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ORIGINAL RESEARCH ARTICLE

Comparative assessment of soil erodibility using SLEMSA and RUSLE models in Maraban Rido, Chikun Local Government Area, Kaduna State, Nigeria

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ABSTRACT

Soil erosion is one of the major environmental problems in tropical Africa; however, it's important to generate information on the amount of eroded soils in part of Kaduna State. The spatial extant of soil erosion in Maraban Rido cannot be over emphases due to it negative consequences on the peoples and their properties. The study aimed at comparative assessment of soil erodibility using SLEMSA and RUSLE models in Maraban Rido, Chikun Local Government Area, Kaduna State, Nigeria. Soil erosion models were used to access this studies. One of the most commonly used soil erosion models is the Universal Soil Loss Equation (USLE) A comparative analysis of the two model (SLEMSA and RUSLE) were used and identified a variation related to reduction in soil quality, loss of organic matter, pore soil textural classes, pore soil fertility, slope instability, soil truncation; etc. Soil erodibility accounts for the influence of soil physical and chemical properties that influences washing away of soil by the agent of denudation. Soil samples from surface depth (5-30 and 30-50 cm) were collected using core sampler from the study area, areas of dominant land uses, fourteen (14) soils samples were collected within the gully site for standard laboratory analysis. The result indicated that in in SLEMSA revealed that Maraban Rido sample point 5 had the highest soil erodibility (k) index of 9.277 t h^{-1} y^{r-1} while the lowest on the same model was found in Maraban Rido sample point 4 and 11 had 0,012 t h^{-1} y^{r-1} the result revealed that SLEMSA had a total soil loss of 9.708 t h^{-1} y^{r-1} and 0.693 t h^{-1} y^{r-1} as the mean, further more the result revealed that RUSLE model had the highest soil erodibility (k) index at sample point at 8 with 4.350 693 t h^{-1} y^{r-1} while the lowest is at sample point 1 had 0.039 693 t h^{-1} y^{r-1} the total erodibility (k) index for RUSLE model was 8.107 693 t h^{-1} y^{r-1} and the mean of 0.579 693 t h^{-1} y^{r-1}. The study recommendations that the models are very relevant and useful in the context of quantifying amount of soil loss in African sub-continent more especially SLEMSA because is design in Zimbabwe to suit African climatic condition. However, there is still ambiguity in the knowledge of our understanding as to which soil erosion prediction model to use.

Keywords: -Soil erodibility; Gully erosion, Gully; RUSLE; SLEMSA; Soil properties; Chikun, LGA.

Introduction

Soils are fundamental to life on earth but human pressures on soil resources are reaching critical limits (Lal, 2020). Soil is the unconsolidated upper layer of the earth that serves as a natural medium for plant growth and supports critical ecosystem services essential for human survival and environmental sustainability (Lal, 2020; FAO, 2015). Soil provides

physical support, water, nutrients, and oxygen to plants (Brady & Weil, 2016). Approximately 95% of global food production depends directly on soil (FAO, 2015). In sub-Saharan Africa, where livelihoods are predominantly agrarian, soil productivity determines food availability, income, and rural employment (Lal, 2009; Stocking, 2003). Soil as a Regulator of Water Cycle and Hydrology cycle by regulating infiltration, water storage, groundwater recharge, and runoff generation (Morgan, 2005). Healthy soils with good structure and high organic matter content increase infiltration capacity and reduce surface runoff, thereby minimizing flooding and soil erosion (Lal, 2020).

Conversely, degraded and compacted soils have low infiltration rates, leading to increased runoff and sediment transport (Lal, 2004; IPCC, 2019). Through carbon sequestration, soil mitigates climate change by removing atmospheric CO2 and storing it as soil organic matter (Lal, 2020). Sustainable soil management practices such as conservation agriculture, agroforestry, and cover cropping can enhance soil carbon stocks and reduce greenhouse gas emissions (FAO, 2017). Soil as a Habitat for Biodiversity about 25% of the global biodiversity, including bacteria, fungi, protozoa, earthworms, and other organisms that are essential for ecosystem functioning (FAO et al., 2020). Soil microorganisms are responsible for nutrient cycling, decomposition of organic matter, nitrogen fixation, and maintenance of soil structure (Brady & Weil, 2016). A single gram of healthy soil may contain over 10 billion microorganisms, which contribute to soil fertility and plant health (FAO & ITPS, 2015). Soil erosion is systematic removal, detachment, transportation and deposition of soil particles from its original place by agents of denudation such as water, wind, gravity and anthropogenic activities (Lal, 1990; Morgan, 2005). It is a natural geomorphic process that is accelerated by human interference through deforestation, overgrazing, bush burning, inappropriate tillage practices and urbanization (Brady & Weil, 2016; FAO, 2019). According to Lal (1990), soil erosion is the physical removal of topsoil, which is the most fertile and biologically active part of the soil profile, resulting in reduction of soil depth, loss of nutrients and decline in productivity.

Soil erodibility (K) is defined as the inherent susceptibility or vulnerability of a soil to detachment and transportation by erosive agents such as rainfall and runoff (Wischmeier & Smith, 1978; Morgan, 2005). It is an intrinsic property of the soil that determines how easily soil particles are detached and transported when all other factors of erosion such as rainfall, slope, cover and management are held constant (Lal, 1990; Elwell, 1977). Consequently, erodibility as a function of the integrated effect of soil properties that influence infiltration, aggregate stability, and resistance to particle detachment by raindrop impact and surface flow. Morgan (2005). Conversely, soil erodibility factor (K) is one of the six factors of the Universal Soil Loss Equation (USLE) and the Soil Loss Estimation Model for Southern Africa (SLEMSA), and is considered the most important intrinsic soil property that determines the vulnerability of soils to erosion (Wischmeier & Smith, 1978; Elwell, 1977). Its importance stems from its central role in erosion prediction, land evaluation, and conservation planning. Moreover, without accurate determination of K, soil loss prediction is impossible or will result in gross overestimation or underestimation (Wischmeier et al., 1971; Morgan, 2005). Elwell (1977) demonstrated in SLEMSA that even a 0.01 error in K can change estimated soil loss by 10-20 t/ha/yr in tropical soils. Therefore, K factor is not optional, it is a compulsory variable in all empirically-based erosion models used globally (Morgan, 2005; FAO, 2019).

SLEMSA model was developed largely from data from the Zimbabwe high vend. According to the model's founder Elwell, (1996), the SLEMSA framework is (Z=K*C*X) is a system, where Z- predicted mean annual soil loss, K- mean annual soil loss and C- vegetation cover factor approach for developing models for estimating sheet erosion from arable lands in southern Africa. The model is based upon a body of experimental data supplemented by data extrapolation in which process relationships are assumed (Stocking, 1980). It is also designed to incorporate the practical advantages of empirical methods with the greater flexibility of introducing variables that have not been individually monitored. It is a relatively widely used soil loss model in African environments (Elwell and Stoking, 1982),

The Revised Universal Soil Loss Equation (RUSLE) is an empirically-based model developed to predict average annual soil loss due to sheet and rill erosion by water (Renard et al., 1997; Wischmeier & Smith, 1978). RUSLE is a revised and improved version of the Universal Soil Loss Equation (USLE) which was originally developed by Wischmeier and Smith (1965, 1978) from over 10,000 plot-years of soil loss data collected across the United States. Due to limitations of USLE in applicability outside the USA and with new data availability, the USDA Agricultural Research Service revised the equation between 1985-1997, leading to RUSLE (Renard et al., 1997). The revision retained the same fundamental structure as USLE but improved the technology for evaluating each factor using modern data, GIS, and computer algorithms (Renard et al., 1997; USDA-ARS, 2008). RUSLE was later updated to RUSLE2 in 2008, which is computer-based and allows daily erosion estimation, but RUSLE remains the most widely used globally for erosion assessment (USDA-ARS, 2008; FAO, 2019).

In Nigeria, the impact of soil erosion when formed expands rapidly coupled with exceptional storm or torrential rain down the stream by “head ward” erosion gulping up arable lands, economic trees, homes, lives and sacking of families and valuable properties that are worth millions of naira (Umudu, 2008). Erosion gnaws away the soil starting with eating away the surface layers as sheet erosion creating small channels as rill erosion and then extending to deep channels as gullies.

Kaduna State Government over the years has attempted to control the problem of erosion through numerous contracts awarded for gully erosion reclamation projects at some key sites in Kaduna town. The Government approved construction works for gully erosion control projects in six locations across the state in the year 2014. These include the gully erosion control projects in Bakin Kasuwa/Kakaki/Kaura in Zaria Local Government Area, Fatswam in Jema’a Local Government, Likarba in Kauru Local Governmenrt, Kakuri/Nasarawa in Kaduna South Local Government, and Kusallo in Ikara Local Government. Similarly, the construction of the Rigasa gully Erosion Control under the execution of the 2013 ecological fund projects in Igabi Local Government Area (Daily Trust, 2014). To this end it is important that risks and management of gully erosion is not overemphasized as assessing the menace of erosion is being beneficial to all in Central Senatorial Zone and Kaduna State at large.

Statement of Problem

At Chikun Local Government Area of Kaduna State, each rainy season is associated with nightmares, particularly for inhabitants living at the proximity of erosion sites (Kaduna State Government, 2014) Each gully incidence is accompanied by landslides and slumping, leaving at the end of each event inhabitants mourning for loss of agricultural lands, ancestral

lands, homes and economic trees, the cumulative effect is that the affected inhabitants are left homeless and/or jobless (Egboka, 2010). The threats posed by gaping and daunting large gullies to farmlands, settlements, roads and human are enormous. Most communities in Kaduna State have been ravaged by soil erosion of different dimensions (Abbas *et al.,* 2020). From the forgoing there is little study ever conducted in the study area using SLEMSA and RUSLE this is the exiting gap in knowledge that this study will address. However, its agents this background that this study seek to address the following research questions:

i. What is the soil erodibility (k) index in the study area?
ii. What is the amount of soil loss in the study area?

This was achieved through the following specific objectives which are to:

i. determine soil erodibility (k) index using SLEMSA and RUSLE models in the study area and
ii. estimate the amount of soil loss in the study area;

Materials and Methods

The study area

The study was undertaken in Chikun LGA of Kaduna State, the area is seriously affected by soil erosion, the area lies between Latitudes 9^0 11' 10" - 10^0 50' 00" North of the Equator and Longitudes 5^0 40' 30" - 8^0 15' 00" East of Greenwich Meridian. The study area has an area of about 4,466 square kilometers. (See Figure 1) Climate in the study area according to Ayoade (1996) is tropical continental type of climate characterized by wet and dry seasons, these seasons reflect the influences of tropical continental and maritime air masses which sweep over the entire country, the wet season is dominated by south-east trade winds which start between May/June to October. The annual rainfall is about 1100mm. The dry season is dominated by the north-east trade wind called Harmattan which prevails between November and February. The dry season is also rainless from October to April (Abaje *et al.,* 2016). The maximum temperature seldom falls below 36°C in April to about 27° C in the heart of raining season (August-September). The geology of the study area is principally comprising crystalline and sedimentary rocks, underlain by Basement Complex rocks (Abubakar, 1995). It is composed of older high grade metamorphosed gneiss interspersed by belt of young meta sediment of mainly quartzite and schist. The drainage is characterized by seasonal ephemeral features. It is a great resource for various water usages (Oguntoyinbo, 1983). The drainage pattern is dendritic with first and second orders tributaries (Adamu, 2004) the study area is covered by tropical ferruginous soils which are heavily weathered and markedly laterized, generally, the soils are red brown to red yellow in color (Abaje, 2007). The vegetation of the study area is the tropical grassland vegetation with the density of trees and other plants decreasing as one move northwards (Abaje, 2007). The structure of the vegetation consists of scattered trees, tall grasses and shrubs.

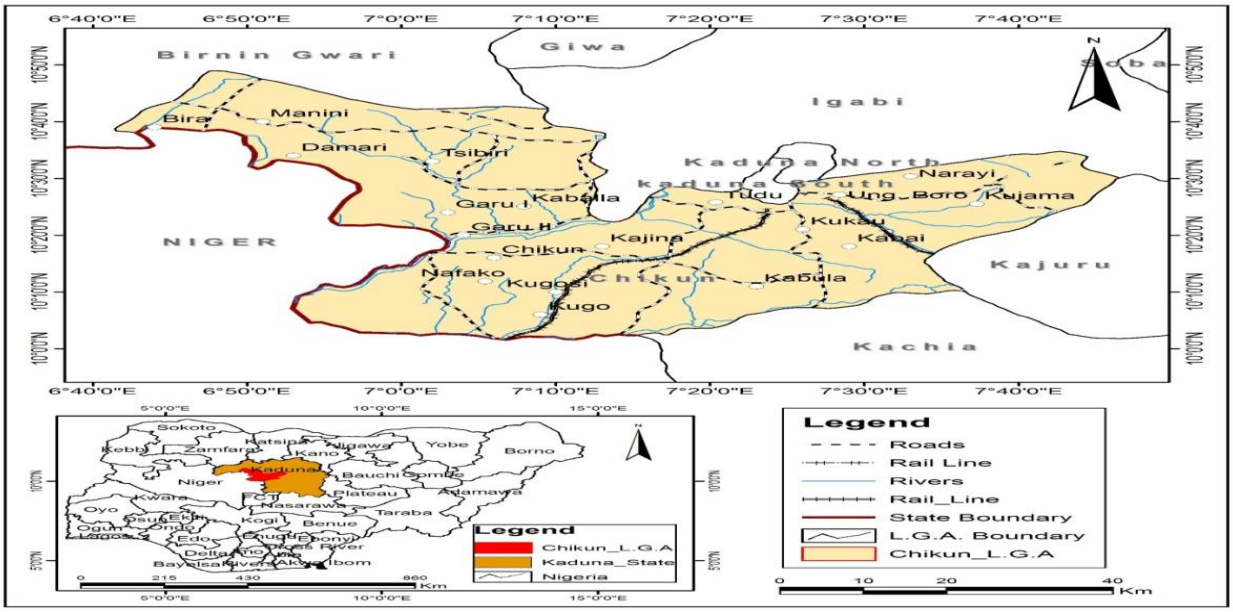


Figure 1 The Study Area.

Source: Modified from Administrative Map of Kaduna State (2021)

The study was undertaken in Chikun LGA Kaduna State, Nigeria. Chikun LGA was identified as high-erosion prone areas, among the LGAs in Central Senatorial Zone, this was purposive selected as the most vulnerable soil erosion areas. The locality with high soil erosion prone area were: - Unguwan Romi, Kuriga, Kujama, Sabon-Tasha Maraban Rido Unguwan Yelwa Based on the reconnaissance survey conducted, the most affect locality was Chikun LGA. Fourteen (14) individual soil samples were collected at interval of 30-50cm from locality of Maraban Rido Chikun LGA.

Data Collection Method

Soil samples were collected at the depths of 0-30cm in transverse direction to take undisturbed soil using core sampler. However, for the gullies that were deeply eroded gullies, soil samples were collected at 30-50cm depth while the shallow eroded gullies were collected at the depth of 0-30cm, as recommended by Cosmas and Johan (2020) who established that collection of soil samples for the analysis of soil properties influencing erodibility is best at the depth of 0-30 and 30-50cm.

Table 1 Sample ID, Coordinate and Depth

S/N	Locatition Maraban Rido	Coordinate	Depth in cm
1	Maraban Rido (1)	N 10 º28.232¹ E 007º32.177¹	0-30
2	Maraban Rido (2)	N 10 º28.286¹ E 007º32.197¹	0-30
3	Maraban Rido (3)	N 10 º28.382¹ E 007º32.123¹	0-30
4	Maraban Rido (4)	N 10 º28.464¹ E 007º32.186¹	0-30
5	Maraban Rido (5)	N 10 º28.477¹ E 007º32.000¹	30-50
6	Maraban Rido (6)	N 10 º28.556¹ E 007º32.070¹	30-50
7	Maraban Rido (7)	N 10 º28.533¹ E 007º32.957¹	30-50
8	Maraban Rido (8)	N 10 º28.629¹ E 007º32.042¹	30-50
9	Maraban Rido (9)	N 10 º28.722¹ E 007º31.951¹	30-50
10	Maraban Rido (10)	N 10 º28.789¹ E 007º32.055¹	30-50
11	Maraban Rido (11)	N 10 º28.883¹ E 007º31.964¹	30-50
12	Maraban Rido (12)	N 10 º28.978¹ E 007º32.064¹	30-50
13	Maraban Rido (13)	N 10 º29.143¹ E 007º32.000¹	30-50
14	Maraban Rido (14)	N 10 º29.246¹ E 007º32.101¹	30-50

The analysis was carried out in the Institute of Agricultural Research, Department of Soil Science Laboratory to test the Physico-Chemical properties, the following laboratory standards were adopted.

(i) S*oil organic matter using carbon wet oxidation* method (*Walkley and Black, 1934)*

Equipment

1. 500 mL Erlenmeyer flasks 2.10 mL pipette 3. 10 and 20 mL dispensers 4. 50 mL burette 5. Analytical balance 6. Magnetic stirrer 7. Incandescent lamp

Reagents

(1) H_3PO_4, 85 percent (2) H_2SO_4, concentrated (96 percent) (3) NaF, solid (4) Standard 0.167 M $K_2Cr_2O_7$: Dissolve 49.04 g of dried (105°C)

Procedure

(1) Weighed out 0.10 to 2.00g dried soil (less than 60 mesh)

(2) Added 10 mL of 0.167 M $K_2Cr_2O_7$ by means of a pipette.

(3) Added 20 mL of concentrated H_2SO_4 by means of dispenser and swirl gently to mix.

(4) Placed the flasks on an insulation pad and letstand 30 minutes.

(5) Diluted the suspension with about 200 mL of water to provide a clearer suspension

(6) Added 10 mL of 85 percent H_3PO_4 using a suitable dispenser, add 0.2 g of NaF, using the "calibrated spatula" technique.

(ii) Method for Measuring Soil Textural classes using (Hydrometer Method (USDA, 1951)

Equipment.

(1) Glass cylinders, 1000-ml capacity (2) Thermometer, Fahrenheit (3) Hydrometer, Bouyoucos (Fisherbrand Model #14-331-5c) (4) Electric mixer with dispersing cup (4) Plunger (5) Balance sensitive to ± 0.01g

Reagents

1. Dispersing solution, 5%: Dissolve 50 g of sodium hexametaphosphate, Na^6 $(PO_3)^6$ in deionized water and dilute to 1 liter.

Procedure

(1) Weighed 50 gram of < 2mm air dried soil samples into a 250mls plastic bottle (2) Transferred the bottle and its content into a mechanical shaker and shake for 20mins.

(3) After 20mins, transferred the sample into a 1000mls measuring cylinder and rinsed the bottle very well and also make it up to mark with water. (4) Prepare a blank, also which those not contain soil sample, but contain only the Calgon solution (100mls) (5) Plunged (disturbed) the sample using a plunger, until the soil particles in the cylinder were fully disturbed. Remove the plunger and (6) Took the 40sec reading using the hydrometer and record it.

(iii) *Measuring soil permeability class using the constant head methods. (SERAS, 2003)*

Equipment

(1) 212-micron sieve (2) 250-micron sieve (3) Sieve Receiver or collector

Reagent

Dispersing Agent (Calgon) or (Sodium hexametaphosphate solution)

Procedure

(1) Weighed 50 grams of < 2mm air dried soil sample into a 250mls plastic bottle (2) Transferred the content of the bottle into a 1000ml, (1 litter) measuring cylinder (3) Plunged the sample in the cylinder in order to obtain a proper separation of the soil particles. (4) Arrange the separating sieves in the order of 250micro on top of the 212 micro sieve and placed on top of the sieve receiver (5) Poured the disturbed samples into the series of sieve under a clean flowing tap water and wash out the clay and the salt separate. Finally, the coarse, medium and fine sand separate were retained on each sieve. (6) Finally weigh the sand. This gave the coarse sand fraction

(7) Calculation of k using the given equation (SESAR, 2003)

$$\mathrm{K} = \frac{qL}{Ak} \tag{12}$$

Where k = coefficient t of permeability in cm/sec

q = Discharge cm/sec. L = Length of specimen in cm^2 A = Cross sectional area of specimen in cm^2 H = Constant head causing flow in cm

(vi) *Measuring Percentage sand, clay and silt content hydrometer method (Saketu & Gezahagn, 2020)*

Equipment:

(1) One test-tube graduated in millilitres

Reagents:

(1) Salt water solution (2) Sand equivalent is equal to

Procedure:

(1) Pour a small amount of salt water in test-tube (2) Add sand up to 100 ml graduation mark; (3) Add salt water up to 150 ml mark; (4) Cover tube; shake energetically; (5) Place tube on flat surface; level sand surface by tapping on test tube; (6) Allow to decant and settle for 3 hours

Calculation.

$$\mathrm{SE} = \frac{H1 \times 100}{H2} \quad (13)$$

Total height of sand plus clay = H2

Height of sand only..... = H1

(i) *Soil erodibility (K) index SLEMSA*

To calculate soil erodibility factor the exponential equation developed by Wischmeier and Smith (1978) was used, equation 1 and 2

$$\mathrm{K} = [2.1 \times 104 \times (12\text{-OM}) \mathrm{M}1.14 + 3.25 (\mathrm{S}\text{-}2) + 2.5 (\mathrm{P}\text{-}3)] \times 0.1317 \quad \text{eqn.1}$$

$$100$$

Where: -

K = erodibility factor (in ton/MJ/mm)

OM = organic matter content (%)

M = texture product

S = structure class

P = permeability class.

The texture product *M* is calculated using soil textural triangle

$$\mathrm{M} = \%\ \mathrm{silt} \times (\%\ \mathrm{silt} + \%\ \mathrm{sand}) \quad \text{eqn. 2}$$

(ii) Rainfall erosivity SLEMSA model

Rainfall erosivity (rainfall data 2021-2025): The monthly rainfall data of the study area was sources from (NiMET, 2025) Kaduna Station. The mean seasonal rainfall was estimated using equation (3&4) (Wischmeier & Smith, 1958). Chow, *et al.,* (1988) in estimating rainfall erosivity two parameters were estimated rainfall kinetic energy and rainfall intensity,

Rainfall kinetic energy

$$\mathrm{KE} = 11.87 + 8.73 \log 10\ \mathrm{I} \quad \text{eqn. 3}$$

Where: KE =kinetic energy (Joules/m^2/mm)

I = Rainfall intensity (mm/hr) (Wischmeier & Smith, 1958)

Rainfall Intensity

$$\mathrm{I} = \frac{P}{T} \quad \text{eqn, 4}$$

Where I = Rainfall intensity (mm/hr)

P = Rainfall amount (mm), T = Duration (hr) (Chow *et al., 1988)*

Table 2 Annual Precipitation Record (mm) 2021-2025

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NEV	DEC	TOTAL	MEAN
2021	0.0	0.0	9.5	55.3	111.4	147.6	121.6	354.5	203.8	61.8	3.0	0.2	1068.7	89.05
2022	0.3	12.1	22.9	40.7	385.5	174.1	101.3	215.6	294.8	30.8	0.0	0.0	1278.1	106.5
2023	0.0	1.9	1.4	14.8	147.4	106.4	138.8	220	283.6	164.7	18.3	0.0	1097.3	91.44
2024	0.0	0.0	21.2	42	90.8	19.5	310	242.8	302.3	92.6	5.6	0.0	1126.8	93.9
2025	15.7	0.0	3.7	15.9	85.1	84.9	64.2	220.2	146.2	81	14.5	33.9	765.3	63.78
Total													5,336.2	444.67

Source: - NIMET (2025)

Soil erodibility (K) index RUSLE

To calculate soil erodibility factor, the exponential equation developed by Chaves *et al.*, (2010) was employed.

$$K = \frac{-0.00043(fs+SiL)}{OC+0.00043+0.000863+SiL} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{eqn. } 5$$

Where: -

K:- Sun of soil erodibility

Fs= % fine sand on the soil A horizon

SiL= % silt from the soil A horizon

OC= % organic Carbon from the A horizon

Ts= % total soil sand.

(iii) *Rainfall erosivity RUSLE model*

Erosive energy for a rain event was calculated using Renard et al. (1996) according to RUSLE using equation (6)

$$e = 0.291[1- 0.72\times\exp(-0.05\times i\ m)] \qquad \text{eqn. } 7$$

Where: -

e - is kinetic energy for the storm and

*i*m - is the total rainfall intensity in mm/h.

Result and Discussion

Result Presentation

The results of organic matter content, % structural class indices, permeability class indices, % silt + % very fine sand and % sand were presented in table 3.

Organic carbon and Matter Content

It was observed that location 8 had the highest percentage (%) organic carbon and matter content

Table 3: Organic Carbon and Organic Matter Content at Maraban Rido Chikun LGA

Locatition Maraban Rido Dept cm 5-30 and 30-50	Organic Carbon	Organic Matter
Maraban Rido (1)	0.42	0.72
Maraban Rido (2)	0.04	0.07
Maraban Rido (3)	0.16	0.28
Maraban Rido (4)	0.13	0.22
Maraban Rido (5)	0.31	0.53
Maraban Rido (6)	0.21	0.36
Maraban Rido (7)	0.03	0.05
Maraban Rido (8)	0.74	1.27
Maraban Rido (9)	0.08	0.14
Maraban Rido (10)	0.23	0.39
Maraban Rido (11)	0.09	0.16
Maraban Rido (12)	0.19	0.33
Maraban Rido (13)	0.25	0.43
Maraban Rido (14)	0.32	0.55

Table 3. revealed that Maraban Rido sample point 8 recorded the highest soil organic carbon content of (1.27%) and (0.74%) organic matter content (OM) whereas Maraban Rido sample point 7 recorded the lowest value (0.03%) organic carbon and (0,05%) organic matter content.

Soil Structural class index

The structural class index of the soil was determined by the method suggested by Udoumah, *et al.*, (2018). On soil erodibility determination. It was determined by taking soil lumps/lumps ie collection of soil sample from each sampling point for lab analysis. At each depths and dropping them from known height of about 1.2 cm watching how the points got broken for classification as shown in the table 4.

Table 4. Structural Class Index

Soil structural	Class index
Very fine granular (<1mm) clay	1
Fine granular (1-2mm) clay silt	2
Medium or coarse granular soil (2-5mm) sandy	3
Massive (Blocky, Platy, Columnari, Primitive) sandy, loamy	4

Therefore, the numbers above were the structural class indices of different soil samples. The depth at different level were observed, each sampler point were worked on and the average obtained

Table 5. Soil Structural Class Index

Locatition Maraban Rido Dept cm 5-30 and 30-50	Structure	Class index
Section A		
Maraban Rido (1) 5-30	Very fine granular (<1mm) clay	1
Maraban Rido (2) 5-30	Very fine granular (<1mm) clay	1
Maraban Rido (3) 5-30	Fine granular (1-2mm) clay silt	2
Maraban Rido (4) 5-30	Fine granular (1-2mm) clay silt	2
Maraban Rido (5) 5-30	Fine granular (1-2mm) clay silt	2
Maraban Rido (6) 5-30	Fine granular (1-2mm) clay silt	2

Locatition Maraban Rido Dept cm 5-30 and 30-50	Structure	Class index
Maraban Rido (7) 5-30	Fine granular (1-2mm) clay silt	2
Section B		
Average		**1.71**
Maraban Rido (8) 30-50	Medium or coarse granular soil	3
Maraban Rido (9) 30-50	Medium or coarse granular soil	3
Maraban Rido (10) 30-50	Medium or coarse granular soil	3
Maraban Rido (11) 30-50	Medium or coarse granular soil	3
Maraban Rido (12) 30-50	Massive (Blocky, Platy, Columnari, Primitive)	4
Maraban Rido (13) 30-50	Massive (Blocky, Platy, Columnari, Primitive)	4
Maraban Rido (14) 30-50	Massive (Blocky, Platy, Columnari, Primitive)	4
Average		**3.43**

The subsoil at the depth of 15-60cm indicated that in table 5. revealed that soil structural class index has shown that the more the soil depth the less the particular sizes increases, this has shown in table 5 section A has the lowest dept of 5-30 cm had an average of 1.71 while in section B had the highest depth with an average of 3.43 cm. the factor responsible is due to it depth of 30-50cm. According to Brady & Weil (2016) the granular and crumb structures are most pronounced in the A horizons (topsoil) where organic matter and biological activity are highest, with increasing depth, structure becomes progressively coarses, weaker, and eventually massive od structureless in the C horizon.

3.1.3 Soil Permeability Class Index

The permeability class index of the soil samples was determined based on Wischmeier and Smith (1963) method. This was done by using a cylinder infiltro meter test. In this method, A constant head permeameter was used, each point location was tested by measuring a known quantity of water (300 ml) and watching how long it takes (readings at minutes 0, 1, 2, 5, 10, 15, 30, etc) to infiltrate into the soil at each depths, samples were collected in the field, Lab preparation, saturation and set up for reading, take reading,

The permeability coefficient or hydraulic conductivity using the equation below

$$V=K\times i$$

Where:

- V= velocity of water (cm/hr)
- K= permeability coefficient (cm/hr)
- what you measure
- i= Hydraulic gradient = H/ L (unitless) Freeze & Cherry (1979)

Table 5. below showed the time to be taken.

Table 6. Permeability Class Index

Time (mins)	Soil class	Remarks
10-11	1	Sandy soil
11-20	2	Sandy-loam
21-30	3	Sandy-clay-loam
31-40	4	Sandy-clay-loam
41-50	5	Clayey-loam
51-60	6	Clayey soil

Percent Silt + Very Fine Sand and Percent Sand

In determining the percent silt+ very fine sand and percent sand of soil samples, the combined analysis of both sieve and hydrometer test methods were employed for soil samples collected at different depths and locations. The average values were then taken for K-factor nomograph, Wischmeier *et al* (1971) defines:

- Silt + Very Fine Sand = 0.002 - 0.10 mm

- Sand = 0.10 - 2.0 mm

Table 7 Present the soil textural class or particle size distribution in the study area.

Table 7 Soil Textural class of the Study Area

S/N	BLK	0.36DT	R	R	% Clay	% Silt	% Sand	Texture Class	Description	WT of CS	WT of MS	WT of VF
1	1	1	27	12	26	30	44	LOAM	M/Rido 02	0.015	0.021	24.653
2	1	1	39	20	42	38	20	CLAY	M/Rido 04	0.021	0.101	0.122
3	1	2	38	20	42	36	22	CLAY	M/Rido 06	0,661	0.422	1.083
4	1	1	38	18	38	40	22	CLAY LOAM	M/Rido 08	16.806	3.564	21.78
5	1	2	40	21	44	38	18	CLAY	M/Rido 10	12.331	4.789	17.12
6	1	1	37	19	40	36	24	CLAY LOAM	M/Rido 12	9.213	3.550	12.763
7	1	1	25	10	22	30	48	LOAM	M/Rido 14	14.433	6.15	24.557
8	1	1	40	18	38	44	18	SILTY CLAY LOAM	M/Rido 01	1.634	9.278	11.623
9	1	2	24	11	24	26	50	SANDY CLAY LOAM	M/Rido 03	0.671	0.891	11.492
10	1	1	32	18	38	28	34	CLAY LOAM	M/Rido 05	6.394	4.484	8.422
11	1	2	30	19	40	22	38	CLAY LOAM	M/Rido 07	6.859	2.192	12.023
12	1	1	20	6	14	28	58	SANDY LOAM	M/Rido 09	8.450	5.828	14.278
13	1	2	24	10	22	28	50	SANDY CLAY LOAM	M/Rido 11	1.536	1.712	9.94
14	1	1	35	18	38	34	28	CLAY LOAM	M/Rido 13	0.76	1.839	10.687

Table 7 revealed that there is significant variation in soil textural class in the study area, therefore the soil clay was very high in Marban Rido sample point 4 and 6 with 42 % clay content, while in Marban Rido sample point 1 the soil textural class was 44 % silt and clay dominated the area, whereas 58 % of sandy and loam soil was recorded at sample point Maraban Rido 9.

Soil Erodibility (K) Index for Chikun LGA

The soil erodibility (k) index for Chikun LGA is presented in Table 8

In table 8, the result revealed that sample points (4 and 11) in Maraban Rido had the lowest soil erodibility (k) index in Chikun LGA, with a value of 0.012 tons $ha^{-1} \cdot yr^{-1}$ for SLEMSA model, however the result indicated that 0.039 tons $ha^{-1} \cdot yr^{-1}$ was the lowest soil loss for RUSLE model, therefore according to Elwell & Stocking (1982) revealed that <5 tons $ha^{-1} \cdot yr^{-1}$ indicated

very low or negligible soil loss in SLEMSA model while in RUSLE model stated that 0-5 tons $ha^{-1}{\cdot}yr^{-1}$ was rated as very low soil loss (Renard *et al* 1997). The RUSLE model indicates that in Maraban Rido sample point (11) had 0.302 tons $ha^{-1}{\cdot}yr^{-1}$ soil erodibilty (k) index with structural code of 02 the very low soil erodibility (k) index, its further reveled that Maraban Rido (5) with the value of 9.277 tons $ha^{-1}{\cdot}yr^{-1}$ soil erodibilty (k) index in SLEMSA model this inducted the most highest soil erodibility (k) index (Elwell & Stocking, 1982) which stated that low to moderate soil erodibility (k) index is within the range of 5-10 tons $ha^{-1}{\cdot}yr^{-1}$. for SLEMSA model. Furthermore the result revealed that soil sample point with the lowest soil erodibility was found in Marban Rido sample point (1) with the value of 0.039 tons $ha^{-1}{\cdot}yr^{-1}$ having structural code 02 under RUSLE model. The low soil erodivility (k) index for RUSLE model was in Maraban Rido (8) with a soil erodibility (k) index of 4.350 tons $ha^{-1}{\cdot}yr^{-1}$ and structural code of 02. However 5-12 tons $ha^{-1}{\cdot}yr^{-1}$ was established by Renard, *et al* (1997) as low soil erodibility index this statement justified the above. The mean SLEMSA soil erodibility (k) index was 0.693 tons $ha^{-1}{\cdot}yr^{-1}$ while for RUSLE model had a mean soil erodibility (k) index of 0.579 tons $ha^{-1}{\cdot}yr^{-1}$.

Table 8. Mean Soil Erodibility (k) index in Chikun LGA

Soil sample points	Structural code	Erodibility (K)	
		SLEMSA	RUSLE
Maraban Rido (1)	02	0.046	0.039
Maraban Rido (2)	04	0.018	0.839
Maraban Rido (3)	04	0.052	0.166
Maraban Rido (4)	03	0.012	0.095
Maraban Rido (5)	04	9.277	0.068
Maraban Rido (6)	04	0.013	0.058
Maraban Rido (7)	02	0.029	0.907
Maraban Rido (8)	02	0.045	4.350
Maraban Rido (9)	03	0.018	0.176
Maraban Rido (10)	04	0.061	0.047
Maraban Rido (11)	02	0.012	0.302
Maraban Rido (12)	04	0.041	0.139
Maraban Rido (13)	02	0.037	0.067
Maraban Rido (14)	02	0.047	0.054
Total		**9.708**	**8.107**
Mean()		**0.693**	**0.579**

These results further indicated that there is no notable discrepancy between the (k) index of the two models. Therefore in Chikun LGA, Maraban Rido sample point (4) had the lowest vulnerability to soil erosion under SLEMSA had 0.012 tons $ha^{-1}{\cdot}yr^{-1}$ followed by Maraban Rido (1), for RUSLE soil erodibiliy (k) index which had a soil loss of 0.039 tons $ha^{-1}{\cdot}yr^{-1}$. The most vulnerable sample point was found in Maraban Rido (5), which reported that SLEMSA erodibility index of 9.277 tons $ha^{-1}{\cdot}yr^{-1}$ and Maraban Rido (8), which had in RUSLE erodibility index of 4.350 tons $ha^{-1}{\cdot}yr^{-1}$. Furthermore the result revealed that the total of 9.708 tons $ha^{-1}{\cdot}yr^{-1}$ for SLEMSA indicated low to moderate, while 8.107 tons $ha^{-1}{\cdot}yr^{-1}$ for RUSLE indicated very low to low soil erodibility (k) index. It's revealed that from the research findings, in Chikun LGA the gully prone areas were dominated by clay loam soils, the clay soil is sticky (cohesion) particles bind together and hard to detach, but once detached, it stays suspended longest (Wischmeier *et al,* 1971) (See table 7)

Conclusions and Recommendations

Comparative assessment of soil erodibility (k) index in Chikun LGA was determine, the field procedure that involved soil samples collection using core simpler for Laboratory analysis was carried out. A total number of fourteen (14) soil samples point was recorded in the study area. The result of the soil laboratory analysis revealed that the soil within the study area were sandy, clay and loamy in most part of Chikun LGA. The result indicated that the highest soil erodibility value was found in Maraban Rido (5) with the value of 9.277 tons $ha^{-1}{\cdot}yr^{-1}$ soil erodibilty in SLEMSA model. The result further deduced that RUSLE erodibility index of 4.350 tons $ha^{-1}{\cdot}yr^{-1}$ was found in Maraban Rido sample point (8) been the second highest soil erodibility. Consequently the result revealed that the total soil erodibility (k) index was 9.708 tons $ha^{-1}{\cdot}yr^{-1}$, for SLEMSA model while 8.107 tons $ha^{-1}{\cdot}yr^{-1}$, for RUSLE model, the SLEMSA mean was 0.693 tons $ha^{-1}{\cdot}yr^{-1}$. and 0.579 tons $ha^{-1}{\cdot}yr^{-1}$. RUSLE model. However, its concluded that soil organic carbon improve soil structure by binding sand, silt, clay into aggregates. It's also control soil erosion through high SOC resulted to low erodibility (k) index, it's also proved K decreases as organic matter increases. its improves on water holding capacity by increasing porosity and infiltration. However organic matter helps to improve soil aggregation fungal hyphae and bacterial gums, without OM, soil collapses and forms crust. Improves water retention, OM, holds 20× of its weight in water. It's improve bulk density. Sand 1.6 g/cm3 clay with OM 1.1g/cm3.

Recommendation

Based on the findings of the study, the following recommendations are made thus:

1. Government, communities and individuals should improve on the implementation of cover management index though farming, afforestation, reducing over grazing, bush fires and logging.
2. State Government should enforce regulations that control building along flood plans to avoid slopes areas prone to gully erosion.
3. Farmers should be encouraged to promote soil conservation practices that mitigate accelerated erosion such as contour ridging and terracing, to reduce gully erosion.
4. Farmers should implement soil fertility management practices, such as crop rotation and organic amendments, to improve soil health and reduce erosion.

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