Resources and Environment 2018, 8(1): 6-13
DOI: 10.5923/j.re.20180801.02

Determination of Soils Erodibility Factor (K) for Selected Sites in Imo State, Nigeria

Okorafor O. O.[1,*], Akinbile C. O.[2], Adeyemo A. J.[3]

[1]Department of Agricultural and Bioresources Engineering, Federal University of Technology, Owerri, Nigeria
[2]Department of Agricultural and Environmental Engineering, Federal University of Technology, Akure, Nigeria
[3]Department of Crop Storage and Pest Management, Federal University of Technology, Akure, Nigeria

Abstract The incidence of erosion in the southeastern part of the country is prevalent and numerous with minimal solutions available to ameliorate its consequences thus reducing the assurances of food security. This study aims at determining the erodibility factor (K) of selected soils in Imo State by measuring parameters such as grain-size distribution, soil structure and texture classification, hydraulic conductivity and organic matter content of soils using standard procedures. The study area soil map was generated from Landsat Imaging and soil samples were collected from eight (8) locations (*Ehime Mbano, Ideato North, Ikeduru, Oguta, Ohaji-Egbema, Okigwe, Orlu* and *Owerri West* Local Government Areas). The K-Values obtained for each of the locations are as follows, 0.023, 0.066, 0.045, 0.053, 0.060, 0.039, 0.062 and 0.067 respectively. *Ideato North, Ohaji-Egbema, Orlu* and *Owerri West* has the highest K-values of 0.066, 0.053, 0.060, 0.062 and 0.067 while *Ehime Mbano, Okigwe* and *Ikeduru* have low to moderate K-values of 0.023, 0.045 and 0.039 respectively all based on standard erodibility indices. The study also implies that areas with high erodibility factor represent areas that have high propensity to erosion or have been eroded while areas showing low to moderate erodibility factor depict areas that have low incidences of erosion. Nevertheless, if all areas (areas with low, moderate and high K values) are properly maintained, managed and conserved fertility levels can be boosted to guarantee assurances for food security.

Keywords Soils, Erosion, Erodibility, Erodibility factor, USLE

1. Introduction

Agricultural soils are the richest supply of nutrients for plant growth and production because of the presence of organic matter and humus which support microbial activities which result in proper soil aeration and good drainage conditions for water movement which enable plants to grow and yield expected outputs. Soil being a key factor of production is subject to degradation due to environmental and human activities which prevents it from offering the expected quality; this particularly is as a result of erosion. It not only causes severe land degradation and soil productivity loss, but also threatens the stability and health of society in general, and sustainable development of rural areas in particular [1]. Soils comprise of minerals, organic matter, nutrients, moisture and living organisms which support growth and ascertain the fertility of the soil for food production, this particular property of the soil is threatened when it undergoes degradation by erosive actions. Erosion is one of the surface processes that sculptures the earth's landscape and constitutes one of the global environmental problems [2]. Soil erosion is a natural process of soil material removal and transportation through the action of erosive agents such as water, wind, gravity, and human disturbance [3]. The problem of soil erosion has really aided in declining the quality of arable land in generating food crops for export and human consumption thus preventing guaranteed food security in the country.

In increasing food production to keep pace with demand while retaining the quality of land and the ecological balance of the production systems are the current challenges to agricultural research and development policy in Nigeria [4]. Currently, efforts to achieve sustainable agricultural development and food self-sufficiency in the country are threatened by widespread environmental degradation resulting from soil erosion menace, characterized by massive soil loss estimated at 30 million tons per annum [5-7]. Erosion is prevalent in all parts of the country as it is experienced in no smaller degree in almost every geo-political region of the country, with specific impact in southeastern part of Nigeria. [8] states that degradation of natural resources in Anambra State and almost everywhere in Nigeria is one of the greatest threats to future food production capabilities and sustained development. In Nigeria desertification and aridity are the major environmental problems of the northern part of the country while the torrential rainfall of the southern Nigeria creates

* Corresponding author:
okoreokorafor@yahoo.com (Okorafor O. O.)
Published online at http://journal.sapub.org/re

enabling environment for catastrophic soil erosion in the region. The greatest threat to environmental settings of southeastern Nigeria is the gradual but constant dissection of the landscape by soil erosion [9].

Soil erosion occurs when the ability of the soil to withstand agents of denudation is overcome; this ability is regarded as soil erodibility. Erodibility is the resistance of the soil to detachment and transport [10]. Soil erodibilty is the susceptibility or vulnerability of a soil detachment by rainfall and or surface flow by runoff/surface flow force [11, 12]. Soil erodibility. Soil erodiblity index is one of the factors of the Universal Soil Loss Equation (USLE), which according to [13] states;

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

Where R = Rainfall Erosivity factor
K = Soil Erodibility factor
S = Slope length and Steepness factor
C = Cover Crop Management factor
P = Conservative/Management practice factor

The USLE is a conservation tool that has been demonstrated to do a reasonably good job of estimating erosion for many disturbed land uses [14]. It was done out of the necessity to understand the concept of soil loss due to environmental factors resulting in depreciation of soil quality leading to degradation. The USLE is an empirical model which has given rise to so many other models like LISEM (Limburg Soil Erosion Model), WEPP (Water Erosion Prediction Project), EUROSEM (European Soil Erosion Model), EGEM (Ephemeral Gully Erosion Model), PESERA (Pan European Soil Erosion Risk Assessment). e.t.c. The USLE was developed on experimental plots and empirical erosion data collected from relatively small plots or sub-watershed on relatively uniform hill slopes resulted in limited estimates of existing situations so this necessitated the evolution of the RUSLE, (Revised Universal Soil Loss Equation) by [15]. The RUSLE still retains all the factors of the USLE, only with further modification in the concepts of obtaining the factors. Soil erodibility is designated by the letter K, this factor is dependent on physical properties of the soil which could be intrinsic or exogenic as the case may be. K-Factor or value is expressed to represent organic matter content, relations of sand, very fine sand , silt and clay contents, soil structure and permeability/hydraulic conductivity to determine the level of deformation a soil has undergone or is undergoing since the K-factor itself is dependent on the soil properties [16]. Erodibility varies with soil textures, aggregates, stability, shear strength, soil structures, infiltration capacity, soil depth, bulk density, soil organic matter and chemical constituents [10]. The erodibilty factor of a soil tells by direct observation the rate and extent at which a soil can be degraded by erosion and an insight on how an eroding soil can be reclaimed or managed to prevent further degradation by whatsoever factors causing the loss in quality.

The objective of this study is therefore to examine soils within Imo State to determine their erodibility factor (K) and ascertain areas prone to erosion. The data obtained from this study will form a reference for consideration in the design of conservation structures within the area of study.

2. Materials and Methods

2.1. Position and Climatic Conditions of Study Area

The study area, Imo State, Nigeria, lies within Latitude 5°45′N - 5°15′N and Longitude 6°45′E - 7°15′E. The study area is within the rain forest belt of Nigeria. Two distinct conditions (*i.e.* wet and dry seasons) exist within the region. These two regimes are derived from the different air masses prevailing over the country at different times of the year namely; the dry northeasterly air mass (north east trade wind) of Saharan origin and the humid maritime air mass (south west trade wind) originating from the South Atlantic. The rainfall pattern in the area is oscillatory, bimodal and usually has two peaks within the year. The peaks vary between June, July and September. The region falls within the rain forest zone, so it experiences annual rainfall ranges from 1600 to 2900 mm [17]. The wet season begins in April and ends in October with a short recess in August usually referred to as August break. The dry season starts in November and ends in March. Monthly temperature is highest in February with a value of 30.1 °C while the lowest is 26.7 °C which is recorded in August, but mean monthly temperatures vary between 25-32°C with a relative humidity range of 75 - 90 % [18].

2.2. Vegetation, Soil, Geology and Groundwater Development of Study Area

The high temperature and humidity experienced in the state favour luxuriant plant growth produce the climax vegetation of the tropical rain forest, thus causing the watershed to be covered by depleted rain forest shrubs having thick underbrushes, creeping vines and deep green vegetation which is as a result of heavy decay of plant droppings and foliage [19]. The watershed or study area is dominated by sandy soil with little percentages of clay, loam and silt. The area is acidic with pH of between 4.67-5.6 for upper and lower layers and 5.0 - 5.6 at the crest and valley bottom and lower at midslope [20]. The watershed also in addition has low organic carbon ranging between 0.676 - 3.764 mg/kg for upper soil layer, 5.34 - 4.27 mg/kg for lower soil layer and lower at the midslope, low nitrogen concentration range of 0.008 - 0.068 % and 0.018-0.048 % for upper and lower soil layers. The soil type within this zone belongs to ferralic group because of the presence of Iron (Fe) and its related nitrides. The soil profile is remarkably uniform throughout the area, deeply weathered and intensely leached. The study area is based on a bedrock of a sequence of sedimentary rocks of about 5480m thick, with two major classes of formation underlying the Imo River Basin of which 80% consists of coastal plain sand, which is composed of non-indurated sediments represented by the Benin and

Ogwashi-Asaba formations and alluvial deposits, while the remaining 20% is underlain by series sedimentary rock units [21]. The formation summarily consists of sand (fine-medium coarsed grained and poorly sorted), sand stones and gravels with intercalations of clay and sandy-clay [22]. The study area is drained by two rivers, namely the Otamiri and Nworie. The Otamiri River has maximum average flow of 10.7 m^3/s in the rainy season (September - October) and a minimum average flow of about 3.4 m^3/s in the dry season (November - February), The total annual discharge of the Otamiri is about 1.7×10^8 m^3, and 22 percent of this (3.74×10^7 m^3) comes from direct runoff from rainwater and constitutes the safe yield of the river. The depth to groundwater varies from 15m - 35m in parts of the Owerri urban area. The aquifers have reasonable thickness and are extensive [18, 19].

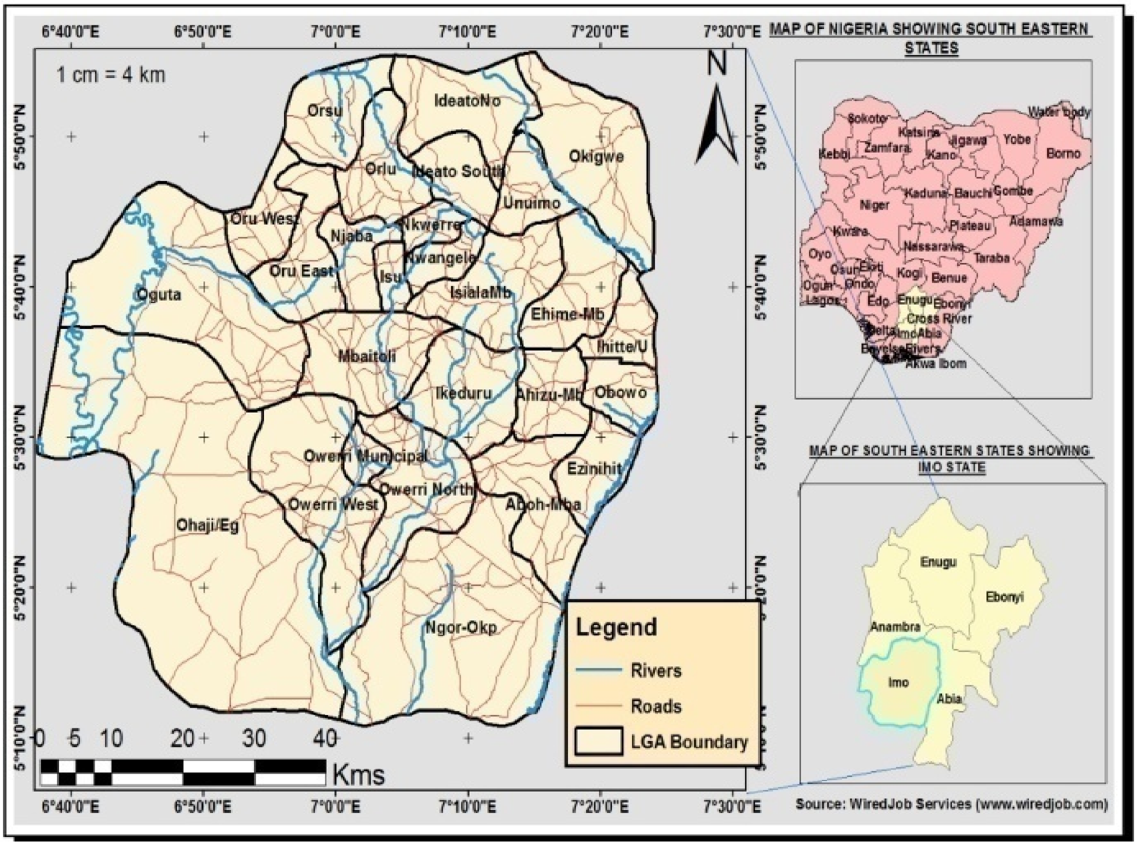

Figure 1. Position and Location of Study Area (Source: Wired-Job Services)

3. Data Collection

3.1. Soil Classification Map

The primary source of Soil map for the study area was generated from Nigeria Geological Survey, Centre. The co-ordinates (Longitude and Latitude) of the study area was used to extract the geological and mineral map from the enlarged soil map of Nigeria. Then the section extracted was imported into ArcGIS 10.1 and was geo-referenced under the WGS84 Cordinate System to give it a spatial attribute. The study area, Imo State was masked from it .Based on the digitized map, Imo State is divided into the following soil regions;

- Clay and Shales (Ebenebe and Umuna sandstones) – Palaocene
- Clayey sands and shales (Bende, Ameke and Nanka stones) – Eocene
- Sand stones (Imo formation Inc) – Palaocene
- Sand stones, Limestone and coal (Upper coal measures) – Maestriclitian-Danian
- Sands and clay (Coastal plains sands) – Plio-pleistocene
- Sands, gravel and clay (Meander belts) – Holocene
- Clay, sandstones, lignite and shales (Lignite formation) – Eocene
- Sands, clay and swamps (Sombreiro Deltaic plane) – Pleistocene-Holocene
- River alluvium

From the soil regions identified within the study area by the soil map different locations were selected for soil sampling. The soil samples were collected in triplicate at varying distances for each location with the use of a global positioning system (G.P.S) and soil collection vessels so as to prevent duplication of soil collection points. Figure 2 shows the soil map of Imo State.

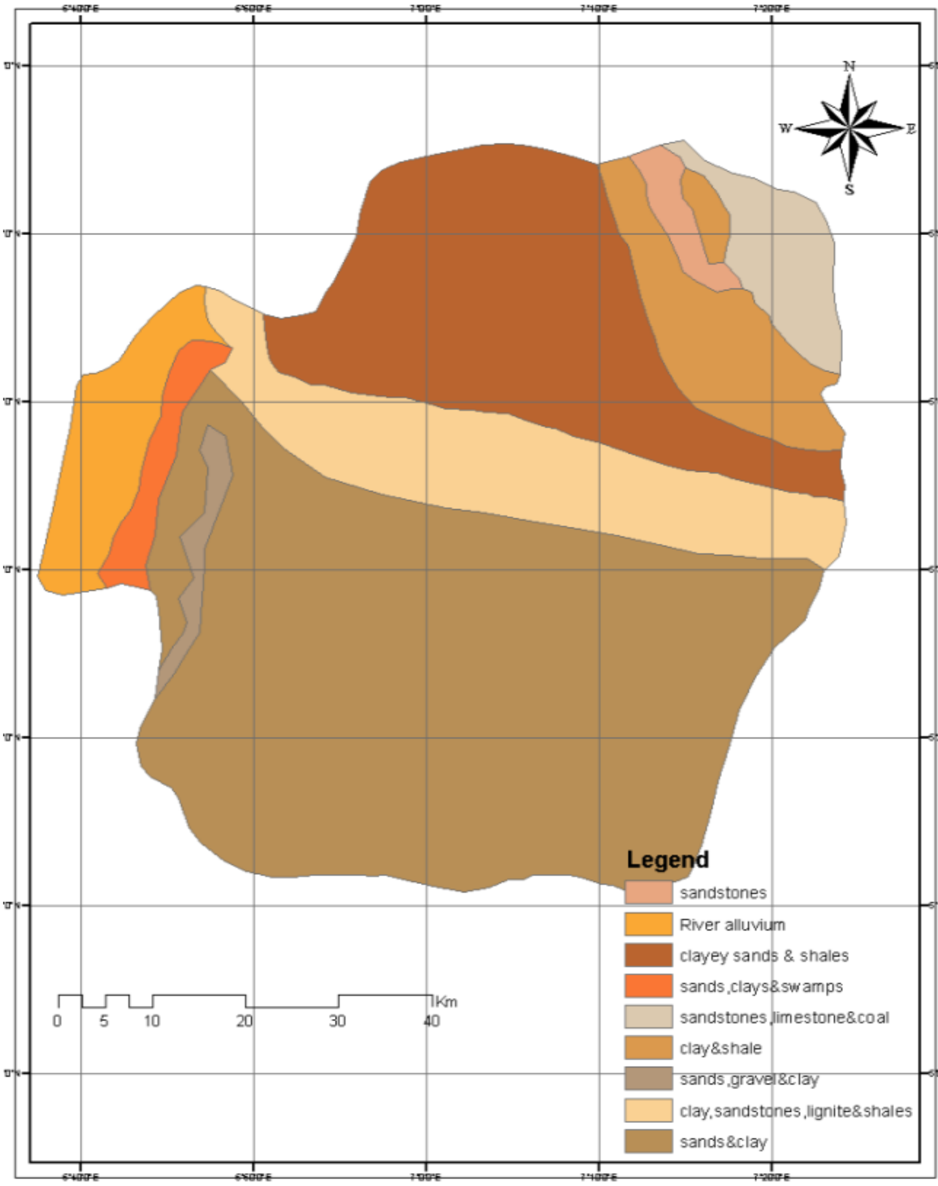

Figure 2. Soil Map of Imo State

The soil samples collected from each of the locations were subjected to the following soil test procedures:

- Constant head hydraulic Conductivity test to ascertain the permeability class of each soil sample
- Grain Size/Particle Size distribution by hydrometer method
- Organic matter content analysis by ignition loss method

With the data obtained from the various tests, the soil erodibility factor (K) for the various soils were obtained from the following relationship from [23, 24];

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

Where; OM = Organic matter content in percentage
N1 = Clay + Very fine sand (0.002-0.125mm) (%)
N2 = Clay + very fine sand + Sand (0.125-2mm) (%)
S = Soil Structure Class
P = Hydraulic Conductivity in (cm/s)

4. Results and Discussion

The position and location of each sample is presented in Table 1.

Each of the samples collected were subjected to ignition under controlled temperatures and the residues obtained after combustion were weighed to obtain organic matter content of the soil samples. Also the soil samples were analyzed in the laboratory for hydraulic conductivity using constant head and falling head piezometers to obtain the hydraulic conductivity. The values obtained are shown in Table 2.

Tables 3 and 4 reveal the values of N1 and N2 which were obtained from the particle size-distribution curve (plot of percentage soil passing through sieve sizes against particle size (mm)) for all the soil samples which was obtained after the soil samples were passed through the series of sieves for particle separation.

Table 1. Position of Sample Collection Points

Location	S1	S2	S3
Ehime Mbano	Latitude: 5°43'310"N	5°43'304"N	5°43'291"N
	Longitude: 7°14'800"E	7°14'804"E	7°14'813"E
Ideato North	Latitude: 5°53'733"N	5°53'743"N	5°53'744"N
	Longitude: 7°12'453"E	7°12'450"E	7°12'447"E
Ikeduru	Latitude: 5°35'230"N	5°35'235"N	5°35'238"N
	Longitude: 7°05'765"E	7°05'774"E	7°05'757"E
Oguta	Latitude: 5°42'47"N	5°42'442"N	5°42'432"N
	Longitude: 6°47'780"E	6°47'977"E	6°47'966"E
Ohaji Egbema	Latitude: 5°27'306"N	5°27'308"N	5°27'316"N
	Longitude: 6°51'971"E	6°51'969"E	6°51'969"E
Okigwe	Latitude: 5°50'451"N	5°50'438"N	5°50'446"N
	Longitude: 7°20'031"E	7°20'036"E	7°20'047"E
Orlu	Latitude: 5°48'605"N	5°48'608"N	5°48'606"N
	Longitude: 6°59'400"E	6°59'403"E	6°59'406"E
Owerri West	Latitude: 5°22'742"N	5°22'960"N	5°23'084"N
	Longitude: 6°59'814"E	6°59'940"E	6°59'935"E

Table 2. Organic Matter Content and Hydraulic Conductivity of the Soil Samples

Location	S1(%)	S2(%)	S3(%)	MEAN	P(cm/s)
Ehime Mbano	2.24	2.24	2.24	2.24	0.0050
Ideato North	2.30	2.31	2.34	2.32	0.0044
Ikeduru	2.87	2.84	2.85	2.85	0.0061
Oguta	3.01	3.04	3.05	3.03	0.0076
Ohaji Egbema	3.02	3.06	3.02	3.03	0.0089
Okigwe	2.05	2.01	2.00	2.02	0.0013
Orlu	2.54	2.53	2.50	2.52	0.0102
Owerri West	2.54	2.51	2.54	2.53	0.0093

Table 3. N1 (Clay + Very Fine Sand (0.002-0.125mm))

Location	S1(%)	S2(%)	S3(%)	MEAN(%)
Ehime Mbano	10.00	5.00	3.00	6.00
Ideato North	10.00	7.00	6.00	7.67
Ikeduru	4.00	3.00	3.60	3.53
Oguta	3.00	2.80	3.00	2.93
Ohaji Egbema	5.00	3.00	3.20	3.73
Okigwe	3.20	3.00	3.10	3.10
Orlu	4.00	2.25	4.00	3.42
Owerri West	8.00	6.00	3.00	5.67

Table 4. N2 (Clay + Very Fine Sand + Sand (0.125-2.00mm))

Location	S1(%)	S2(%)	S3(%)	MEAN(%)
Ehime Mbano	89.80	73.00	74.00	78.93
Ideato North	90.00	72.00	77.00	79.67
Ikeduru	94.00	94.00	96.00	94.67
Oguta	95.00	96.00	96.00	95.67
Ohaji Egbema	92.80	93.00	95.00	93.60
Okigwe	92.20	94.50	93.35	93.33
Orlu	93.20	92.80	94.00	93.33
Owerri West	92.00	73.00	72.00	79.00

Table 5. Soil Structure Class

Structure Class	Soil Structure	Particle Size (mm)
1	Veryfine and very thin	<1.0
2	Fine or thin	1.0-2.0
3	Medium	2.0-3.0
4	Medium or Coarse	3.0-4.0
5	Coarse or Thick	4.0-10.0
6	Very coarse, thick, blocky shale	>10.0

Source: [27].

From Table 5 the gradations of various soils are shown. Considering the area in which the study is being carried out the soil samples fall within the coarse-thick coarse sand group which is poorly sorted. Thus falling in tandem with is the Benin- Ogwashi-Asaba rock formation from which the soils within the region take their origin [21]. The soil structure group class therefore is taken as soil structure class 5.

Table 6. Summary of Soil Erodibility Parameters

Location	OM(%)	N1(%)	N2(%)	S	P (cm/s)
Ehime Mbano	2.24	6.00	78.93	5	0.50
Ideato North	2.32	7.67	79.67	5	0.44
Ikeduru	2.85	3.53	94.67	5	0.61
Oguta	3.03	2.93	95.67	5	0.76
Ohaji Egbema	3.03	3.73	93.60	5	0.89
Okigwe	2.02	3.10	93.33	5	0.13
Orlu	2.52	3.42	93.33	5	1.02
Owerri West	2.53	5.67	79.00	5	0.93

All the values obtained from the various laboratory/experimental procedures were summarized in Table 6.

Table 7. Soil Erodibility Factor (K) for the Locations

Location	K-Value
Ehime Mbano	0.023
Ideato North	0.066
Ikeduru	0.045
Oguta	0.053
Ohaji Egbema	0.060
Okigwe	0.039
Orlu	0.062
Owerri West	0.067

The values shown in Table 6 were substituted into equation 2.0 and the soil erodibility factor (K) for each of the locations were obtained and expressed in Table 7. The K-values obtained from the study have slight increments when compared to K-Values obtained from previous researches [10, 25] within the area, this can be considered as a result of environmental changes. According to [26], the K-values obtained for the various locations and their positions (Longitude and Latitude), ArcGis 9.0 and 3D-Mapper softwares were used to export the data on the map of the study area to obtain the soil erodibility map of Imo State. The map is shown in the figure 3.

Table 8. Standard Erodibility Indices

Group	K-Value	Nature of Soil
I	0.0-0.1	Permeable out wash well drained soil, slowly permeable substrata
II	0.11-0.17	Well grained soils in sandy gravel free material
III	0.18-0.28	Graded loams and silt loams
IV	0.29-0.48	Poorly graded moderately fine textured soil
V	0.49-0.64	Poorly graded silt, very fine sandy soil, well and moderately graded

Source: [25]

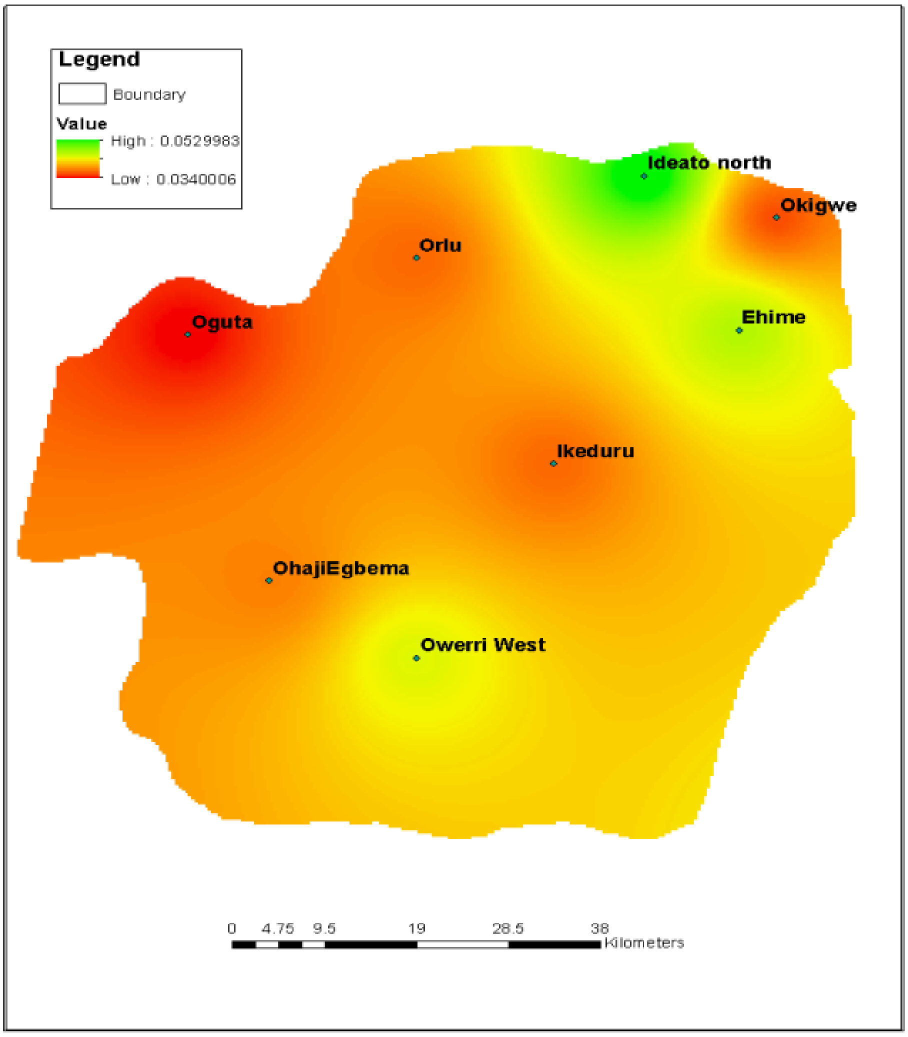

Figure 3. Soil Erodibility Map of Imo State

5. Conclusions

From the K-Values obtained for all the locations, the locations with the highest K-values are *Owerri West*, *Ideato North, Orlu* and *Ohaji-Egbema* which are 0.067, 0.066, 0.062 and 0.060 respectively, this concurs with the reconnaissance survey carried out within the study area depicting that those areas specifically have the highest incidences of gullies in Imo State. *Okigwe, Ikeduru* and *Oguta* showed moderate K-values of 0.039, 0.045 and 0.053 while *Ehime Mbano* showed the least K-value of 0.023. From the Table of standard erodibility indices all the soils fell into group 1, which implies that the soils in Imo State are permeable outwash well drained soils with permeable sub-strata. The data obtained from this study is a knowledge base reference for design of control structures which will be necessary for soil conservation and management practices within the study area.

ACKNOWLEDGEMENTS

The research was supported by TETFUND (Tertiary Education Trust Fund). The authors are grateful to the personnel of the Federal University of Technology Owerri (FUTO) Erosion Research Institute for all the experimental analysis and field observations.

REFERENCES

[1] Wang, L., Huang, J., Du, Y., Hu, Y., and Han P., 2013, Dynamic Assessment of Soil Erosion Risk Using Landsat TM and HJ Satelite Data in Danjiangkou Area, China. Journal of Remote Sensing 5(4): 3826-3848.

[2] Abdulfatai, I.A, Okunlola, I.A, Akande, W.G, Momoh, L.O and Ibrahim, K.O 2014, Review of Gully erosion in Nigeria: Causes, Impacts, and Possible Solutions. Journal of Geosciences and Geomatics 2(3): 125-129.

[3] Gunawan G., Dwita S., Herr S. and Sulostiowemi, W, 2013, Soil Erosion Estimation based on GIS and Remote Sensing for Supporting Integrated Water Resources Conservation Management, International Journal of Technology, 2(1): 147-156.

[4] Onu, D. O., 2013, Farm Level Analysis of Investment Behaviours in Soil Conservation and Erosion Control Practices in the Ecologically Vulnerable Communities in Southeast Nigeria. Agriculture and Biology Journal of North America: 2013 4(4): 441-458.

[5] Igbokwe, J. I. 2004. Gully erosion mapping / monitoring in parts of South–Eastern Nigeria. Paper presented at the National workshop on satellite remote sensing and GIS: a solution to sustainable national development challenges. Abuja. June, 15 – 17.

[6] Lal, R. 2001. Soil Degradation by Erosion. Land Degradation and Development 12: 519 – 539.

[7] Onu, D. O. 2006. Socioeconomic factors influencing farmers adoption of Alley farming Technologies under intensified agriculture in Imo State Nigeria. The Philippine Agricultural Scientist. 89(2): 521 – 543.

[8] Eze A.N. (2000) Strategies for Enhancing the Adoption of Soil Conservation Technologies in School Farms in Anambra State. In Environmental Review 3(2): 412-419.

[9] Igwe, C.A., 2012, Gully Erosion in Southeastern Nigeria: Role of Soil Properties and Environmental Factors; InTech Open Science Publishers, Pp.157-171.

[10] Idah, P.A, Mustapha, H.I, Musa, J.J and Dike, J. 2008, Determination of Erodibility Indices of Soils in Owerri West Local Government Area of Imo State, Nigeria. AU J.T. 12(2): 130-133.

[11] Egwuonwu, C.C and Okereke, N.A.A 2012, Characterization of Erodibility Using Soil Strength and Stress-Strain Indices for soils in Selected sites in Imo State. Research Journal of Environmental and Earth Sciences 4(7): 688-696.

[12] Vaezi, A.R, Sadeghi, S.H.R., Bahrami, H.A and Mahdian, M. H., 2008, Modeling the USLE K-Factor for Calcareous Soils in Northwest Iran. Geomorphology 97(2): 414-423.

[13] Wischmeier, W.H., and Smith, D.D., 1965. Predicting rainfall erosion losses from cropland east of the Rocky Mountains: United States Department of Agriculture Agricultural Handbook, 282. U.S. Government Printing Office, Washington D.C.

[14] Morgan, R.P.C and Nearing, M.A 2011, Handbook of Erosion Modelling, Wiley Online, 17-19.

[15] Renard, K.G., Foster, G. R., Weesies, G.A, McCool, D. K., and Yoder, D.C., 1997, Predicting Soil Erosion by water: A guide to Conservation Planning with the Revised Universal Soil loss equation (RUSLE).USDA, Agriculture Handbook No.703, Washington DC.

[16] Colombo, C., Palumbo, G., Ancelli, P.P.C., Angelis, A.De and Rosskopt, C. M. Relationships between soil properties, erodibility and hillslope features in Centeal Apennines, Southern Italy. A paper presented at the 19th World Cngress of Soil Science, Soil Solutions for a changing World 1-6, August, 2010, Brisbane, Australia.

[17] Selemo, A.O, Ananaba, S.E, Nwagbara, J.O, Egejuru, V.E and Nwugha, V., 2012, Geostatistical Analysis of Rainfall Temperature and evaporation Data of Owerri for Ten years. Journal of Earth and Environmental Sciences, 2012(2): 195-205.

[18] Ibe, K.M, and Uzoukwu, S. C., 2001, An Appraisal of subsurface geology and groundwater resources of Owerri and environs, based on electrical resistivity survey and bore-hole data evaluation. Environmental Monitoring Assessment, 70(3): 303-21.

[19] Okorafor, O.O, Okereke, N.A.A and Egwuonwu, C. C., 2013. Evaluation of the hydropower potential of Otamiri river for Electric power generation. Research Journal of Appled Sciences, Engineering and Technology 6(24):4541-4547.

[20] Njoku, J.D, A.O Nnaji and Iwuji, M. C., 2011, Spatial Analysis of Soil Fertility using Geographical Information System (G.I.S) Technology, African Research Review, 4(2): 511-524.

[21] Ijeh, B.I, and Onu, N. N. 2013. Assessment of Pollution Levels of Groundwater in Parts of Imo River Basin, South-Eastern Nigeria. International Journal of Water Resources and Environmental Engineering 5(4): 194-202.

[22] Ekwe, A.C, Onu, N.N and Onuoha, K. M., 2009. Estimation of Hydraulic Characteristics from Electric Sounding data: the case of middle Imo River Basin Aquifers, South-eastern Nigeria. Journal of Spatial Hydrology 6(2): 121-132.

[23] Kamaludin, H., Lihan, T., Rahman, A, Mustapha, M.A, Idris, W.M.R, and Rahim, S.A, 2013, integration of remote Sensing, RUSLE and GIS to model Potential Soil Loss and Sediment Yield. Journal of Earth Systems Sciences, 10-4567-2013.

[24] Wischmeier, W.H., and Smith, D.D., 1978. Predicting rainfall erosion losses. A guide to conservation planning: United States Department of Agriculture Agricultural Handbook, 537. U.S. Government Printing Office, Washington D.C., USA.

[25] Emeka-Chris, C.C, 2014. Determination of Erodibility Index (K) of Soil in Michael Okpara University of Agriculture, Umudike. International Journal of Engineering and Science 3(12): 30-38.

[26] Ogbonna, J.U, Alozie, M., Nkemdirim, V and M.U. Eze, M. U., 2011, GIS analysis for mapping gully erosion impacts on Geo-information of the old Imo State, Nigeria. ABSU Journal of Environment, Science and Technology, 1(1): 48-61.

[27] Agriinfo. 2015, Soil Structure Classification of soils. Amazon Publishers.