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Mapping of Soil Erosion Risk in Ezeagu Local Government Area of Enugu State, Nigeria

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Abstract

This study centres on mapping soil erosion risk in Ezeagu Local Government Area of Enugu State, Nigeria. A multi-criteria research design was adopted in carrying out this study by using remote sensed images, topographic, soil and rainfall data. K Factor, R Factor, P Factor, K Factor and Digital Elevation Model were generated. SWAT model was used to generate surface runoff and sediment yield and AHP model were used to identify and map levels of soil erosion risk in the study area. *Loamy sandy soil with a K Factor value of 0.23 – 0.34 (t h MJ^{-1} mm^{-1}) and loam soil with a K factor Value of 0.08 – 0.14 (t h MJ^{-1} mm^{-1}) dominates the study area. The organic matter contents for all the soils were rated low with an average measured organic matter of 0.97 (%). The rainfall erosivity factor (R-factor) results showed variations across the study area from 1029.295 to 1343.092, 1343.092 to 1589.713, 1589.713 to 1744.922, 1744.922 to 1965.777, and 1965.777 to 2060.864 MJ mm ha $year^{-1}$, h^{-1} $year^{-1}$. Areas with dense vegetation had lower P-factors indicating better protection against erosion, while areas under cultivation, especially those with poor management practices and without cover crops show higher P-factors. Almost all the area has a moderate (0.5-0.6) C factor which means moderate protection, areas with higher protection (0.6-1) C factor occupied a small portion towards the east while patches of low C factors are found scattered in the north, west northwest, south and eastern part of the study area. The eastern part of the study area are more susceptible to soil erosion with value ranging from 3.2-5.8, 5.9-9.9 and 10.0-19. Slope steepness and slope length is lower in the northern, western and south-west of the study area. Areas with annual soil loss between 0 to 10 grams, 10 to 20 grams and 30 to 40 grams dominates the northern, western and southern parts of the study area. The erosion risk map depicts that very low-risk area coverage of 24.06%, low risk covers 20.29%, moderate risk occupies 17.75% and high risk erosion risk covers 21.30% while very high risk occupies 16.61% of the total area. This study recommends terracing and gabions in areas identified at risk of erosion, promotion and adoption of agronomic soil conservation methods of mulching, cover cropping and planting plants to enhance soil stability and reduce erosion.*

Keywords: Erosion Risk Mapping, K Factor, C Factor, P Factor and R Factor.

INTRODUCTION

Erosion of soil as a global environmental problem is jeopardizing soil quality and the environmental condition of an area (Nosipho *et al.,* 2018). This is often caused by anthropogenic activities such as farming, settlements and deforestation amongst others (Adepoju and Adekoya, 2018). It is also caused by natural forces such as water, wind and gravity (Nosipho *et al.,* 2018). The occurrence of erosion in an area affects food production,

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degrades the quality of the environment and creates an atmosphere that is unfavourable to man, plants and animals (Nwakwasi, 2018) thereby affecting the sustainable development of rural areas as well as the stability and health of the general society (Igwe *et. al.,* 2017, Chalise *et. al.,* 2019; Eekhout & Vente, 2022). The problem associated with soil erosion is expected to increase due to climate change as the erosion process is largely exacerbated by variations in extreme rainfall, increase in population and anthropogenic activities (Eekhout & Vente 2022; Peng et. al., 2022).

Soil erosion in Nigeria is a common phenomenon leading to issues with great environmental concern most especially in the south of the country. In southern Nigeria, the phenomenon of soil erosion is mainly linked to the action of extreme weather events (floods or running water) which are processes that involve the detachment, transportation and deposition of soil particles by water, rainfall, and runoff (Isife 2019; Mushi *et al.,* 2019). These processes are accelerated by anthropogenic activities such as deforestation, overgrazing, and unsuitable farming practices leading to more soil loss than soil formation (Ahmad *et al.,* 2020).

The growth of the world population resulted in a continual transformation of vast areas of natural vegetation into areas for human use, mainly for agricultural expansion becomes pronounce contributing factors to soil erosion (Xiong *et al.,* 2019). This is having devastating impacts and has led to land degradation (gullies), infrastructural damage as well as loss of lives and properties (Adepoju, & Adekoya, 2018). Most of the erosion problems currently being experienced in South-Eastern Nigeria are generating a high level of concern among researchers and the populace (Obioji and Eze, 2019; Anejionu *et al.,* 2018).

Over the years, several models have been used in assessing soil vulnerability and risk to erosion across the globe such as Dike *et al.,* 2015; Igwe *et al.,* 2020; Odunuga *et al.,* 2018; Haidara et al., 2019; Saha *et al.,* 2019; Surjit, Ravinder & Kaushik, 2015; and Zeghma, 2021. In Ezeagu LGA, Enugu State, soil erosion is a major challenge leading to the loss of fertile topsoil, reduction in agricultural yields, and degradation of natural habitats. In recent years, studies conducted in Ezeagu LGA, Enugu State, focused on the Erodibility index of soils along Ezeagu-Umulokpa road (Okoro et al., 2022) and environmental assessment of gully erosion in parts of Enugu North (Ekwueme et al., 2021). Despite the critical importance of this issue, there is a deficiency of comprehensive, geo-spatially informed assessments that integrate climatic, topographic, soil, and land use data to evaluate soil erosion risk in Ezeagu LGA, Enugu State. This gap in information affects the development and implementation of reliable soil conservation strategies and sustainable land management practices in Ezeagu LGA, Enugu State, hence the drive for this study.

Mapping of soil erosion risk areas in Ezeagu LGA of Enugu state by utilizing remote sensing and Geographic Information System and GIS applications of geospatial technology in mapping soil erosion risk areas to help create detailed maps that identify areas at risk of soil erosion by integrating various data layers such as soil type, land use, topography and rainfall patterns (De Jong *et. al.,* 2019). This is done by developing and integrating rainfall erosivity (R Factor), evaluating soil characteristics (K Factor), assessing topography (LS Factor) and Digital Elevation Models (DEMs), determining cover and management practices (C and P Factors) towards producing soil risk map (Moore & Burch, 2016; Renard *et al.,* 2017; Pimentel *et al.,* 2020).

STUDY METHODOLOGY

Study Area

The study is restricted to Ezeagu Local Government Area of Enugu State, South-Eastern Nigeria. It is situated within the latitude 6°15' 5" to 6°17' 10" N and longitude7°3'25" to 7°23'3" with an area extent of approximately 633.014km square (Ekwueme, *et al.,* 2021) (See Figure 1). Ezeagu LGA is characterized by wet and dry seasons with slightly high temperatures throughout the year. The dry season usually starts from November to March, with minimal rainfall. The temperature is relatively high, with daytime temperatures often exceeding 30°C. The wet season usually starts in April and ends in October with the annual total amount of rainfall ranging between 1,600 mm to 1,800 mm contributing to the LGA lush vegetation and agricultural productivity (Onyemaechi *et al.,* 2019). The soil type predominantly found in Ezeagu LGA includes Ultisols, Alfisols and Inceptisols having limited weathering and moderate fertility, making them suitable for crop production with sustainable soil management (Ekwueme *et al.,* 2021). The characterization of the land use in the area reflects the environmental and socio-economic activities in the area. Agriculture is a predominant land use in Ezeagu LGA, with farmers cultivating various crops such as cassava, yam, maize, vegetables, and fruits. Livestock rearing, including cattle, goats, sheep, and poultry, is common in Ezeagu LGA, contributing to the local economy and food supply (Onyemaechi *et. al.,* 2019). Given the environmental and climatic conditions of the area these land uses exacerbate the risk of soil erosion.

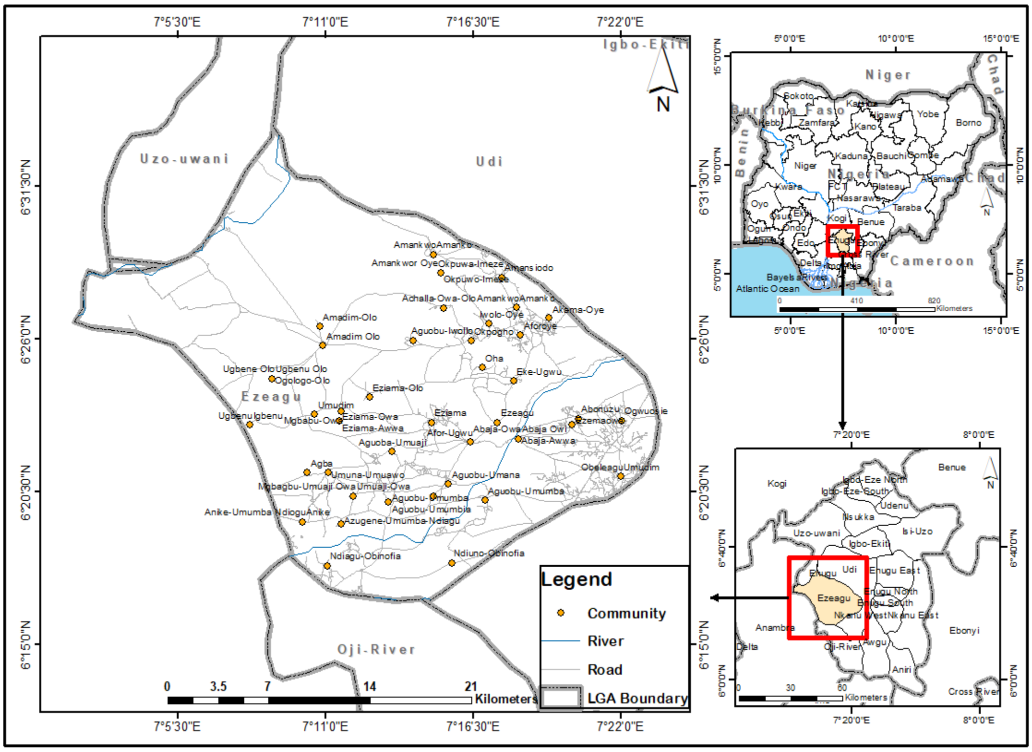

Figure 1 Study Area
Source: Adopted from the Administrative Map of Enugu State (2024).

Research Design

In carrying out this study, a multi-criteria (geo-informatics) research design which is a mixed method investigating variables of soil erosion risk e.g., how different factors, such as rainfall patterns, land use/land cover, soil character and slope determines soil erosion was adopted.

Types, Sources of Data Used and Preparatory Data Analysis
For the conduct of this research, the following types of data will be collected:
i. **Remote sensed images:** Various remote sensing data (Landsat images) of four medium resolution Landsat TM, ETM, and ETM+ images were utilized in detecting land use/land cover types in Ezeagu LGA. The images were obtained from the United State Geological Survey (USGS) website for the same season at 30 meters spatial resolution. The data sets used were geometrically referenced to the WGS 1984, UTM Zone 32N projection system.
ii. Topographic Data: High-resolution DEMs from the United State Geological Survey (USGS) website which were analyzed using the raster surface tool in the ArcGIS to develop the slope of Ezeagu LGA to understand its influence on soil erosion. In line with the erosion model or criteria, the slope was classified indicating different levels of soil erosion risk from a very low-risk area to very high-risk area.
iii. Soil data: Soil map was obtained from local sources and the data was digitized to unveil the terrain and soil characteristics such as texture, structure, organic matter content and permeability for the research area that critical factors in erosion.
iv. Rainfall Data: Rainfall data of Ezeagu LGA was obtained from the Nigerian Meteorological Agency (NIMET) and **https://power.larc.nasa.gov/data-access-viewer/.**

Method of Data Analysis
In achieving the aim of this study, the data obtained were analyzed in line with the research objectives which are thus;
1. Integration analysis was used to classify soil types with other GIS layers, to further refine soil characterization and understand how these factors influence soil distribution and properties. The soil erodibility factor (K Factor) is the function of grain size, drainage potential, structural integrity, organic content and cohesiveness were used. The soil map of the study area was used to develop the K Factor. The soil erodibility map was produced by linking the different types of soil to corresponding K values. The soil types were identified based on organic matter content and texture.

2. Spatial analysis was used to evaluate the factors contributing to soil erosion susceptibility including rainfall patterns, land use/land cover, soil properties, and slope, contributing to the soil erosion risk.
*i. **Rainfall Erosivity (R Factor)***
Rainfall erosivity is the potential of rainfall to cause erosion in an area without protection. R Factor considers both rainfall intensity and kinetic energy of raindrops that fall on the soil and its effects. The rainfall erosivity factor (R) was determined using Leprun's equation;

$$Rx = 0.13 \times (M x^{1.24})$$

Where;
Rx= The rainfall erosivity factor (MJ mm ha^{-1}) (h^{-1} yr^{1}), and
Mx = Annual mean rainfall in mm.
*ii. **Land Use/Land Cover (LU/LC)and Vegetation Index (P Factor)***
The preparation of the P Factor map involved the Landsat satellites image classification Ezeagu LGA to produce the LU/LC. The pre-processing of the images involves the Landsat 8 calibration to digital numbers to physical units, such as sensor radiance and surface reflectance through Landsat calibration and fast one-of-sight atmospheric analysis of spectral hypercubes tools using ENV software. The staking of image bands was done using the stacking-layer tool and mosaicked into a single file. The P Factor was developed by merging the slope map extracted from DEM and LULC.
*iii. **Soil Properties (K Factor)***

Different types of soil depict different degrees of erodibility thereby leading to varied degrees of soil erosion extent. The long-term average rate of soil susceptibility in response to rainfall and runoff is referred to as the soil erodibility factor (K Factor) which given thus;.

K = fcsand·f cl-si ·forgc ·fhisand

Where; K represents erodibility factor (t.ha.hr/ha.MJ.mm)

fcsand = Factor that provides low soil erodibility for soils with high-coarse sand contents and high values for soils with little sand,

fcl-si =Factor that provides low soil erodibility for soil with high clay-to-silt ratio ratios,

forgc = Factor that decreases soil erodibility for soils with high organic carbon content and fhisand = Factor that decreases soil erodibility for soils with extremely high sand content.

*iv. **Slope (DEM)***

The topographical factor depends on the level of slope steepness and length of slope (LS). It is a vital parameter for quantifying erosion generated as a result of the influence of speed and surface runoff.

$$LS = \left(\frac{[V].[Cell\ Size]}{22.13}\right)^{0.4} \left(\frac{[\sin(Q)]}{0.0896}\right)^{1.3}$$

Where;

V is flow accumulation, and

Q is the slope in degrees.

The accumulated slope and flow map were deduced from DEM 30m resolution using Aster-GDEM using ArcGIS 10.8.1.

3. RUSLE model was used to predict annual soil loss. This was assessed using this equation;

A = R x K x LS x C x P.

Where;

A= The average soil loss per unit area (t/ha/year)

R= The Rainfall erosivity factor (MJmm/ha/h/year),

K= The soil erodibility factor (t ha h/ha/MJ/mm)

LS = Topographic factor (dimensionless)

C = Cover and management practice factor (dimensionless) and

P = The conservation support practice factor (dimensionless).

4. The SWAT model was utilized to assess the rate of soil erosion by water and the sediment yield in Ezeagu LGA. It is utilized to assess the influence of land use effects on sediment loading in low-elevated areas. The model considered soil properties such as texture, depth, hydraulic conductivity, and organic matter content, which influence water movement.

The model outputs were used to create maps showing the severity and extent of soil erosion across Ezeagu LGA by highlighting critical areas where soil erosion exceeds sustainable threshold and analysing the spatial distribution of erosion risk and hotspots in relation to rainfall patterns, soil types, topographical features, land use practices, or the lack of effective conservation measures.

5. RUSLE models were used to investigate the impact of anthropogenic activities on soil erosion. Input factors for these models were adjusted based on observed or anticipated changes in land use, agricultural practices and urban expansion.

6. AHP model was employed to identify and map out areas considered at risk of soil erosion in Ezeagu LGA. The risk map classifications with regards to the severity of soil erosion contributory features (slope, soil properties, rainfall pattern, land use, land cover, etc.) used in the development of the model pair-wise comparison matrix using the AHP approach, relative weight calculation, consistency ratio (CR) calculation, and model validation. This involves weighing each factor based on its influence on erosion and integrating them to produce the erosion risk map. To ensure the accuracy of the derived weight for each parameter, the quality of the pair-wise comparison will be assessed using the consistency ratio calculation.

CR = CI/RI

Where RI represents the Random index, and

CI is the consistency Index and it is determined using the equation below

CI = (λmax – n) / (n - 1)

Where;

λmax represents the largest eigenvalue of the matrix

RESULTS

Soil Texture and Soil Erodibility Factor (K Factor)

Loam sand soil dominates the eastern and western parts of Ezeagu LGA while the central part of the study area is dominated by loam soil. Findings from analysis of existing soil databases depict soil classes such as loamy sandy soil with a K factor value of 0.23 – 0.34 (t h MJ^{-1} mm^{-1}), and loam soil with a K factor Value of 0.08 – 0.14 (t h MJ^{-1} mm^{-1}) (Figure 3). Soils with high sand content, generally have higher K-factors due to their poor structure and easy detachability. Areas with soils having high K-factors were identified as more at risk to erosion, particularly under conditions of poor vegetation cover, and intensive agricultural use. Obinna, et al., (2018) observed more areas with higher K factor for the different soil types in the entire South-East of Nigeria as well as Ayadiuno et al., (2021) observed in Anambra state, South-East with higher K values being more susceptible to soil erosion and that areas with lower K values were less susceptible to soil erosion.

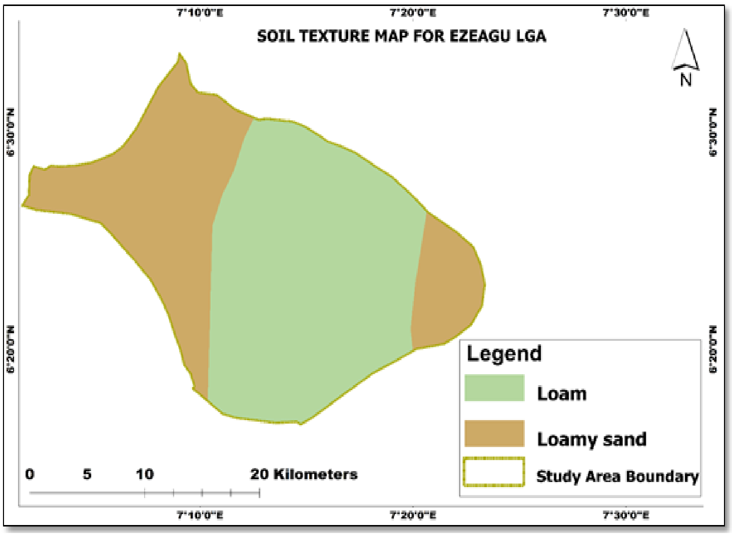

Figure 2: Soil Texture and Soil erodibility factor (K Factor)
Source: Researcher Analysis, 2024.

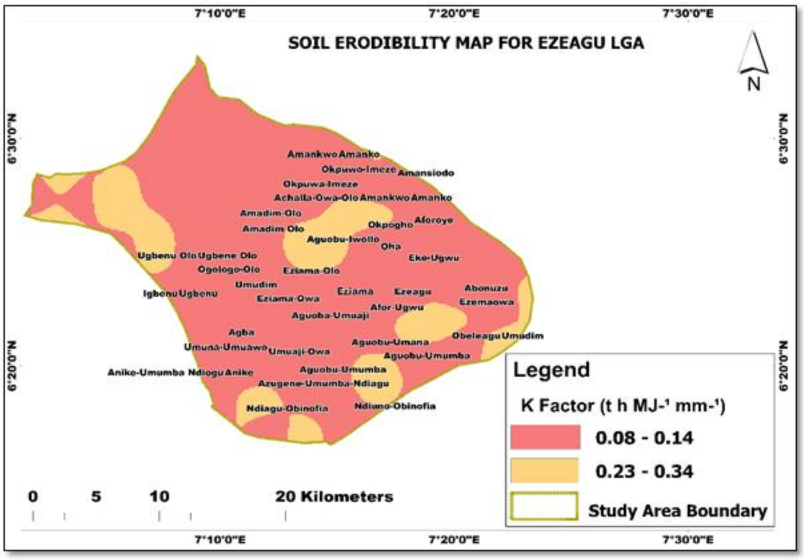

Figure 3: Soil Erodibility (K-Factor) within the Study Area
Source: Researcher Analysis, 2024.

Table 1: Soil Texture and Soil erodibility factor (K Factor)

Soil Type	K factor Value
Loam Soil	0.08 – 0.14
Loamy Sand Soil	0.23 – 0.34

Source: Researcher Analysis, 2024.

Organic Matter (OM)

Organic matter content is important for soil fertility, providing nutrients, improving soil structure, and enhancing moisture retention. Table 2 shows that organic matter concentration of between 2.5-4.2 covered an area of 5,254.29ha (8.30%), organic matter concentration between 1.7 – 2.4 covered an area of 7.310.42ha (11.52%), OM concentration between 0.9–1.6 covered an area of 11.449.39ha (18.89%), OM concentration between 0.5– 0.9 covered an area of 20.874.74ha (32.98%), and OM concentration between 0.5 – 0.7 covered an area of 187412.57ha (29.09%). The average measured organic matter was 0.97 (%) and the organic matter contents for all the soils were rated low in the study area which may be partly because of land use activities. The low organic matter content of the soils was attributed to continuous cultivation and the addition of organic residues and their loss through mineralization. Most of the soil organic matter content in the study area is at a critical level, below the suggested level of 2%, which led to soil structural stability decline and such decline in structural stability increases the susceptibility of the soils to erosion.

Table 2: Organic Matter Concentration in the Study Area

Range of Organic Matter Concentration (%)	Area (ha)	Area (%)
2.5 – 4.2	5,254.29	8.30
1.7 – 2.4	7,310.42	11.55
0.9 – 1.6	11,449.39	18.09
0.5 – 0.9	20,874.74	32.98
0.5 – 0.7	18,412.57	29.09
Total	**63,301.41**	**100**

Source: Researcher Analysis, 2024.

These soils' poor organic matter contents make them loose. Consequently, slides may occur under heavy rainfall, easily detaching the soils (See Table 2 and Figure 4). These findings are in line with that of Okoro et al., (2022) on the erodibility index of soils along Ezeagu-Umulokpa road, Enugu state where they found out that soils with less than 2% of soil organic matter content dominates the study area. Ekwueme, et al., (2021) assessment of gully erosion in parts of Enugu North, found an average soil organic matter content of the soil sampled ranges from 0.17% to 1.81%with less than 3.5% organic matter content i.e. 2% soil organic matter content were considered erodible which is similar to the findings of this study.

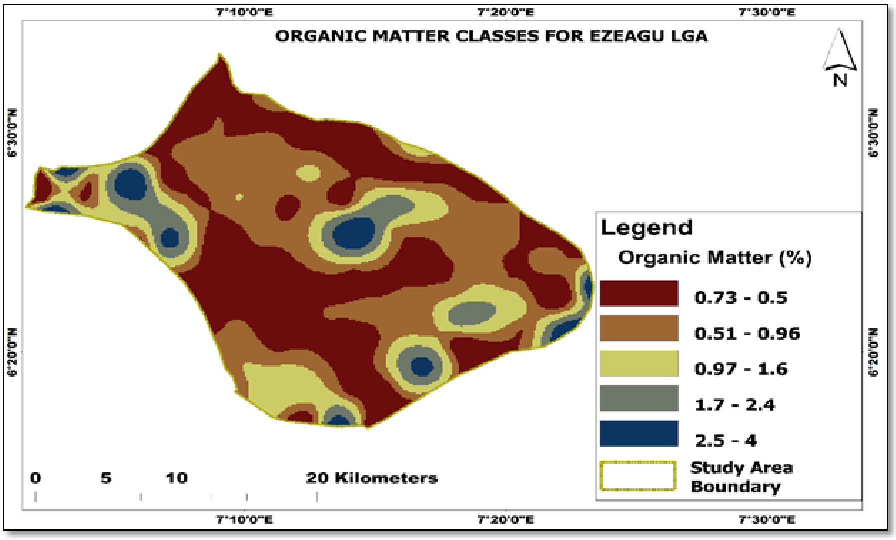

Figure 4: Organic Matter Classes for the Study Area
Source: Researcher Analysis, 2024.

Rainfall Erosivity (R-Factor)

The analysis of the rainfall erosivity factor (R-factor) is crucial for understanding the potential for soil erosion driven by rainfall in the study area. The R-factor as a component of the Revised Universal Soil Loss Equation (RUSLE), was used to estimate the impact of rainfall impact and runoff on soil erosion.

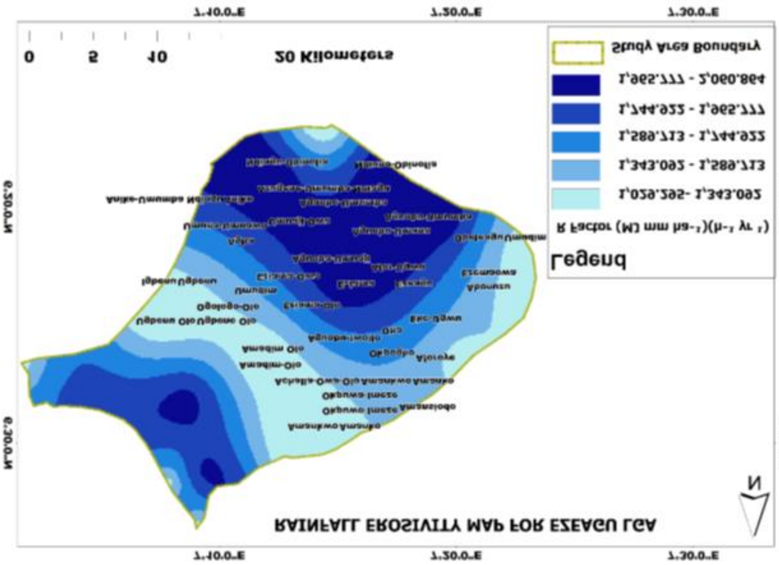

Figure 5: Rainfall Erosivity (R-Factor) within the Study Area
Source: Researcher Analysis, 2024.

The result in Figure 5 shows variations in the R-factor over the study area from 1029.295 to 1343.092, 1343.092 to 1589.713, 1589.713 to 1744.922, 1744.922 to 1965.777, and 1965.777 to 2060.864 MJ mm ha year^{-1}, h^{-1} year^{-1}. For Ezeagu LGA, higher erosivity was found during the peak rainy seasons, specific periods and areas have high erosivity dominantly observed in the south and north-western of the study area (See figure 5). These findings are not farfetched to that of Obinna, *et al.,* (2018) in South-East Nigeria and Ayadiuno *et al.,* (2021), in Anambra State, These changes in the R-factor affect the soil's composition and increase the erosion rate.

Land Use/Land Cover and Vegetation Index (P-Factor)

Based on the land cover types and NDVI values, the P-factor for different areas was estimated. Areas with dense vegetation typically have lower P-factors indicating better protection against erosion, while areas under cultivation, especially those with poor management practices and without cover crops during the off-season show higher P-factors (Figure 6). Areas with lower P Factor (0.5-0.6 and 0.6-0.7) dominate the study area. The P-factor was computed from the slope and LULC, and the slope map extracted from the DEM was merged with values attributed to the different classes its spatial distribution was mapped, and P-factor values ranged from 0.5 to 1. These findings coincides with the observation of Uluocha & Uwadiegwu (2015) in Abia State and Ekwueme *et al.,* (2021) in some parts of Enugu State.

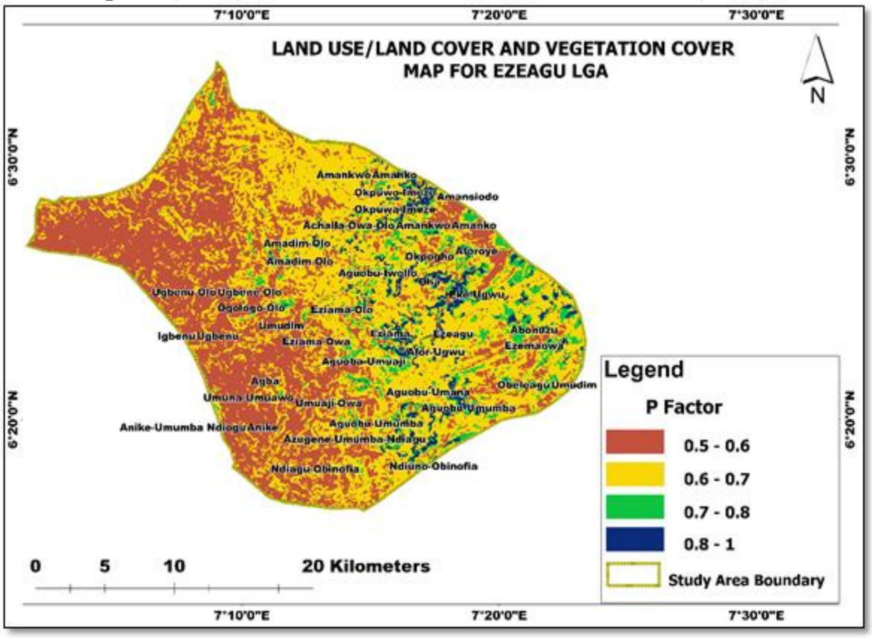

Figure 6: Land Use/Land Cover and Vegetation Cover (P-Factor) within the Study Area
Source: Researcher Analysis, 2024.

Vegetation Cover Management (C-Factor)

The C-factor in soil erosion modelling represents the cover and management factor, which reflects the effect of vegetation and land management practices on soil erosion. Figure 7 depicts that almost all of the areas have a moderate (0.5-0.6) C Factor which means moderate soil protections. Areas with higher protection (between 0.6-1 C Factor) occupy small portion of the eastern part of the study area. Patches of low C Factors are found scattered in the north, west northwest, south and eastern parts of the study area. A lower C Factor indicates less effective cover and management, meaning there's less protection for the soil against erosion. The findings agreed with the study of Uluocha & Uwadiegwu (2015) in Abia State and Ekwueme et al., (2021) in parts of Enugu North where they observed that most areas are dominated with moderate C factors but steep slope areas, areas with less vegetation and intense androgenic activities have higher C factors as equally observed in this study.

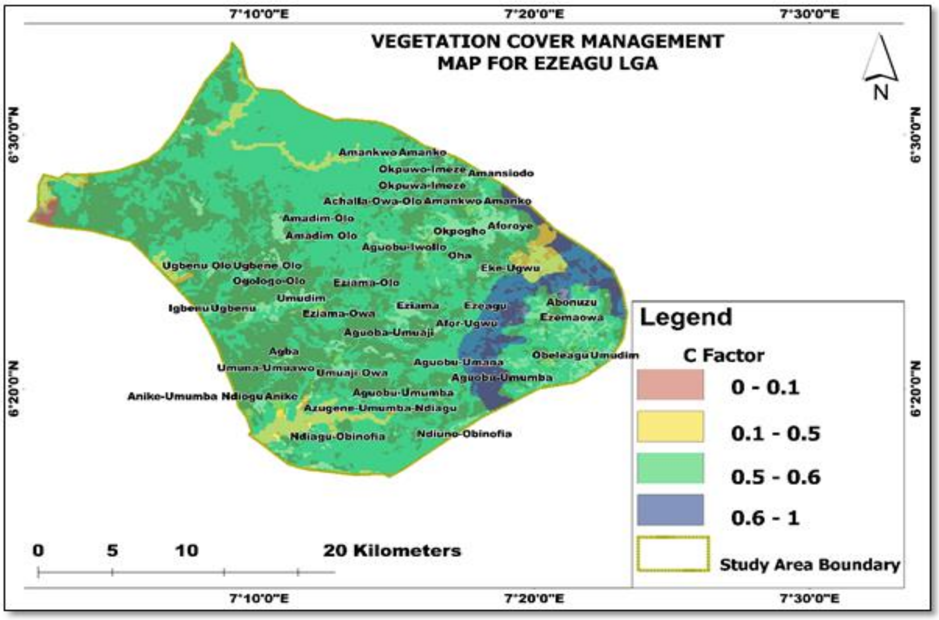

Figure 7: Vegetation Cover Management (C-Factor) within the Study Area
Source: Researcher Analysis, 2024.

Slope Steepness and Slope Length (LS-Factor)
The analysis of the slope steepness and slope length factor (LS factor) quantifies the effect of topography on erosion rates. A higher LS factor indicates a higher risk and potential rate of erosion due to the impact of slope gradient and length. The findings of this study depict that the eastern part of the study area is more susceptible to soil erosion with value ranging from 3.2-5.8, 5.9-9.9 and 10.0-19 (Figure 8a and 8b). Slope steepness and slope length is lower in the northern, western and south-west of the study area.

Table 3. Slope Steepness and Slope Length (LS-Factor) Within the Study Area

Slope Range (degrees)	Area (ha)	Percentage (%)
0.1 – 1.4	17,150.22	27.09
1.5 – 3.1	10,627.17	16.79
3.2 – 5.8	14,534.62	22.69
5.9 – 9.9	9,112.91	15.60
10.0 – 19.01	11,112.37	17.56
Total	**63,301.41**	**100**

Source: Researcher Analysis (2024)

Table 3 depicts a LS Factor of 0.1 to 1.4 covering 17,150.22ha (27.09%) of the total land area, followed by areas with 1.5 to 3.1 with 10,627.17ha (16.79%), 3.2 to 5.8 covers 14,534.62ha (22.69%), 5.9 to 9.9 covers 9,112.91ha (15.60%), and while areas with slope range between 10.0 to 19.01 occupies 11,112.37ha (17.56%) of the total area. Areas with steep slopes and long slope lengths were identified as hotspots where soil erosion prevention and control measures are most needed. Ekwueme *et al.,* (2021) and Ayadiuno, *et al.,* (2021) affirmed that steep land has more potential for soil erosion than flat land.

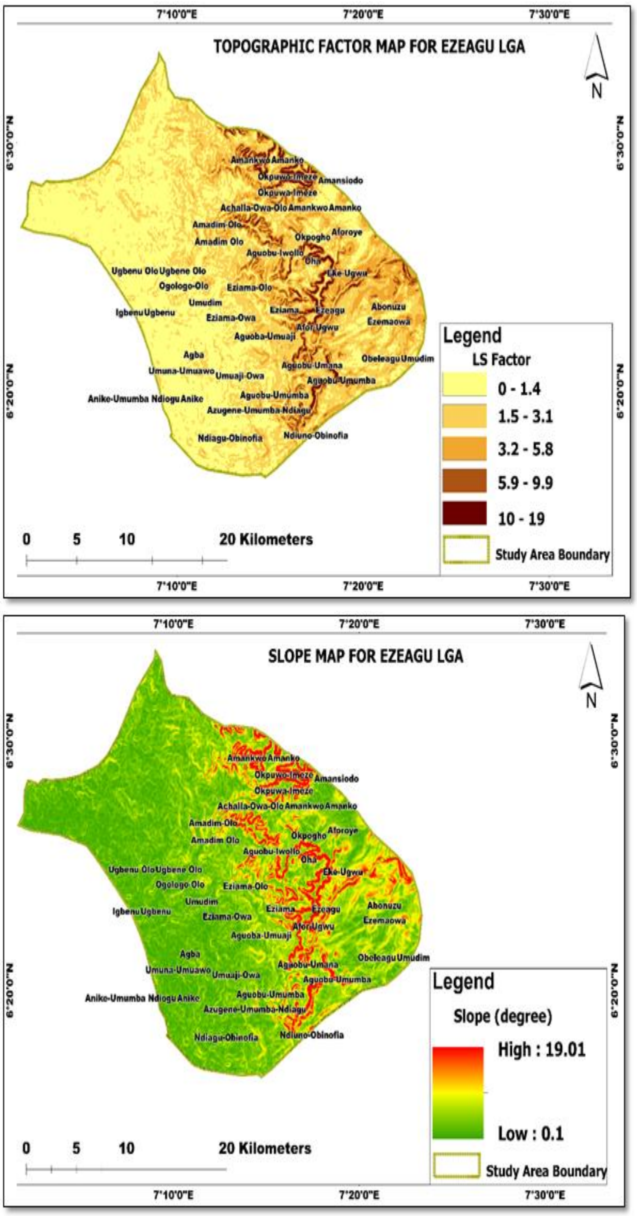

Figure 8a&b: Slope Steepness and Slope Length (LS-Factor) within the Study Area
Source: Researcher Analysis, 2024.

The Annual Soil Loss in the Study Area

Revised Universal Soil Loss Equation (RUSLE) model incorporated with Rainfall erosivity (R-Factor), Land use/land cover and vegetation index (P-Factor), Soil Erodibility (K-Factor), Topography (LS-Factor), Vegetation Cover Management (C-Factor), were combined to generate average annual soil loss with the study area.

Table 4: Average Annual Soil Loss in the Study Area.

Annual Soil Loss (gram)	Area (ha)	Percentage (%)
0 – 10	17,250.39	27.25
10 – 20	14,331.07	22.64
20 – 30	7,455.02	11.78
30 – 40	15,615.88	24.67
>40	8,649.05	13.66
Total	**63,301.41**	**100**

Source: Researcher Analysis, 2024.

Figure 9 and Table 4 depicts categorized degrees of erosion risk, highlighting critical areas with soil loss of between 0 to 10 grams annually covering a total land area of 17,250.39ha (27.25%), 10 to 20 grams of soil loss with 14,331.07ha (22.64%), 20 to 30 covers a total area of 7,445.02ha (11.78%), 30 to 40 covers 15,615.88ha (24.67%), and while areas with soil loss of >40 grams covered a total land of 8,649.05ha (13.66%). Areas with annual soil loss between 0 to 10 grams, 10 to 20 grams and 30 to 40 grams dominate the northern, western and southern part of the study area. These findings are contrary to that of Emeribeole, and lheaturu, (2015) but affirm the part of the findings of Uluocha & Uwadiegwu (2015) in Abia State where they observed that areas with annual soil loss between 0 to 10 grams and 10 to 20 grams dominating.

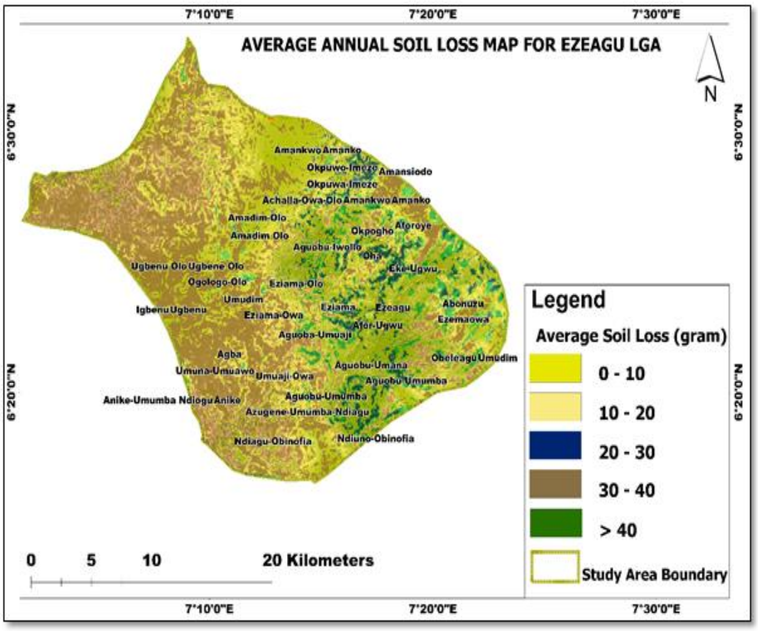

Figure 9: Slope Map of the Study Area
Source: Researcher Analysis, 2024.

Erosion Risk Map of the Study Area

Soil erosion risk map, combines vulnerability with the potential consequences of erosion. It not only considers the likelihood of erosion but also evaluates the impact of erosion on the environment. The erosion risk map of the study area was classified into five risks classes (Table 5 and Figure 10) depicting that very low-risk areas covered 15,230.12ha (24.06%) of the total land area, low-risk covers 12,842.11ha (20.29%), moderate risk occupies 11,234.30ha (17.75%), and high-risk erosion prone areas covers 13,482.51ha (21.30%), while very high risk occupies 10,512.37ha (16.61%) of the total area. Generally, the study area can be considered to be at risk of soil erosion with over 55% of the area at risk of soil erosion. Specific areas identified as significantly higher erosion risk may be attributed to steeper slopes, poor vegetation cover, weaker soil structures, rainfall characteristics and land use activities. The findings of this study shows the same pattern as the observations of Ajibade, et al., (2020), in Anambra State and Uluocha & Uwadiegwu (2015) in Abia State linking high soil erosion risk to steeper slopes, poor vegetation cover, weaker soil structures, rainfall characteristics and land use activities.

Table 5. Soil Erosion Risk Levels

Erosion Risk Levels	Area (ha)	Percentage (%)
Very Low Risk	15,230.12	24.06
Low Risk	12,842.11	20.29
Moderate Risk	11,234.30	17.75
High Risk	13,482.51	21.30
Very High Risk	10,512.37	16.61
Total	**63,301.41**	**100**

Source: Researcher Analysis, 2024.

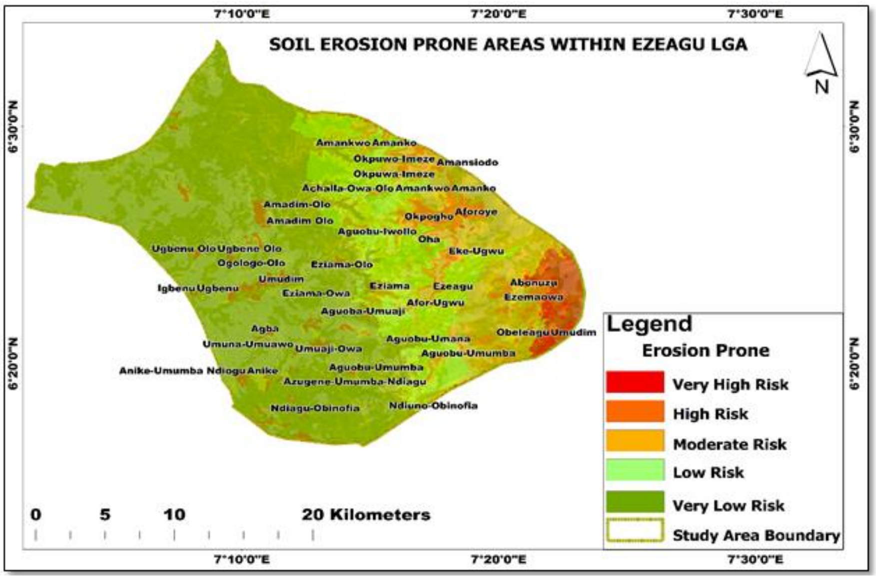

Figure 10: Soil Erosion Risk Map of the Study Area
Source: Researcher Analysis, 2024.

Conclusion and Recommendations

This study on soil erosion risk mapping in Ezeagu Local Government Area of Enugu State, Nigeria concludes that given the fact that the study area is dominated by loam and loamy sand soil the erodibility factor of 0.23 to 0.34 was glaring which implies a high tendency of erodibility. Places with soils having high K-factors were identified as more at risk of erosion, particularly under conditions of poor vegetation cover, and intensive agricultural use, areas with soils with less than 2% of soil organic matter content, areas with lower P Factor (0.5-0.6 and 0.6-0.7) dominates the study area. It can be concluded that almost all the area has moderate protections against soil erosion with a 0.5-0.6 C factor of which the eastern part of the study area is more susceptible to soil erosion with areas with annual soil loss between 0 to 10 grams, 10 to 20 grams, 30 to 40 grams dominating the northern, western and southern part of the study area. Generally, Ezeagu Local Government Area of Enugu State can be considered be at risk to soil erosion with over 55% of the area at risk of soil erosion. Specific areas identified as significantly higher erosion risk are attributed to steeper slopes, poor vegetation cover, weaker soil structures, rainfall characteristics and land use activities.

Based on the conclusion of this study on soil risk mapping in Ezeagu Local Government Area of Enugu State in Nigeria the following recommendations were made;

i. Encourage the use of structural interventions such as terracing and gabions in areas identified at risk of soil erosion. These can help reduce runoff velocity and soil displacement.
ii. Promote the adoption of agronomic soil conservation techniques, including mulching, cover cropping, and the use of perennial vegetation to enhance soil stability and reduce erosion.

iii. Initiate reforestation and afforestation programs in erosion-prone areas. Planting trees and shrubs can significantly reduce soil loss by stabilizing the soil and increasing water infiltration.
iv. Support agroforestry practices that integrate trees and shrubs into agricultural landscapes, providing economic benefits while enhancing soil stability.
v. Establish a monitoring system using remote sensing and GIS technologies to continually assess soil erosion dynamics and the effectiveness of existing management practices.

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