systems the PH level is 6 to 8.5. Hence the soil water in the study area is a bit acidic. Potasium chloride (KCl) found in the sample areas ranges from 3.6% to 4.9% and an average of 4.11%. Carbon ranges from 0.50% to 2.48 and an average of 1.52%. Organic matter ranges from 0.86% to 4.28% and an average of 2.61%. Percentage moisture content is from 6.16% to 31.61% and an average of 20.61%. The base saturation level ranges from 11.73% to 38.68%. Cation-exchange capacity (CEC) measured in millequivalents per 100 grams of soil (meq/100g) range from 8.80% to 34.40%. Nitrogen (N) ranges from 0.182% to 0.332% and an average of 0.25%, Sodium (Na^+) ranges from 0.08% to 0.129% and an average of 0.10%, Potassium (K^+) ranges from 0.305% to 0.420% and an average of 0.36%, Calcium (Ca^+) ranges from 0.4% to 4.4% and an average of 1.64%, Magnesium (Mg^+) ranges from 0.80% to 2.6% and an average of 1.64%, The Slope Angle is from 2^0 to 4^0 at the top slope, less than 5^0 at the toe slope, 7^0 - 10^0 at the middle or talus slope and is suitable for developmental purpose except at the scarp face where the slope is greater than 35^0. Elevation is from 350m to 400m high above sea level, this shows that these places are not floodable but may be prone to erosion.

Principal Component Analysis (P.C.A)

Principal Component Analysis for the soil variables of the study area was carried out using the Statistical Package for the Social Sciences (SPSS) Version 15. The result of the soil samples across the four slope segments (top, scarp face, talus and toe slope) were subjected to the analysis. The results are shown in Tables 2 and 3

Table 2: Total Variance Explained

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.929	30.804	30.804	4.929	30.804	30.804	4.362	27.265	27.265
2	3.891	24.321	55.125	3.891	24.321	55.125	3.452	21.574	48.840
3	2.966	18.538	73.663	2.966	18.538	73.663	3.337	20.855	69.695
4	2.359	14.746	88.410	2.359	14.746	88.410	2.994	18.714	88.410
5	.912	5.698	94.107						
6	.409	2.555	96.662						
7	.214	1.336	97.998						
8	.152	.953	98.951						
9	.103	.644	99.594						
10	.051	.321	99.916						
11	.013	.084	100.000						
12	5.390E-16	3.369E-15	100.000						
13	2.582E-16	1.613E-15	100.000						
14	-4.973E-17	-3.108E-16	100.000						
15	-7.933E-17	-4.958E-16	100.000						
16	-2.717E-16	-1.698E-15	100.000						
Extraction Method: Principal Component Analysis.									

Source: Computer Output, (2020)

The variables in the soil result were collapsed into four components. It used the component to extract total variance explained with Eigen-value 1 and above. This means that the component with Eigen-value 1and above explained the majority of the variance (88.410%).

The first component has Eigen value of 4.929 and explained 30.804% of the total variance. The second component has Eigen value of 3.891 and explained 24.321% of the total variance. The third component has Eigen value 2.966 and explained 18.538% of the total variance. The fourth component has Eigen value 2.359 and explained 14.746% of the total variance. In all, the four components explained 88.410% of all the total soil variables analyzed.

Table 3: Rotated Component Matrix

Rotated Component Matrix[a]				
	Component			
	1	2	3	4
Na+	.908			
K+	.906			
Coarse sand	-.848			
Ca+	.831			
N	-.687			.531
CEC Meq/100g	.652	-.631		
Base saturation		.949		
KCl		.903		
PH level		.897		
Silt			.908	
C			.876	
OM			.871	
Mg+				.954
Clay				-.853
Fine sand	.512		-.537	.628
Moisture		-.502		.530
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.				
a. Rotation converged in 5 iterations.				

Source: Computer Output, (2020)

Component 1 - Sodium Na^+ (.908), Potassium K^+ (.906), Calcium Ca+ (.831), CEC Meq/100g

Component 2 - Base saturation (.949), Potassium Chloride KCl (.903), PH level (.897), Moisture (-.502) and CEC Meq/100g (-.631),

Component 3 - Silt (.908), Carbon C (.876), Organic Matter (.871) and Fine sand (-.537)

Component 4 – Nitrogen N (.531), Mg^+ (.954), Fine sand (.628), Moisture (.530) and Clay (-.853).

Component 1: Sodium Na^+ (.908), Potassium K^+ (.906), Calcium Ca+ (.831), Cation exchange capacity CEC Meq/100g (.652), loaded very strong and positive while Coarse sand (-.848) and Nitrogen N (-.687), loaded very strong but negative showing no correlation to other variables in this component. Sodium, Potassium and Calcium are chemical elements soluble in water and are present in rock formations in the study area. There is a high concentration of these elements and all dissolved elements are transported and deposited at the base slope. Cation exchange capacity (CEC) measures the soil's ability to hold positively charged ions. It is a very important soil property influencing soil structure stability, nutrient availability, soil pH and the soil's reaction to fertilizers and other ameliorants (Hazleton and Murphy, 2007). Soil particles get finer further away from the high lands, this is why clay, fine sand and silt dominate the toe slope which is a zone of colluviation and seasonal moisture variation, and are basically on the valley floors underlain by shale. This zone is endowed with fertile soil and supports massive farming. The soil types retain much water leading to high moisture content adding to the fact that the segment receives abundant water from runoff as well as head streams of the higher slope zones.

Component 2: Base saturation (.949), Potassium Chloride KCl (.903) and PH level (.897), loaded very strong and positive while Moisture (-.502) and CEC Meq/100g (-.631), loaded strong but negative showing no correlation to other variables in this component. This explains the soil water PH level which ranges from 4.6% to 6.1% and an average of 5.51%. According to Brian Oram (n.d), the normal range for pH level in surface water systems is 6.5 to 8.5 and for groundwater systems the PH level is 6 to 8.5. Base on the postulation of Brian Oram (n.d), the soil water in the study area is a bit acidic.

Coponent 3: Silt (.908), Carbon C (.876), and Organic Matter (.871), loaded very strong and positive while Fine sand (-.537), loaded strong but negative showing no correlation to other variables in this component. These elements improve soil fertility and encourage crop farming in the study area especially at the talus (middle) and toe slope. This explains the presence of thick vegetation and massive farm practices in the area.

Component 4: Nitrogen N (.531), Magnesium Mg^+ (.954), Fine sand (.628) and Moisture (.530) loaded very strong and positive while Clay (-.853), loaded very strong but negative showing no correlation to other variables in this component. Fine sand allows all the water that percolated at the top slope to emerge as streams because of the difference in permeability of the sandstone and shale that make up the bedrocks of the study area. This explain the presence of capillary water at all the segment of the slopes even at the highest altitude in the study area.

Conclusion And Recommendation

Conclusively, it is now very understandable why the features of landform have critical implication on soil characteristics, land related socio - economic activities and all other human activities. The findings of this research further justify the views of Young (1972) that geomorphic surfaces end up translating into economic surfaces. Land is the primary resource of man and understanding the nature and processes of landforms could help in ensuring food security, improving standards of living and eradication of poverty in the study area and Nigeria at large. It also helps in managing the land to avoid degradations that could cause environmental hazards like landslide, erosion, among others.

The study therefore recommends based on the findings and the concept of sustainable development which requires that use of land should be carried out in a way that will provide man's needs but without jeopardizing future use of the land, that governments at all levels should seek for technology transfer on farming practices, how to optimize inputs, how to improve unsuitable lands in order to ease off the impact of land related socio – economic activities in the study area and improve the general economy of the people.

Towards curbing the effect of topography on land related socio - economic activities, it is recommended that practices such as terracing on slope should be done to reduce the velocity of surface runoff and loss of soil nutrient. Constructions of any kind should be in alignment with the slopes. Unsupervised excavation and mining should be discouraged. Also the application of appropriate fertilizers on farmland can be done to improve the quality of the soil for farmers.

Furthermore, given the landscape features of the study area, some area are susceptible to erosion, it is a recommended that drainage channels should be constructed to check erosion of the landscape by surface runoff as suggested by Ayadiuno; Mozie and Ndulue (2020). Community partnership and participation is very essential and should be encouraged in a bid to conserve the environment.

References

[1] Aitchinson, G.D. and Grant, K. (1967): "The PUCE Programme of terrain description, Evaluation and Interpretation for engineering purposes." *Proc. 4th Reg. Conf. Africa Soil mech fdn Engang 1,1.*

[2] 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.

[3] Anyadike, R.C.N. (2009). *Statistical methods for the social and Environmental Sciences.* Spectrum Books Limited: Ibadan.

[4] Ayadiuno, R. U; Ndulue, D.C; Mozie, A.T; Phil-Eze, P.O, (2020). Geomorphological Analysis and Terrain Characterization of the Du and Anambra River Systems of Southeast, Nigeria. *Palarch's Journal of Archaeology of Egypt/Egyptology 17(9). ISSN 1567-214x*

[5] 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

[6] Beckett, P.H.T. and Webster, R. (1965). *A Classification System for Terrain,* Military Engineering Experimental Establishment, Christchurch, UK. Reprint.

[7] Brian Oram (n.d) Water Research Center, accessed on 15th march, 2020 from https://water-research.net/index.php/water-treatment/tools/the-ph-of-water

[8] Bunting, N.C. (1965): Geography of Soil. Hutchinson University Library, London.

[9] Evans, I.S. (1998). "What do terrain statistics mean?" In Lane, S.N., Richards,

K.S. and Chandler, J.H. Eds *Landform monitoring, modelling and analysis*, Chichester, J. Wiley, Chapter 6, pp. 119 – 138.

[10] Ezeaku, P.I. (2012) Methodologies for Agricultural Land use planning. Great AP publishers, Nsukka.

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

[12] Holland, P. G and Steyn, D. G. (1975). Vegetational responses to latitudinal variations in slope angle and aspect, *J. Biogeogr*. 2 179–83

[13] Inyang, P.E.B. (1975): "Climatic Regions". In Ofomata, G.E.K (ed.). In Nigeria in Maps: Eastern States, Ethiope Publ. House, Benin City p. 27.

[14] King, L.C. (1953): "Analysis of landscape evolution". *Bulletin of the Geologic society of America* Vol.62, Pp.72-63

[15] Klingebiel, A. A and Montgomery, P. H. (1961). *Land Capability Classification*, Agric. Handbook No 18, Washington DC, department of Agriculture.

[16] Maren, I. E., Karki, S., Prajapati, C., Yadav, R. K., & Shrestha, B. B. (2015). Facing north or south: Does slope aspect impact forest stand characteristics and soil properties in a semiarid trans-Himalayan valley? *Journal of Arid Environments*, *121*, 112–123. https://doi.org/10.1016/j.jaridenv.2015.06.004

[17] Monanu, P.C. (1975). *Humidity*. In Ofomata, G. E. K. (Ed), Nigeria in Maps; Eastern States. Benin-City: Ethiope Press.

[18] Mozie, A.T. (1992): Terrain Evaluation for Urban Development Purposes in Onitsha and Environs. Unpublished M.Sc Thesis, Dept of Geography, Univ. of Nigeria, Nsukka.

[19] Mozie, A.T. (2011): "Analysis of Settlement Distribution Pattern in two Terrain Tracts: The Udi-Awgu plateau and Cross River plain in Enugu State, South Eastern Nigeria". *Nigeria Journal of Geography and Environment* Vol.2, Pp. 237-246

[20] 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

[21] Njoku, A.O. (2013). "The relationship between topography, Soil characteristics and Agricultural Land Use in Awgu L.G.A, Enugu State. Unpublished B.Sc project, Department of Geography, University of Nigeria, Nsukka.

[22] Norton, K.P.; von Blanckenburg, F. & Kubik, P. W. (2010). Cosmogenic nuclide-derived rates of diffusive and episodic erosion in the glacially sculpted upper Rhone Valley, Swiss Alps. Earth Surface Processes and Landforms: *The Journal of the British Geomorphological Research Group*, 35(6), 651-662. doi: Doi 10.1002/Esp.1961

[23] Nwankwo, C.F. (2014). *Residential Water Demand and Supply in Awgu Local Government Area, Enugu State, Nigeria.* Unpublished B.Sc Project, Department of Geography, University of Nigeria.

[24] 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.

[25] Obeta, M.C. and Nwankwo, C.F., (2015). Factors Responsible for Rural Residential Water Supply Shortage in Southeastern Nigeria; Journal *of Environmental Geography* 8 (3–4), 21–32. DOI: 10.1515/jengeo-2015-0009 ISSN: 2060-467X

[26] Ochege, U.F. (2009*). "Physical Constraints to Urban Development: In Arochukwu Urban* Unpublished B.Sc. Project, Department of Geography, University of Nigeria, Nsukka.

[27] Ohamobi, S.F. (2011) "Selection of Road Transport Corridor in Sokoto State Nigeria, using Remote Sensing and GIS",

Nig. Journ of Geog and the Environt, Vol. 2, No. 2.

[28] Ohmori, H. (2003): *"The Paradox of the Davisian End – Penplain and Peckian primary Peneplain: In concepts and Modelling in Geomorphology":* In I.S. EVANS (Ed) International Perspectives pp 3-32 Terrapub, Tokyo.

[29] Prayfull, S; JAY, K. T and Singh U.C (2013). Morphomeric analysis of Morar River Basin, Madhya Pradesh, India, using remote sensing and GIS techniques*: Environmental earth Sciences, April 2013, vol. 68, issue, pp 1967-1977*

[30] Stewart, C.A. (1968). *Land Evaluation.* Melbourne. Macmillan.

[31] Strahler, A.N. (1950): "Equilibrium theory of erosional slopes approached by frequency distribution analysis*". American Journal of science, Vol. 248, 673 -698 and 800 -814.*

[32] Strahler, A.N. (1952): "Dynamics basis of Geomorphology". Bull. *Geological Soc. Of America, vol 63, 923-938.*

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

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

[35] Umeuduji, J. E. (1989) "*Terrain Constraints to Urban Land Use: The Case of Enugu, Nigeria*", Unpublished M.Sc Project, Department of Geography, University of Nigeria, Nsukka.

[36] Wilson, J.P. and Gallant, J.C. (2000). Eds. (2000). *Terrain Analysis: Principles and Applications* New York, J.Wiley

[37] Young, A. (1972): *Slope Mechanisms*. McGraw- Hill Book Company, New York and London, Pp112-118.

[38] Zobeck M.C., Baddock R.S. and van Pelt (2013) Anthropogenic Environment. *Reference module in Earth System and Environmental Sciences from Treatise on Geomorphology pp. 395-413- Elsevier*