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From the Editor-in-Chief

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LJGIS is a journal in the field of Geo-information Sciences in Africa. The journal is for the advancement of contemporary research and knowledge in the revolutionary and state-of-the-art fields of Geo-Sciences, Information Systems, Technology and Application. It publishes original research papers, reviewed articles, technical notes, professional evaluation and workshop / conference reports and papers in related fields of Geography, Remote Sensing, Surveying/Geo-informatics, Urban and Regional Planning, Spatial Environment, Pure and Applied Sciences.

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Sincerely.

Editor-in-Chief.

Lagos, 2019

ASSESSMENT OF LAND SUSCEPTIBILITY TO GULLY EROSION IN ORUMBA NORTH LGA, ANAMBRA STATE, SOUTH EASTERN NIGERIA

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ABSTRACT

This study utilizes GIS technique to determine land susceptibility to gully erosion in Orumba North LGA of Anambra State. Environmental variables of interest in the study include: land use, slope (DEM), drainage and soil. The methodology also involves land use classification and reclassification in raster format. Weights are assigned to each raster cell of selected environmental variables according to their level of significance to soil erosion and the combination of individual variable layer susceptibility weight through overlay technique used Math Raster Calculator in GIS environment was used to determine the actual susceptibility of the land to gully erosion. The result showed that built-up land use which increased from 0.62% in 1986 to 4.43% in 2016, is the most dynamic variable that drives the development of gully erosion in the area. The 1st order streams drains about 60.58% of the study area with a total stream length of 192.65km. Over 40% land area has a slope higher than 50^0 and relief of 157m-203m and 203m-255m values which contribute to increase runoff velocity in the study area; thereby catalyzing erosion activities. Loamy sandy soil type covers about 51.47% and has the highest erodibility factor of 0.38. In all, the 'very high susceptibility' land area to gully erosion constitutes 18.78km^2 (5.12%). These are the 'Erosion Hotspot Areas'. The study recommend the provision of green belts infrastructures in the developmental strategies of the city planning authorities. This strategy will mitigate further development and expansion of gullies as the cities expand.

KEYWORDS: Land use, Soil, Erodibility, Slope and Drainage

INTRODUCTION

Soil erosion is one of the major environmental challenges that pose a danger to human food productivity and security by degrading agricultural land. Scherr and Yadav (1996) argue that by the year 2020, soil erosion may pose a serious threat to food production and livelihoods by continousy degrading arable land, particularly in poor and densely populated areas of the developing world. Although, soil erosion is perhaps the most serious mechanism of land degradation (El-Swaify *et al.*, 1982), gully is visually the most impressive of all types of soil erosion (El-Swaify, 1990) due to massive soil that is potentially loss and the deep and large channels that it creates on land. Thus, the phenomenon of gully erosion, whether it is naturally-induced or artificially-induced or both - causes monumental destruction to land resources and, in particular, soil. In Nigeria, soil erosion has been recognized as one of the serious geo-environmental hazards (Ofomata, 1987; Albert *et al.,* 2006), especially in the South Eastern part of the country. It is a widespread environmental problem occurring in many parts of the country under different geologic, climatic and soil conditions (Onu, 2011). The degree of occurrence, types and factors responsible for their initiation vary considerably from one part of the country to another (Onwueme and Asiabaka, 1992) but the negative impacts on both land and human resources are similar. The Nigeria Erosion and Watershed Management Project (NEWMAP, 2012) noted that gully erosion contributes to environmental problems and damage estimated at over $100 million annually (mostly in South-Eastern Nigeria). The gully situation in the south eastern Nigeria poses the greatest threat in Anambra State where communities such as Agulu, Nanka and Oko communities of Orumba North Local Government Area (LGA) are badly hit. Specifically a field work carried out in Orumba North Local Government Area (LGA) reveals that the situation has reached a disaster state owing to the continuous degradation of the land space by gully morpho-dynamic. Valuable agricultural land has been loss to gully, communities have been separated by deep gullies, highways have been damaged and properties have been damaged by gullies, most especially buildings which led to the displacement of people. The development and advancement of gully in the area resulted from both natural and human induced factors including intense subsistence farming, undulating topography, climate, geology and soil factor (erodibility). Consequent upon this background, this study assesses the land susceptibility in Orumba LGA of Anambra State (Nigeria), to gully erosion with the view to showing gully erosion susceptibility distribution as the first step towards preventive measures.

STUDY AREA

The study area, Orumba North Local Government Area of Anambra State is geographically located within Latitude 6^0 00' N to 6^0 15.5'N and Longitude 7^0 02' E to 7^0 16' E (Fig 1). Approximately it covers a land area of about 368 km^2. The dominant geological formation is the Nanka sands, which lies conformably on the Imo Shale of Paleocene age and overlain by the Ogwashi-Asaba formation. The Basin delineates the southern border (or section) of the Benue Trough which was formed (along with the Afikpo syncline and Abakaliki Ridge) during the santonian tectonism. Climatically, the area lies within the humid tropical rainforest belt of Nigeria with an average annual rainfall of 1800mm (Oyebande, 1983). The rainfall is mostly torrential and of short duration; high intensity rainfall with high potent for soil erosion is common. The soil is loam and of different types while vegetation is secondary rainforest. The drainage systems in the area include: Nwaobunagu River, Iyiocha River and Ahommiri River. Human prevalent in the area include subsistence agriculture and urbanization which have transformed the original rainforest to secondary and derived forest. The palm tree is the most prominent economic tree in the area and farm produce includes: yam, vegetables and maize. Figure 1 shows Orumba Local Government Area in Anambra State.

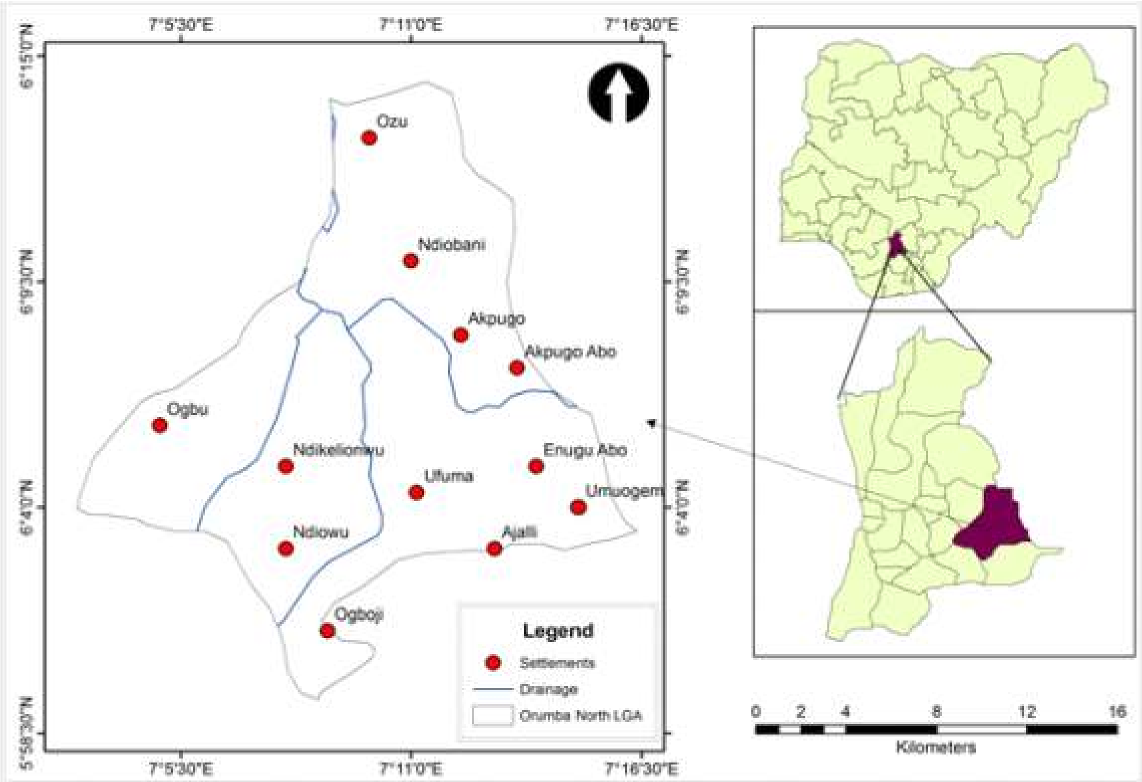

Figure 1: Orumba LGA in Anambra State, Nigeria.

METHODOLOGY

Data Sources and Characteristics

Table 1 shows the data sources and their characteristics used for this study. The study uses Remote Sensing and Geographical Information System through classification and reclassification of image raster and grid maps of the physical landscape variables. The methodology involves assigning weights to each raster (cell) or grid of the variables according to their degree of susceptibility to gully. This was based on experts judgments (Tsangaratos and Rozos, 2013, Odunuga *et al.*, 2018). The variable includes: land use, slope (DEM), drainage and soil. The methodology also involves a combination of individual variable layer susceptibility weight through overlay and the use Math Raster Calculator in GIS environment to calculate the actual susceptibility of the grid area to gully erosion.

Table 1: Data Sources and Characteristics

Data	Characteristics	Scale	Source	Meta data
Landsat Imagery	Band 7-Red	30 meters	Earth explorer (www.earthexplorer.org.usgs)	L7189056 Jan 11, 1986; 09:50
	Band 5-Green	30 meters		
	Band 3-Blue	30 meters		LC8189056 Mar 26, 2016; 10:50
Digital Elevation	Nigeria DEM	10 meters	Office of the Surveyor General of the Federation (OSGOF)	August, 2010
Soil Map	Nigeria Soil Map	State-Level	Department of Geography, University of Lagos	Jan, 2000
GPS Readings	Coordinates	> $\pm$3m error margin	Field survey	2017
Field Survey	Gully Sites	N/A	Field survey	2017

Source: Author, 2017

Characterization of the Physical Landscape Variables

Land use/land cover classification

The modified Anderson's land use / land cover classification (Odunuga & Oyebande, 2007) was used to classify the landscape (land use / land cover) of the study area. This classification was based on the spatial, spectral and temporal resolution of the Landsat obtained in two periods (1986) and (2016). Five (5) classes were extracted from the imageries. Training obtained datasets were randomly sampled from the spectral signature of each of the classes to define their respective land use / land cover type. Each of the classes of the land use was reclassified based on their rate of sediment generation. Table 2 shows the classification schema used for the study.

Table 2: Land use Classification schema

Code	**Class**
1	Built-up Area
2	Water body
3	Heavy Forest
4	Light Forest
5	Wetland

Source: Author, 2017

Slope classification

The raster pixels from DEM data was used to extract slope into ranges. These pixels were extracted into point values and quantified into degree and grouped, as demonstrated by Pike (2002). Furthermore the slope was classified using the Spatial Analyst tool box in ArcGIS based on the contour interval, degree of the change in slope as well as the height of the releif (Pike, 2002). The slope with < 2^0 and contour interval of 5m represents plain landscape while slope between 2^0 and 6^0 was classified as upland with 80 to 300 meters height. Hillslope is generally described as slope between 6^0 and 10^0 with about 300 to 600 meter height. The last category of slope is slope greater than 20^0 of above 600 meters height. Table 3 shows slope classification.

Table 3: Slope Classification

Terrain Type	CI (m)	Slope (degrees)	Relief (Height Range) m
Plain	5	< 2	< 80
Upland	10	2-6	80-300
Hill	20	6-25	300-600
Mountain	20	> 25	> 600

Source: Adopted from Pike RJ (2002)

Soil classification

The soil component of the physical landscape of the study area was characterized into four major soil types as depicted in the soil map. These include loam, sandy loam, clay loam and gravely loam. These soils are deep, moderately deep, and shallow well or imperfectly drained. Thus, the soils are further reclassified based on Garde (2011) soil erodibility factor. Soil erodibility depends on the texture, aggregate stability, shear strength, infiltration capacity, and organic and chemical contents. The coarser the particles the smaller their erodibility. Similarly the greater the relative density the less will be its erodibility (Garde, 2011). Table 4 shows the Soil Erodibility Factor K adopted from Garde, 2011 and used for this study.

Table 4: Soil Erodibility Factor K

Soil	Range of K
Soil Loams	0.4 - 0.7
Clay Loams	0.3 - 0.4
Sandy Loams	0.1 - 0.3
Gravely loams	0.03 - 0.1

Source: Adopted from Garde, 2011

Assessment of the susceptibility of the landscape to soil erosion

Rainfall is the most important factor affecting erosion because of its power to weather and detach soil particles as well as its ability to produce runoff, which causes erosion and transportation of the eroded material (Garde, 2011). However, based on the fact that Orumba North LGA falls within the same rainfall zone (Oyebande, 1983), the rainfall parameter was held as a constant variable. Other variables considered include; land use / land cover, slope, soil and drainage. The susceptibility of the landscape to soil erosion based on the individual variable classes was determined. This was achieved by assigning a uniform susceptibility rating scale (weight) to all the identified classes for each of the variables based on the class liability to influence or harm to cause soil erosion. The class weight ranges between 1 and 5 and the class that is least resistance to soil erosion has the highest weight (5) while those with high resistance to soil erosion obtain the least weight (1). In other words, Class ranking / scores were used to describe the influence of classes of each parameter on erosion initiation and gully development.

The variables were then converted into grid (raster format) with individual cell having the score obtained by the most significant class it covers. The variables layers (land use / land cover, slope, soil and drainage) were overlain and their class weight added together using the Math Raster Calculator to calculate the degree of susceptibility to gully (soil) erosion based on the cumulative scores from all the variable layers weight. The susceptibility level for each grid cell is the linear sum of the ranking/weight scores (Tsangaratos and Rozos, 2013, Odunuga *et al.*, 2018) for all the variables at the cell spatial resolution. The scores were thus, reclassified into a common level of classes of susceptibility (very low susceptibility, low susceptibility, medium susceptibility, high susceptibility and very high susceptibility) and used for mapping (Odunuga et al, 2018). This provides the level of exposure of the unit area, taking into consideration all the parameters leading to erosion at this micro-unit while maintaining the variation in the spatial interplay of the parameters at the macro-level (Odunuga *et al.*, 2018).

RESULTS AND DISCUSSION

Environmental Characteristics contributed to Gully Development in the Study Area

Land use change

The land use analysis shows that built-up area increased from 0.62% in 1986 to 4.43% in 2016 with settlements such as Adikelionwu, Ndiowu, Ajali and Ndioban showing significant expansion. As observed during fieldwork, this development does not follow a predefine pattern in the form of planning, rather it is haphazard and devoid of basic infrastructures like tarred road and drainages; the consequences of which is the initiation of rill erosion. Many of these have metamorphosed into gullies. As urbanization intensified, the surface landscape was continuously and fundamentally altered in quantity, morphology, while the structure of the landscape is steadily inadvertently influenced along with land use change (Ollero, 2010; Julian *et al.*, 2015). Forest land cover reduced from 86.63% in 1986 to 78.82% in 2016. The losses recorded by the forest were gains to built-up, gully scars / cultivation and open spaces, thereby, increasing the vulnerability of the soil to erosion by surface runoff. Similarly, the Gully scar/cultivation area in 1986 increased from 10.38% in 1986 to 13.34% in 2016. The scars include not only the eroded surfaces but also the spread area of the eroded debris which were intertwined with cultivated area. This, therefore, confirms the increasing degradation of the land resources in the study area owing to soil erosion. The open space land use and cover increased from 2.02% in 1986 to 3.15% in 2016. Table 5 and figure 2 show the Land use changes between 1986 and 2016.

Table 5: Land use Characteristics between 1986 and 2016

	1986		2016		
Land use class	**Area (km^2)**	**%**	**Area (km^2)**	**%**	**% Change**
Built-up	2.3	0.62	16.33	4.43	3.81
Forest	319.01	86.63	290.22	78.82	-7.81
Gully scar / Cultivation	38.23	10.38	49.1	13.34	2.96
Open space	7.45	2.02	11.6	3.15	1.13
Water body	1.23	0.33	0.97	0.26	-0.07
Total	368.22	100	368.22	100	

Source: GIS Analysis, 2017.

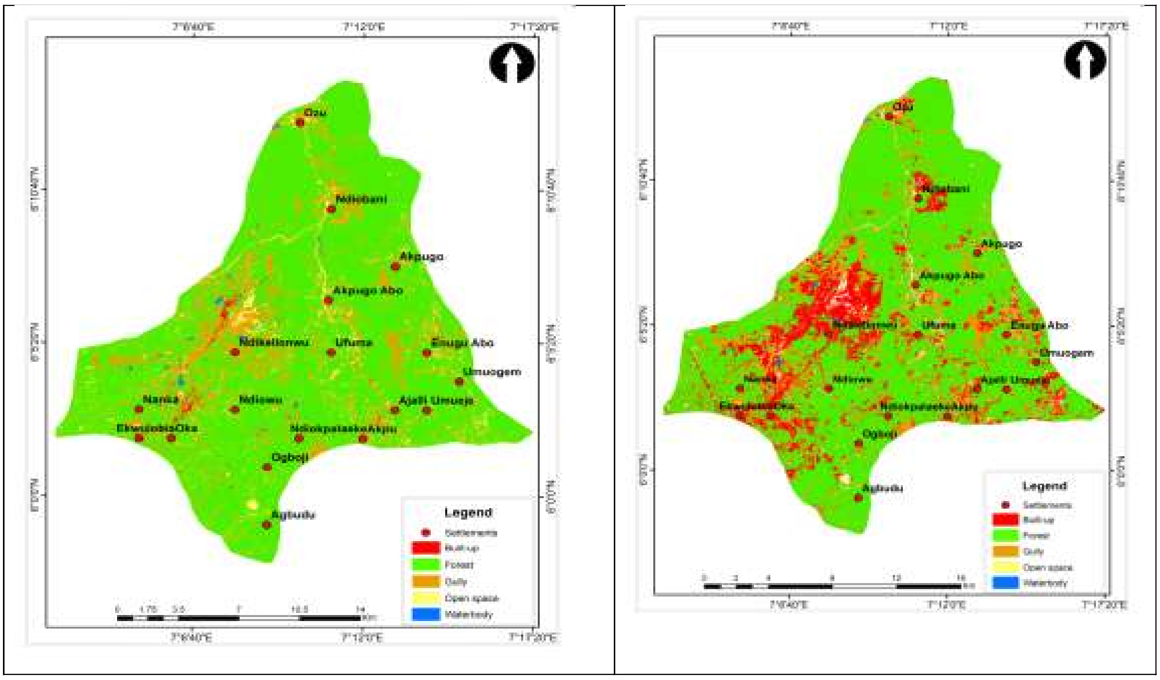

Figure 2: Land use Characteristics of Orumba North LGA between 1986 and 2016.

Drainage

Table 6 shows the classification of the drainage system in Orumba North L.G.A. The drainage system is of the 4th order, which has the capacity to erode, transport and deposit sediment from the upper streams to the lower streams. The 1st order streams drains about 60.58% of the study area with a total stream length of 192.65km. The 2nd order streams drain about 23.08% of the basin with about 73.4km stream length; the 3rd order streams drain 16.03% while, 4th order streams drain about 0.31% of the study area. The implication of this to erosion is so significant in the lower order streams (1st and 2nd

order streams), which are the primary collectors of rainfall and surface runoff processes. These lower order streams are usually perturbed by human activities especially urbanization, in a manner that usually block free flow of water or even buried the streams (Wu *et al.*, 2018). In addition, the land use analysis reveals that most 1st order streams in the study area have been modified to meet the needs of human development in the areas of agriculture and urbanization. Consequently, it is shown many gullies initiating point originated from previously 1st order stream valley depression. Figure 3 shows the drainage system within the study area, showing its dendritic pattern.

Table 6: Drainage System Classification in Orumba North LGA

Stream order	Stream length (km)	% of Drainage
1	192.65	60.58
2	73.41	23.08
3	50.97	16.03
4	0.98	0.31
Total	318.01	100

Source: GIS Analysis, 2017

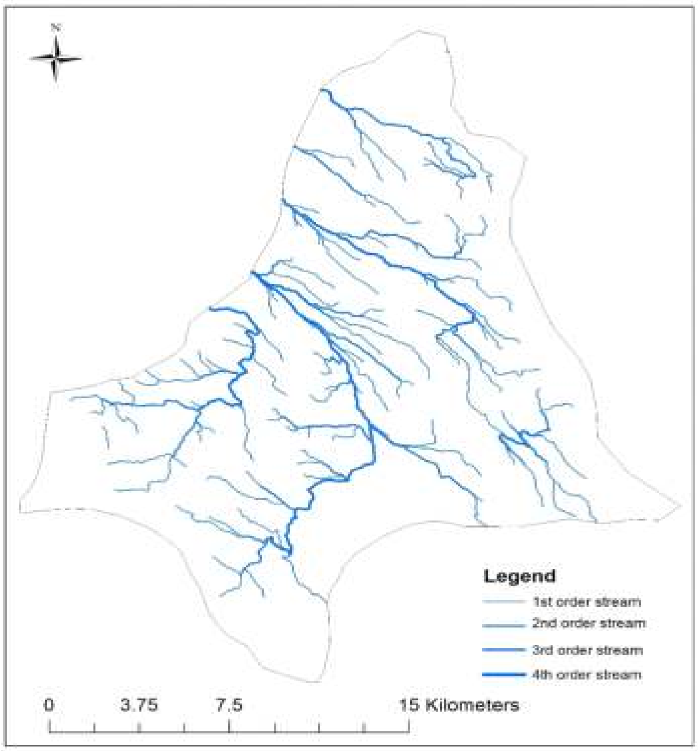

Figure 3: Drainage System within Orumba North LGA

Slope

The degree of ***slope*** of land has long been considered one of the major factors governing the amount of run-off and ***soil erosion***. Five major classes of slope were identified in the study area (Table 7). These include: slope of between 0-15^{o} which covers about 28.63% of the entire landscape; slope of between 15-35^{o} (17.26%); slope between 35-50^{o} and 50-65^{o} which cover about 13.59% and 17.42% respectively. Lastly, slope of between 65-82^{o} covers about 23.10% of the study area landscape. It has been established in the literatures that slope contributes significantly to the development of gully erosion and that the relationship between slope gradient and soil erosion is cause effect, such that as the slope gradient increases so also the potency of soil erosion increases (Jordan *et al.*, 2005). The steeper and longer the slope of a field, the higher the risk for erosion, that is, places with high slope are more susceptible to erosion than places in the downstream.(Ofomata, 1985; Hudson, 1981; Lal, 1976a; Igwe, 1997). However, the relationships could be different for different slope conditions, landforms, soil types and other factors (McCool *et al.*, 1987; Zhang, 2015). Furthermore, slope can act as a buffer, depending on the aspect and initial stability of the soil. Nevertheless, over 40% land area in Orunmba North LGA has a slope higher than 50^0 (Figure 4) which contributes significantly to soil erosion and the emergence and development of gullies in the area. Also, soil erosion by water increases as the slope length increases due to the greater accumulation of runoff. Consolidation of small fields into larger ones often results in longer slope lengths with increased erosion potential due to the increased velocity of water, which permits a greater degree of scouring (carrying capacity for sediment).

Table 7: Slope Classification of Orumba North L.G.A

Slope (Degree)	Pixel Count	%
0-15	263590	28.63
15-35	158894	17.26
35-50	125068	13.59
50-65	160390	17.42
65-82	212668	23.10
Total	920610	100

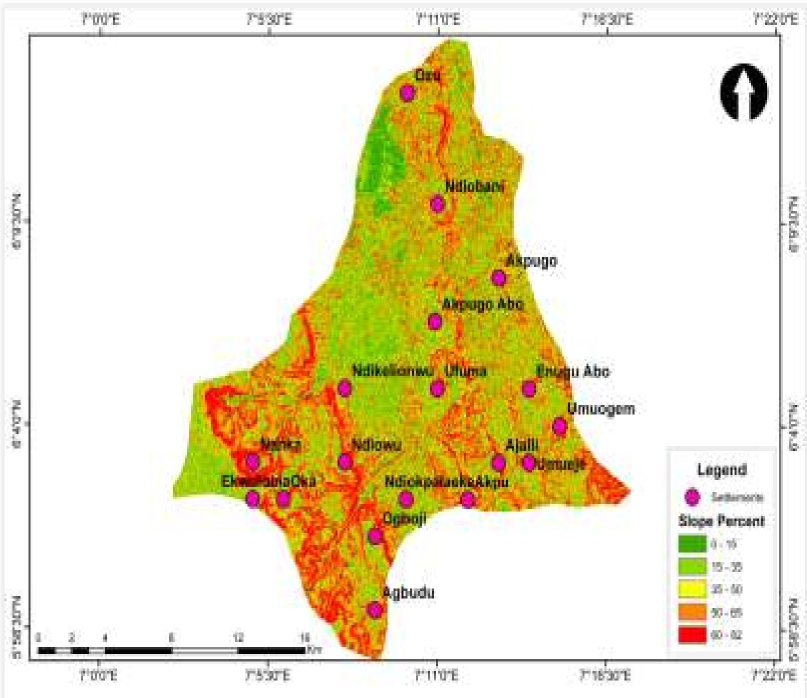

Figure 4: Slope Classification of Orumba North LGA

Source: GIS Analysis, 2017

Elevation

Table 8 shows the elevation ranges of the study area while figure 5 reveals its digital terrain analysis. Regarding its elevation ranges, 0-45m amsl corresponds to the very low elevation, 49-91m amsl indicates a relatively low elevation while 91-157m value indicates a medium level elevation forming the drainage channels and valley floor. The terrain / relief of 157-203m and 203-255m values were ridges and elevated areas, as shown in figure 5. These terrains are characterized by gently undulating plains and rugged plains respectively. They however, form areas with the greatest contribution of slope to increase the runoff velocity in the study area; thereby catalyzing erosion activities in the area. Slope and elevation have been recognized as increasing runoff velocity and therefore poses a greater erosion risk (Farris *et al.*, 2014). High elevation and slope areas are highly susceptible to erosion with minimal human influence.

Table 8: Elevation Classification in Orumba North LGA

Meter	Count	%
0-45	95905	6.06
45-91	400994	25.34
91-157	49278	3.11
157-203	920610	58.17
203-255	115779	7.32
Total	**1582566**	**100**

Source: GIS Analysis, 2017

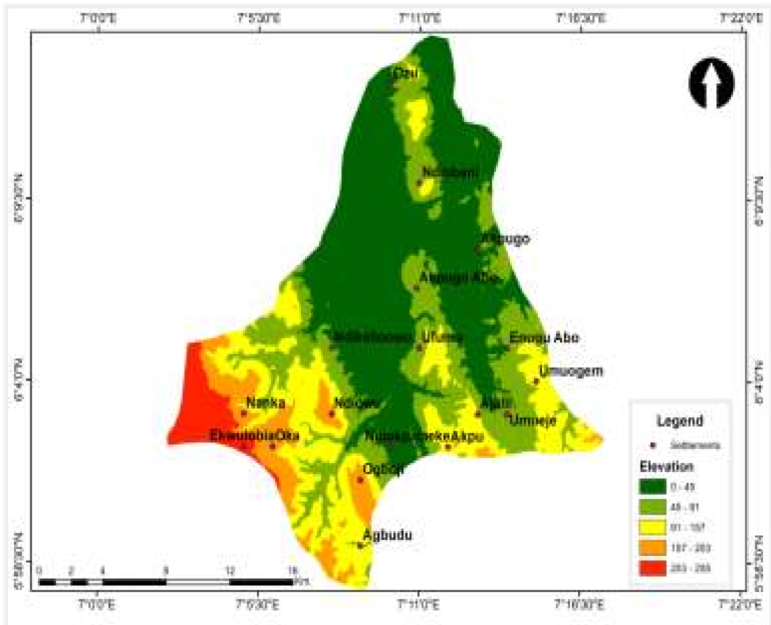

Figure 5: Terrain Elevation Pattern of Orumba North LGA

Soil

Four major classes of soil can be identified in Orumba North LGA as shown in Table 9 and Figure 6. These are loamy sandy, loamy clay, sandy clay and sandy loamy. These soils have their geological origin from Shales, Sandstone and Recent alluvium. The Loamy Sandy and Loamy Clay soil cover 51.47% and 21.63% respectively. They are mostly deep well drained soil. Sandy clay and Sandy loamy cover 16.62% and 10.27% of Orumba North LGA respectively. They are characterized as deep, moderately deep and shallow well or imperfectly drained soils. (See figure 6).

Table 9: Soil Classification in Orumba North LGA

Soil Class	Area (km^2)	%
Loamy Sandy	189.53	51.47
Loamy Clay	79.66	21.63
Sandy Clay	61.21	16.62
Sandy Loamy	37.82	10.27
Total	**368.22**	**100**

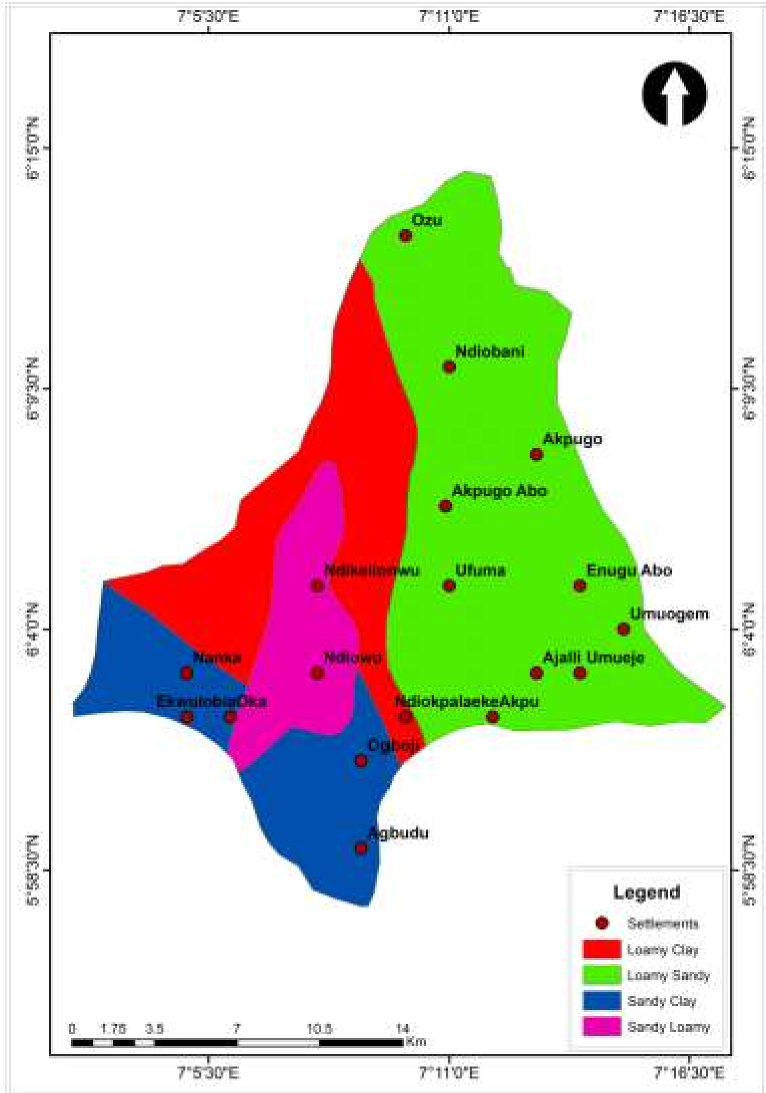

Figure 6: Major Soil Characteristics of Orumba North LGA

Source: GIS Analysis, 2017

Assessment of Susceptibility of the Landscape to Soil Erosion

Land use susceptibility

Land use pattern contribute to the initiation and development of gully erosion especially in developing countries where physical planning processes are not usually adequately adhered to

(Galang *et al.*, 2007)**.** Misuse of land and poor farming systems encourage accelerated runoff while indiscriminate foot paths created on the landscape expose unconsolidated soil to soil erosion that might eventually developed to gully. There are evidences of these scenarios in the study area. Also, road constructions with poor or badly terminated drainages, including uncontrolled infrastructural developments, have also contributed significantly to the gully developments in the area (figure 7). Table 10 presents the susceptibility of the five major classes of Land use and their susceptibility weight.

Table 10: Susceptibility of classes of land use

Land use	Area (km^2)	% Covered	Susceptibility (Weight)
Built-up	16.33	4.43	4
Forest	280.23	76.11	2
Gully scar	59.1	16.05	5
Open space	11.6	3.15	3
Water body	0.97	0.26	1
Total	368.22	100	

Source: GIS Analysis, 2017

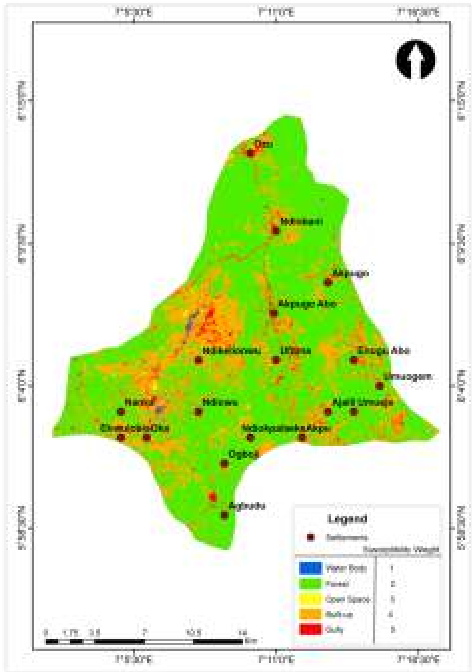

Figure 7: Reclassification of Land uses according to their susceptibility

Drainage susceptibility

The area is drained by a 4th order stream, Ahommiri River. Other streams are the Nwaobunagu River and Iyiocha River. These rivers drain beyond the Orumba LGA boundary. The 1st order streams watersheds cover about 60.58% of the LGA and the fluvial works of 1st order streams are mainly erosion and transportation of the sediment. Therefore, as shown in table 12, the 1st order stream has the highest susceptibility weight of five (5). This is followed by the 2nd order stream with susceptibility of four (4). The 3rd order and 4th order however, have susceptibility weight of 3 and 2 respectively because most of their fluvial activities are deposition. Table 11 and Figure 8 show the Susceptibility of the drainage system according to the order of the stream.

Table 11: Susceptibility of Drainage system

Stream order	Stream length	% of Drainage	Susceptibility weight
1	192.65	60.58	5
2	73.41	23.08	4
3	50.97	16.03	3
4	0.98	0.31	2
Total	318.01	100	

Source: GIS Analysis, 2017

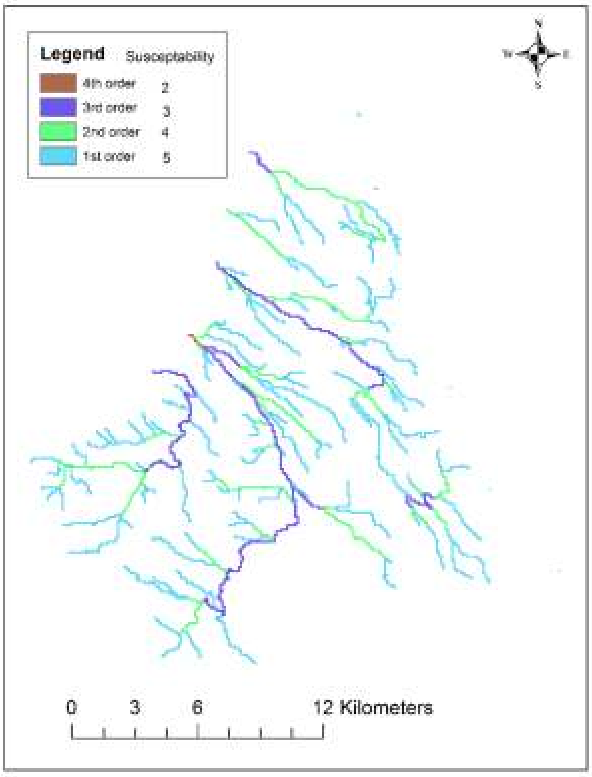

Figure 8: Reclassification of the Drainage system according to their susceptibility

Slope susceptibility

Slope is a very important factor or variable of gully erosion development. Higher slope generates high erosive force than the lower slope, which consequently triggers erosion. As it is shown in Table 12 and Figure 9, a slope of between 0-15^o has susceptibility weight (1) to erosion, slope of between 15-35^o has susceptibility weight 2 while those of between 35-50^o has 3 susceptibility weight. A slope of between 50-65^o and 65-82^o have the susceptibility weight of 4 and 5 respectively, which implies that the probability of erosion development in the slope area of 50-65^o and 65-82^o is higher than other areas when slope is singled out as a triggering factor of erosion.

Table 12: Susceptibility of the slope

Slope (^{o})	Pixel Count	Percentage (%)	Susceptibility Weight
0-15	263590	28.63	1
15-35	158894	17.23	2
35-50	125068	13.59	3
50-65	160390	17.42	4
65-82	212668	23.10	5
Total	920610	100	

Source: GIS Analysis, 2017

Soil susceptibility

Generally, soils with faster infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosion. Thus, cropping practices lower soil organic matter levels, cause poor soil structure and contribute to increases in soil erodibility. Thus, four major classes of soil types were identified in Orumba North LGA as presented in Table 13. Each of these soil types varies in the level of their erodibility factor and erosion susceptibility. Loamy sandy soil type which covers about 51.47% has the highest erodibility factor of 0.38, which corresponds to susceptibility weight of 5. This is followed by sandy loamy erodibility factor of 0.30 corresponding to susceptibility weight of 4. Sandy clay and loamy clay have low level of erodibility of 0.27 and 0.20 with 3 and 2 erosion susceptibility weights respectively (see figure 10).

Table 13: Susceptibility of the Soil

Soil Class	Area (km^2)	%	Erodibility	Susceptibility weight
Loamy Sandy	189.53	51.47	0.38	5
Loamy Clay	79.66	21.63	0.20	2
Sandy Clay	61.21	16.62	0.27	3
Sandy Loamy	37.82	10.27	0.30	4
Total	368.22	100		

Source: GIS Analysis, 2017

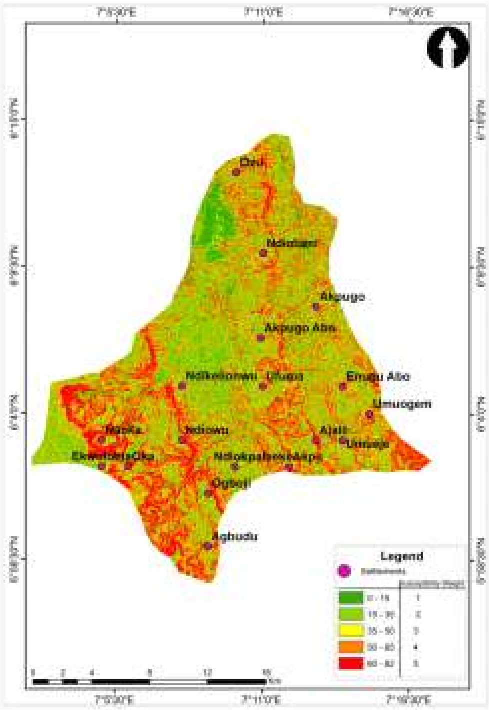

Figure 9: Reclassification of the Slope according to their susceptibility

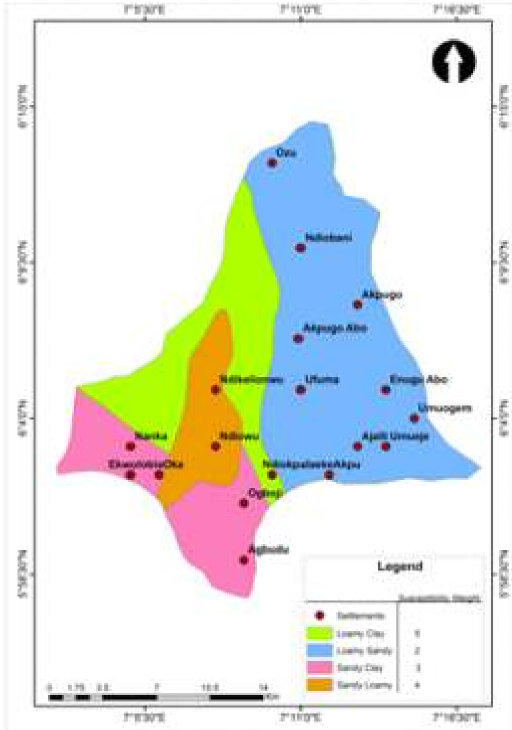

Figure 10: Reclassification of the Soil according to their susceptibility

Source: GIS Analysis, 2017

General susceptibility

Figure 11 and Table 14 reveal five major classes of erosion susceptibility severity based on the final scores of each cell when the weights of all the susceptibility variables (land use, drainage, slope, soil) are added up. The first class score which ranges between 1 and 4, indicates area of 'Very Low erosion susceptibility. The communities under this class include Agbudu and Ogboji. The second class score ranges between 5 and 8 and is described as 'Low Susceptibility', which include communities such as Nanka, Ndiowu, Ndiokpalaeke. The third class, which is the 'Medium Susceptibility' class, has its score ranges between 9 and 12. The communities under this class include Ekwulobia, Oka, and Umueje. The fourth class shows area of 'High Susceptibility' with score ranges of between 13 and 16. The communities include Akpugo Abo, Ajalli and Umuogem. The fifth class score ranges between 17 and 20 and it is termed 'Very High Susceptibility'. In other words, the very high susceptibility can be described as 'Erosion Hotspot Areas' These hotspot areas are found in most of the major towns where urbanization and developmental activities are on the increase. These communities include Ndikelionwa, Ufuoma, Enugu Abo, Akpu, Ndiobani and Ozu.

Table 15: Landscape Susceptibility of Orumba North LGA

Class	**Total weight Score Range**	**Area in Km^2**	**% of Total**	**Degree Severity**	**Vulnerable Communities**
1	1-4	45.32	12.34	Very Low Susceptibility	Agbudu, Ogboji
2	5-8	99.49	27.09	Low Susceptibility	Nanka, Ndiowu, Ndiokpalaeke
3	9-12	102.93	28.03	Medium Susceptibility	Ekwulobia, Oka, Umueje
4	13-16	100.72	27.43	High Susceptibility	Akpugo Abo, Ajalli, Umuogem,
5	17-20	18.78	5.12	Very High Susceptibility	Ndikelionwu, Ufuma, Enugu Abo, Akpu, Ndiobani, Ozu

Source: GIS Analysis, 2017

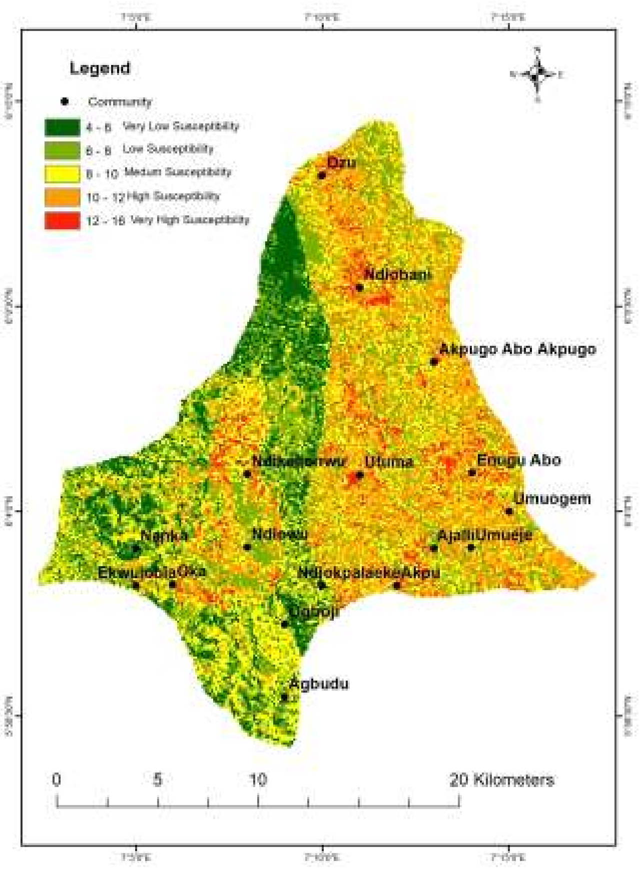

Figure 11: Susceptibility Mapping of the Orumba North Landscape

CONCLUSION AND RECOMMENDATION

Gully erosion is a serious environmental problem in most of the Eastern and South-South area of Nigeria with attendant effect on human lives and properties. Thus, the study has shown the susceptibility of the Orumba North LGA Landscape to the gully erosion and has identified areas that exhibit hotspot erosion scar using Geographic Information System (GIS) technique through weighted overlay analysis. It is recommended that the urban land use management approach in Orumba LGA should be more of green infrastructures within the ever increasing brown cities in the gully hotspot areas. Also, the town and regional developmental plan of Anambra State should ensure that green belts for recreational purposes that are devoid of physical structures are created in areas within the 1st order streams as the villages and cities in the state expand.

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