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Evaluation of Rainfall Erosivity and Soil Erodibility in Agbor, Delta State, Nigeria Using the RUSLE Model in GIS

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Abstract: *This research work focuses on the determination of rainfall erosivity and soil erodibility in Agbor, Ika-South Local Government Area, Delta State, Nigeria applying Ruscle model in conjunction with geographical information system (GIS) techniques. Reconnaissance survey was conducted in the study area and soil samples were collected randomly at 150 meters apart. The longitudinal/latitudinal positions of the sample sites were obtained together with their corresponding heights above sea level using global positioning system (GPS). A total of 23 soil samples were collected within the study area and subjected to standard soil tests to obtain parameters for soil erodibility factor (K). Rainfall data covering a period of 10 years 2011 to 2021 was analyzed to obtain the rainfall erosivity factor (R). All these factors were synchronized in the raster calculator of the ArcGIS 10.8 interface using RUSLE model to generate standardized maps for the RUSLE. This research area showed a notable spatial range in rainfall erosivity, with the maximum erosivity value being 631.39 MJ mm ha^{-1} h^{-1} yr^{-1} and the lowest being 563.28 MJ mm ha^{-1} h^{-1} yr^{-1} while the soil erodibility values for the sample locations vary between 0.2935 to 0.5387 [t h MJ -¹mm -¹]. With highest value in location SID_7 Sakapoba and lowest in location SID_17 Imudia St.*

Keywords: *Soil, Soil Loss, Soil Erosion, Geographical Information System, RUSLE Model*

INTRODUCTION

Water-induced soil erosion is the primary cause of soil degradation and depreciation worldwide thereby reducing soil quality and performance. It manifests as gullies, tunnels, splash/interrails, rills, stream banks, and coastal erosion (Blanco, 2010). Erosion is a fully natural process that occurs throughout geological time and has a significant impact on the earth's topography resulting in the development of sediments. Uncontrollable soil losses brought on by this increased erosion could have detrimental effects on the economy, natural ecosystems, human health, and the climate (Konstantinos *et al.*, 2019). It has been believed that soil erosion is a natural geological occurrence that happens when soil particles are carried away by gravity, wind, water, and ice. Today, soil resources and productive potential are being depleted because of the rate of soil erosion surpassing the rate of soil formation over large areas (Toy *et al.*, 2002).

An estimated $400 billion is lost annually due to the eroding of 75 billion tons of soil from agricultural lands worldwide, according to the Food and Agricultural Organization (FAO)led Global Soil Partnership. Montgomery (2003) asserts that soil deterioration is a global issue. According to engage in a variety of soil related activities, which subsequently cause the soil to deteriorate through landslides and soil erosion (Olori, 2006).Similar to this, erosion is primarily categorized according to the erosive agents that produce it, which are water and wind (Yu *et al.,* 2010).According to Suresh and Chandrashekara (2012), water erosion is the process by which soil is removed by precipitation flowing over an exposed surface. Raindrops strike exposed soil hard enough to shatter soil clumps to produce dislodged soil particles. The pieces wash into the soil's pores because of this separation, keeping water from penetrating the soil. Water then builds up on the surface and promotes runoff, which carries dirt with it. Wind erosion is the process by which soil particles are dislodged, detached, moved, transported, and eventually deposited from one location to another due to the influence or impact of wind. Localized blowout or almost all uniform layers may be used for the removal and re-deposition. According to Yu *et al.* (2010), sheet, rill, stream bank, and gully erosion are the different types of water erosion. The movement of soil caused by splashing raindrops and runoff water is known as sheet erosion. Yu *et al.* (2010) states that the idea of progressive erosion severity serves as the foundation for the classification of sheet and rill erosion. The projected dimensions of the rill are 50 to 150 mm deep and 100 to 300 mm wide (Tesfamichael, 2004). When surface water concentrates, tiny yet distinct channels are created, leading to this type of water erosion (McDonald, 2010). Gully erosion is the term used when rills go deeper than 0.3 meters. The overall amount of water erosion on the landscape's overland flow zones is known as inter-rill and rill erosion. Steenhuis (2019) asserts that riling is among the most prevalent types of erosion. Gully erosion happens when runoff water builds up and swiftly flows in small channels during or right after intense rains, removing soil to a significant depth (Reubens *et al.,* 2007). Gully erosion is one of the most damaging soil/land erosion processes, according to Rădoane and Rădoane (2017). In a short amount of time, runoff removes the topsoil and the underlying unconsolidated rock substrate, creating a steep sided channel deeper than 2 meters with an abrupt gully head cut and multiple thresholds in the channel. Additionally, gully eroded soil can harm infrastructure by burying fence lines, obstructing streams, and silting them up. Similarly, soil erosion is influenced by four main variables. These include land usage, geography, soil type, climate, and agricultural conservation techniques. Because topography is influenced by geology, which in turn can affect climate, these elements are interdependent. Numerous factors influence the likelihood of erosion, such as the type of soil, slope, and the force or energy of precipitation anticipated during the surface disturbance period (Ezemonye and Emeribe, 2012).The Ephemeral Gully Erosion Model (EGEM), which was created especially to predict soil loss, is one of many soil erosion models that have been developed in the study of soil erosion to help quantify soil loss by erosion, make appropriate decisions on how to manage soil erosion, and offer solutions to the problems created by soil erosion. The Revised Universal Soil Loss Equation (RUSLE) is a lumped empirical model that does not separate factors that influence soil erosion, such as plant growth, decomposition, infiltration, runoff, soil detachment, or soil transport (Spaeth *et al.,* 2003).

In general, erosion can also have negative economic impacts on businesses in Agbor, causing poor crop yield and reduced patronage, destruction of public utilities, and disruption of transport infrastructures. High velocity runoff also causes continuous erosion in built-up areas. Therefore, an evaluation of the potential rate of soil erosion is helpful in designing soil conservation strategies within the framework of integrated watershed management (Gunawan *et al.,* 2013). There is a great need to assess soil erosion in Agbor, Delta State-Nigeria to map the extent of soil loss, estimate the volume of soil loss and land degradation within the area. This study will ascertain any significant relationship between the effects of soil erosion and the level/rate of settlement development in the study area. This study will also look at the factors responsible for the degradation of the natural environment especially in Agbor, Delta State and offer suggestion(s) on the causes of soil erosion and its advance effect on settlement development. Also, the climatic factors of the study area will be examined to determine the extent to which soil erosion is triggered and eventually degraded. The main objective of this research therefore is to determine the rainfall erosivity factor/index (R) and soil erodibility factor (K) for Agbor and its environs using the revised universal soil loss equation principles.

MATERIALS AND METHODS

2.1 Materials

The following materials were used:

Hardware: NASA/POWER CERES/MERRA2 sensor: The data used for the determination of the rainfall erosivity factor (R), is a ten-year period data for mean monthly rainfall amount, duration of mean monthly rainfall and number of days of rainfall all obtained from NASA/POWER CERES/MERRA2 sensor.

Global Positioning System (G.P.S): To determine spot heights (heights above mean sea level) at boundary locations within the study area.

Lenovo T460: Used for analysis using different software.

ArcGIS 10.8 Software: It was used to generate thematic maps for each of the RUSLE parameters generated.

Raster Calculator: It was used to generate the maps of each parameter in layers and each of the layers was overlaid using colour composite analysis.

Software: ArcMap 10.8, Microsoft Office Suite (Microsoft word): used for different analysis and visualization.

Data: Digital Elevation Model (D.E.M), Rainfall Data, Sentinel II, Satellite Imagery

2.1.1 Description of Study Area

The study area, Agbor, is located within Latitude 6.264092 and Longitude 6.201883 and spans approximately 1000 km^2. The wet season in Agbor is typically warm, muggy, and overcast, while the dry season is typically hot and partly cloudy. Throughout the year, the temperature typically ranges between 18ºC and 30.5ºC, with the occasional temperature below 14ºC or above 33ºC. The cloudier part of the year starts around February 11 and lasts for 9 months, ending around November 13. The rainy season lasts for 10 months, from February to December, with a sliding 31day rainfall of at least 12. 7mm.June and September mark the height of the rainy season. Over the course of the year, Agbor's average hourly wind speed varies significantly by season. The four months from June to September are the windiest times of the year, with average wind speeds exceeding 5.4 miles per hour. With an average hourly wind speed of 6.8 miles per hour, August is the windiest month of the year in Agbor.

2.1.2 Vegetation of Study Area

Typically, Niger Delta consists of mangrove, lowland rainforest, freshwater forest and aquatic habitat. These provide as plentiful rare natural resources to the indigenous people of the region and West African economy at large. One of Nigeria's many intricate natural zones is the lowland rainforest. According to Ayanlade (2014), tall trees make up the rainforest zone's first layer, or stratum, which is distinguished by dense forest; second, or stratum, which consists of plants with high branches that are 2035 meters tall and can offer shade; third, or stratum, which consists of plants that are 20 meters tall; and fourth, or stratum, which consists of mosses, small-stemmed shrubs, lichens, herbs, and ferns.

2.1.3 Geology of Study Area

The study area is underlaid with the Benin Formation. This formation is the youngest lithostratigraphic unit of the tripartite subdivision of the Niger Delta. The Niger Delta is essentially a Paleogene-Recent basin which began progradation during late Eocene times. The clastic fills of the Niger Delta and other coastal sedimentary basins in Nigeria developed because of alternations between transgressive and regressive phases (Emeka *et al.,* 2023). The subsurface geology of Delta State which is part of the Niger Delta Basin is depicted in Fig. 1. The basin fill is made up of three formations, namely from the oldest to the youngest, Akata, Agbada, and Benin formations. Textural characteristics and sedimentary structures have presented indispensable tools for interpretation of the mechanisms of sediment transport, sedimentary processes and depositional environment of the Benin Formation. The continental Miocene-Recent Benin Formation conformably overlies the Agbada formation. It is composed of more than 90% sands and about 10% shale/clays. The sands range in size from gravelly, coarse to fine grained. They are also poorly sorted, sub-angular to well-rounded, and bear lignite streaks and wood fragments. The Benin formation occurs just west and northwest of Asaba town (Esi, 2011) and this extends into Agbor town.

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The Benin Formation is beneath the study area. The Niger Delta's tripartite subdivision's youngest lithostratigraphic unit is this formation. In essence, the Niger Delta is a Paleogene. Recent basin that started to degrade in the late Eocene. Alterations between transgression and regressive stages led to the development of the clastic fills of Nigeria's coastal sedimentary basins, including the Niger Delta (Emeka *et al.,* 2023). Fig.1 shows the subsurface geology of Delta State, which is a portion of the Niger Delta Basin. The Akata, Agbada, and Benin formations are the three oldest to youngest formations that make up the basin fill. To analyze the mechanics of sediment transport and sedimentary processes, textural features and sedimentary structures have proven to be invaluable resources. Recent Benin Formation, which is located just west and northwest of Asaba town (Esi, 2011) and extends into Agbor town. The Benin formation is made up of over 90% sands and roughly 10% shale/clays, with sands that range in size from gravelly to fine grained, poorly sorted, sub-angular to well-rounded, and bearing lignite streaks and wood fragments.

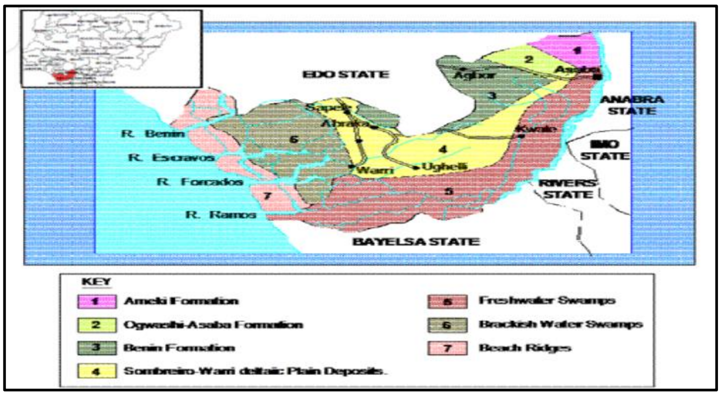

Fig. 1 Geological map of Delta State (Esi, 2011)

2.2 Methods

2.2.1 Determination of RUSLE Parameters

Soil erosion is estimated as the product of six major erosion factors (climatological, pedological, topographic, land cover, anthropogenic), which values can be expressed numerically in Equation (1).

$$A = R.K.L.S.C.P \quad (1)$$

Where,

R = the rainfall erosivity [MJ mm ha−1h−1yr^{-1}], also known as the R-factor, which is the primary driver of erosion and depends on the dynamics of snow cover, air temperature, and precipitation rate.

A= Average annual soil loss [T/ha/yr]

K= K is the soil erodibility [t ha h ha−1MJ−1mm^{-1}], also called K-factor, which describes the soil properties (i.e. soil structure and organic matter content) that influence the predisposition of soil to erosion.

LS is a dimensionless combined parameter, also called LS-factor, that describes the impact of slope length and slope steepness on soil erosion

C is a dimensionless parameter, also called C-factor, that describes how land-use and land-cover that protect the soil from erosion (lower C-factor values correspond to higher protection, thus to lower erosion)

P is a dimensionless parameter, also called P-factor, that describes the impact of soil conservation practices to reduce the potential erosion.

2.2.2 Soil Erodibility Factor (K)

The letter K stands for soil erodibility, which is defined by Kamaludin *et al.* (2013) as indicated in Equation (2) and is defined as the soil's resistance to both detachment and transport (Idah and Musa, 2008). It is also referred to the soil's susceptibility or vulnerability to erosion and runoff.

$$K = [\, 2.1 \, * \, 10^{-4} \, (12 - OM\%)(N1 * N2)(N1 * N2)^{1.14} + 3.25(S - 2) + 2.5(P - 3)]/100 \quad (2)$$

Where:

OM = organic matter content (%)

N1 = clay + very fine sand (0.002-0.125mm)

N2 = clay + very fine sand + sand (0.125-2.000mm)

S = Soil structure group or code
P = hydraulic conductivity (cmh-1) or permeability class.

2.2.3 Determination of Rainfall Erosivity Factor (R)

This is known as rainfall's capacity to disturb, separate, move, and ultimately deposit soil (Egboka *et al.,* 2019). It depends on the features/parameters of the rainfall, including its distribution, amount, duration, etc. According to Campos-Herrera *et al.* (2022); Suresh and Chandrashekara (2012); Oliviera et al. (2020), as indicated in Equation (3), this component is typically denoted by the letter (R).

$$R = {EI_{30}}/{170.2} \quad (3)$$

$$E = 9.28P - 8838.15 \quad (4)$$

Where:
R= Rainfall erosivity factor (MJ mm ha-1 h-1 yr^{-1})
E = Total storm kinetic energy (MJ/Ha)
I_{30}= 30 minutes rainfall intensity (mm/hr)
P = Annual rainfall (mm)
From the above equation to obtain the kinetic energy of the storm or rainfall events the relationship is given by Tey (2011) as shown in Equation (5).

$$R = \frac{2.5P^2}{100(0.073P+0.73)} \quad (5)$$

The data used for the determination of the rainfall erosivity factor (R), is a ten-year period data for mean monthly rainfall amount, duration of mean monthly rainfall and number of days of rainfall all obtained from NASA/POWER CERES/MERRA2 sensor. The R factor was extracted for the individual sample points using the extract values to points from the ArcMap 10.8 tool. The rainfall data of Agbor was generated from the hundred data points using the Inverse distance Weight interpolation method thereafter incorporating equation 2.4 into the raster calculator.

2.2.4 Use of GIS Software to Generate Maps for RUSLE Parameters

Thematic maps were created for rainfall erosivity factor (R) and soil erodibility factor (K) using ArcGIS 10.8 software. The data for the parameters were generated in layers based on field observation, while the raster calculator performed the calculations and color composite analysis was performed to overlay each layer to develop the map. The software examined information based on the location, characteristics, and configuration or interaction of various objects within the study area.

RESULTS AND DISCUSSION

3.1 Rainfall Erosivity Factor (R): The annual average rainfall data for Agbor and environs was acquired for a period of 10 years, from the NASA/POWER CERES/MERRA2 sensor 2011 to 2021, for 100 data point at a granulated scale presented in Table-1.

Table-1 Mean Monthly Precipitation data for all sample locations in Agbor

SAMPLE_ID	LONGITUDE	LATITUDE	Annual Average Precipitation 2011-2021 (mm)
P 0	6.14466	6.21982	1853.60
P 1	6.1533298	6.2197599	1853.60
P 2	6.1619902	6.2197099	1853.60
P 3	6.17066	6.2196598	1853.60
P 4	6.1793299	6.2196102	1853.60
P 5	6.1880002	6.2195601	1853.60
P 6	6.1966701	6.2195001	1853.60
P 7	6.2053399	6.21945	1853.60
P 8	6.2140002	6.2193999	1853.60

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P 9	6.2226701	6.2193499	1853.60
P 10	6.14469	6.2259498	1853.60
P 11	6.1533599	6.2258902	1853.60
P 12	6.1620302	6.2258401	1853.60
P 13	6.1707001	6.22579	1853.60
P 14	6.1793699	6.22574	1853.60
P 15	6.1880398	6.2256899	1853.60
P 16	6.1967101	6.2256298	1853.60
SAMPLE_ID	LONGITUDE	LATITUDE	Annual Average Precipitation 2011 to 2021(mm)
P 17	6.2053699	6.2255802	1853.60
P 18	6.2140398	6.2255301	1853.60
P 19	6.2227101	6.2254801	1853.60
P 20	6.1447301	6.23208	1853.60
P 21	6.1533999	6.2320199	1853.60
P 22	6.1620698	6.2319698	1853.60
P 23	6.1707401	6.2319198	1853.60
P 24	6.17941	6.2318702	1853.60
P 25	6.1880698	6.2318201	1853.60
P 26	6.1967402	6.23176	1853.60
P 27	6.20541	6.23171	1853.60
P 28	6.2140799	6.2316599	1853.60
P 29	6.2227502	6.2316098	1853.60
P 30	6.1447701	6.2382102	1853.60
P 31	6.15344	6.2381501	1853.60
P 32	6.1620998	6.2381001	1853.60
P 33	6.1707702	6.23805	1853.60
P 34	6.17944	6.2379999	1853.60
P 35	6.1881099	6.2379498	1853.60
P 36	6.1967802	6.2378898	1853.60
P 37	6.2054501	6.2378402	1654.72
P 38	6.2141199	6.2377901	1654.72
SAMPLE_ID	LONGITUDE	LATITUDE	Annual Average Precipitation 2011-2021(mm)
P 39	6.2227898	6.23773	1654.72
P 40	6.1448002	6.2443399	1654.72
P 41	6.15347	6.2442799	1654.72
P 42	6.1621399	6.2442298	1654.72
P 43	6.1708102	6.2441802	1654.72
P 44	6.1794801	6.2441301	1654.72
P 45	6.1881499	6.2440801	1654.72
P 46	6.1968198	6.24402	1654.72
P 47	6.2054901	6.2439699	1654.72
P 48	6.21415	6.2439198	1654.72
P 49	6.2228198	6.2438598	1654.72
P 50	6.1448398	6.2504702	1654.72

P 51	6.1535101	6.2504101	1654.72
P 52	6.1621799	6.25036	1654.72
P 53	6.1708498	6.2503099	1654.72
P 54	6.1795201	6.2502599	1654.72
P 55	6.18819	6.2502098	1654.72
P 56	6.1968498	6.2501502	1654.72
P 57	6.2055202	6.2501001	1654.72
P 58	6.21419	6.2500501	1654.72
P 59	6.2228599	6.24999	1654.72
P 60	6.1448798	6.2565999	1654.72
SAMPLE_ID	LONGITUDE	LATITUDE	Annual Average Precipitation 2011-2021(mm)
P 61	6.1535501	6.2565398	1654.72
P 62	6.16221	6.2564902	1654.72
P 63	6.1708798	6.2564402	1654.72
P 64	6.1795502	6.2563901	1654.72
P 65	6.18822	6.25634	1654.72
P 66	6.1968899	6.2562799	1654.72
P 67	6.2055602	6.2562299	1654.72
P 68	6.2142301	6.2561798	1654.72
P 69	6.2228999	6.2561202	1654.72
P 70	6.1449099	6.2627301	1654.72
P 71	6.1535802	6.26267	1654.72
P 72	6.16225	6.26262	1654.72
P 73	6.1709199	6.2625699	1654.72
P 74	6.1795902	6.2625198	1654.72
P 75	6.1882601	6.2624602	1654.72
P 76	6.1969299	6.2624102	1654.72
P 77	6.2055998	6.2623601	1654.72
P 78	6.2142701	6.26231	1654.72
P 79	6.22294	6.2622499	1654.72
P 80	6.1449499	6.2688599	1654.72
P 81	6.1536198	6.2687998	1654.72
P 82	6.1622901	6.2687502	1654.72
SAMPLE_ID	LONGITUDE	LATITUDE	Annual Average Precipitation 2011-2021(mm)
P 83	6.1709599	6.2687001	1654.72
P 84	6.1796298	6.2686501	1654.72
P 85	6.1883001	6.26859	1654.72
P 86	6.19697	6.2685399	1654.72
P 87	6.2056398	6.2684898	1654.72
P 88	6.2143002	6.2684398	1654.72
P 89	6.22297	6.2683802	1654.72
P 90	6.14499	6.2749901	1654.72
P 91	6.1536598	6.27493	1654.72
P 92	6.1623302	6.2748799	1654.72

P 93	6.171	6.2748299	1654.72
P 94	6.1796598	6.2747798	1654.72
P 95	6.1883302	6.2747202	1654.72
P 96	6.197	6.2746701	1654.72
P 97	6.2056699	6.2746201	1654.72
P 98	6.2143402	6.27457	1654.72
P 99	6.2230101	6.2745099	1654.72

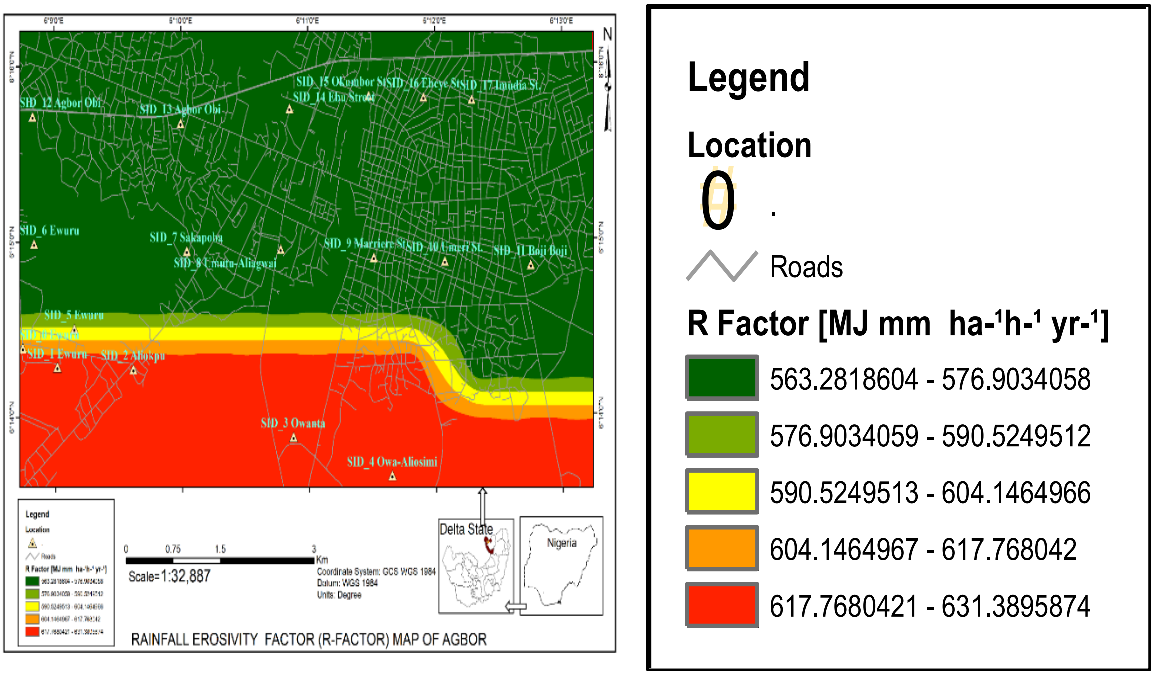

Fig. 1 Rainfall erosivity factor (R) map for Agbor

Applying Equation (3) for determining R factor), the precipitation values ranged from 1654.723mm to 1853.604mm. The map as shown in Figure 3.1 shows that the rainfall erosivity values is higher at data points where the rainfall quality and intensity is higher within the period of investigation. For varying intensities of rainfall, the values of erosivity were obtained and divided into the following five classes: 563.28 – 576.90 MJ mm $ha^{-1}\ h^{-1}\ yr^{-1}$, 576.90 – 590.52 MJ mm $ha^{-1}\ h^{-1}\ yr^{-1}$, 590.52 – 604.15 MJ mm $ha^{-1}\ h^{-1}\ yr^{-1}$, 604.15 – 617.77 MJ mm $ha^{-1}\ h^{-1}\ yr^{-1}$, 617.77 – 631.39 MJ mm $ha^{-1}\ h^{-1}\ yr^{-1}$. Additionally, based on Table 3.1, the study area can be categorized as having medium-strong erosivity. This is because the study area falls within the tropical rainforest region which is characterized by heavy downpours during the rainy season (Okorafor *et al.,* 2019). Generally, all states saw the extremely low erosivity (563.28 – 576.90) between November and February, which corresponds with the dry season months in southeast Nigeria (Ezemonye and Emeribe, 2012). This further demonstrates the significant erosive effect of raindrop impact. June and September were the rainy season peak times when the high erosivity indices were observed. All the stations' mean monthly distributions of storm kinetic energy were found to be erosive from April to October, which is consistent with the pattern of the erosivity index. This implies that the rainy seasons in Southeast Nigeria are linked to very intense rainfall that cause erosion. This research area showed a notable spatial range in rainfall erosivity, with the maximum erosivity value being 631.39 MJ mm $ha^{-1}\ h^{-1}\ yr^{-1}$ and the lowest being 563.28 MJ mm $ha^{-1}\ h^{-1}\ yr^{-1}$. In Agbor and environs, the annual average rainfall erosivity was estimated from the year 2011 to 2020. The ability of the rain's kinetic energy to cause erosion produced positive results, indicating that in disturbed conditions, the rains will greatly accelerate erosion by causing the soil material in the study region to detach.

3.2 Soil Erodibility Factor (K)

The soil erodibility factor (K) for all the locations is presented in Table-2.

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Table-2 Soil erodibility factor (K) for Agbor and environs

LOCATION	Longitude	Latitude	K_FACTOR [t h MJ-¹ mm -¹]
SID_0 Ewuru	6.150191952	6.238065073	0.53
SID_1 Ewuru	6.145657444	6.239875225	0.44
SID_2 Aliokpu	6.160169277	6.23780724	0.36
SID_3 Owanta	6.181165278	6.231270147	0.39
SID_4 Owa-Aliosimi	6.194125533	6.22751515	0.51
SID_5 Ewuru	6.152440395	6.241704493	0.44
SID_6 Ewuru	6.147188446	6.249808572	0.30
SID_7 Sakapoba	6.167254	6.249021308	0.54
SID_8 Umutu-Aliagwai	6.179598	6.249135591	0.39
SID_9 Marriere St	6.191795	6.248278108	0.35
SID_10 Umeri St.	6.201132	6.247894823	0.44
SID_11 Boji Boji	6.212403	6.247485354	0.49
SID_12 Agbor Obi	6.147048999	6.261931463	0.35
SID_13 Agbor Obi	6.166492001	6.261172583	0.30
SID_14 Ebu Street	6.180803	6.262497977	0.46
SID_15 Okumbor St	6.191213	6.263689584	0.38
SID_16 Ebeye St	6.198413999	6.263499025	0.48
SID_17 Imudia St.	6.204735998	6.263261001	0.29
SID_18 Odi St	6.149301616	6.273577432	0.48
SID_19 Agbor-Obi	6.164456621	6.273999515	0.34
SID_20 Alihame	6.183997	6.272435924	0.39
SID_21 Alihame	6.193723	6.27257241	0.46
SID_22 Alihame	6.204120001	6.27318	0.32
SID_23 Alihame	6.20867	6.272786785	0.29

From Table-2 the values for K for the sample locations vary between 0.2935 to 0.5387 [t h MJ -¹mm -¹]. With highest value in location SID_7 Sakapoba and lowest in location SID_17 Imudia St. Subjecting the K values for all the locations to spatial estimation using Inverse Distance Weight (IDW) interpolation and deploying Equation 2.2 in the map algebra tool produced the soil erodibility map given in Fig. 2. Table-2 which shows the nature of soils within soil erodibility factor ranges for all the soil samples obtained in Agbor cab be classified as having moderate K-value. Averaging the erodibility values within the study area produced 0.40527 t h MJ -¹mm -¹ with a standard deviation of 0.077924. The locations with the highest K-values, which are 0.5387726, 0.5315167, 0.5069008, and 0.4880863, respectively, are SID_7 Sakapoba., SID_0 Ewuru, SID_4 Owa-Aliosimi, and SID_11 Boji Boji. These results are consistent with the results of the reconnaissance survey that was conducted within the study area, which showed that those areas have the highest incidences of soil loss in Agbor & Environs. SID_17 Imudia St. had the lowest K-value of 0.293561, while SID_23 Alihame, SID_6 Ewuru, and SID_13 Agbor Obi displayed moderate K-values of 0.293563, 0.2954717, and 0.2991888. All the soils in the study area were classified as having a moderate qualitative rank in the Table of Standard Erodible Indexes, indicating that they are permeable outwash well-drained soils with permeable substrata. The information gathered from this study serves as a foundational reference for the design of control structures, which are required for soil conservation and management techniques in the research region in consonance with Okorafor *et al.*, (2018) which states that soils within the south region fall within coarse-thick-coarse sand group which are poorly sorted resulting in permeable outwash well drained soils. The K values range from 0.293 to 0.538 t h MJ -¹mm -¹, indicating a considerable degree of erodibility.

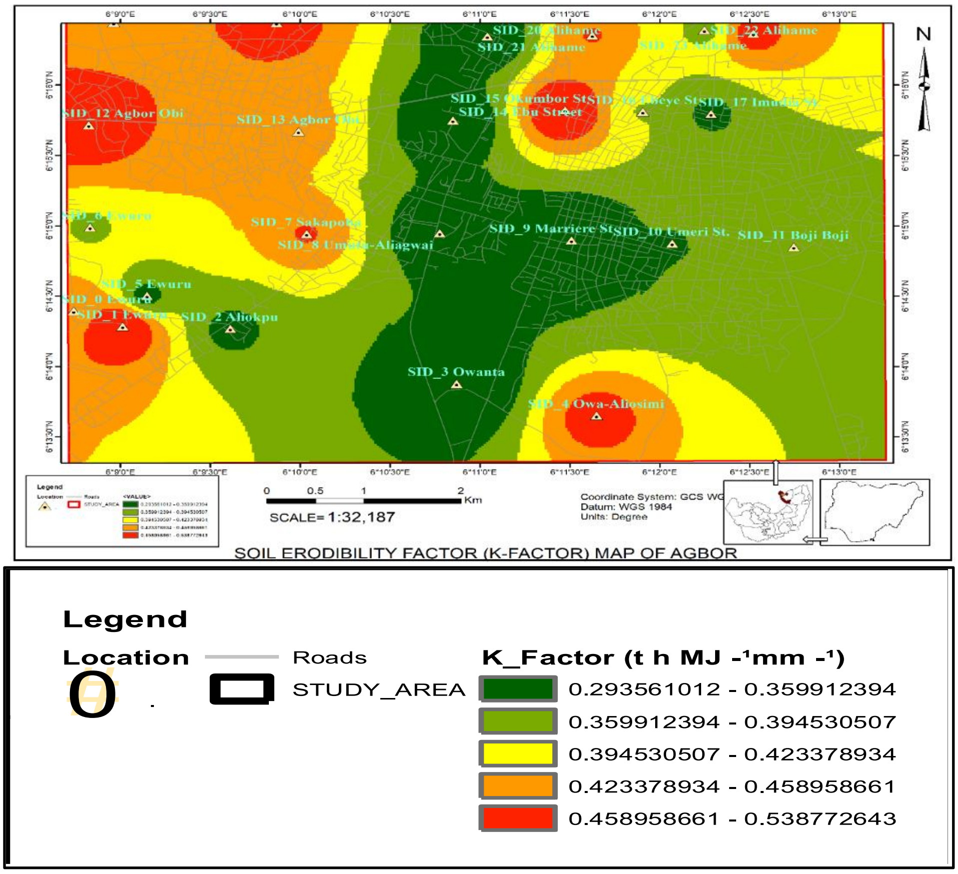

Fig. 2 Soil erodibility factor (K) map and legend for Agbor

CONTRIBUTION TO KNOWLEDGE

The major contributions to knowledge, following the findings from this study include:

i. Determination of location specific input parameters of the revised universal soil loss equation (RUSLE) model for Agbor and its environs, and
ii. Generation of location specific thematic maps depicting the RUSLE input parameters and their ranges for Agbor and its environs.

CONCLUSION

The following conclusion(s) were drawn from the study;

i. The soil erodibility factor (K) for the study area ranged from 0.2935 tons/ha/yr to 0.5387 tons/ha/yr, while the lowest K-values were seen at Imudia Street and SID_23 Alihame and the highest K-value was observed at SID_0 Ewuru.
ii. The rainfall erosivity factor (R) for the study area ranged from 563.28-631.389 MJ/mm/ha/hr/yr.
iii. The soils within Agbor and environs can be classified as soils with moderate soil erodibility value.
iv. The study area can be categorized as having medium-strong erosivity

RECOMMENDATIONS

Considering the outcome of the results obtained from the study regarding Agbor and its environs, the following practices/activities are recommended.

i. Long-Term Monitoring of vegetative patterns/trends and adaptive management of vegetative cover to reduce erosivity of rainfall and enhance runoff interception thereby reducing the generation of sediments and sediment flow, and

ii. Provision of easy access to climatic/climatological data to enable future studies on the existing trends of erosion in the long run with regards to rainfall specifically

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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