International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 03, March-2015

The use of Revised Universal Soil Loss Equation (RUSLE) as a Potential Technique in Mapping Areas Vulnerable to Soil Erosion in the Upper Yedzaram Catchment of Mubi

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***Abstract*-The hazardous effect of uncontrolled and indiscriminate bush burning, deforestation as a result of road construction and land clearing for agricultural use have resulted to wide spread soil erosion over the yedzaram catchment. This research tends to determine the mean annual soil loss rate using the RUSLE model for the Upper Yedzaram Catchment for the year 1999 and to proffered solutions in order to mitigate the effects of this menace. The False Colour Composite (FCC) of the image was derived by using band 4, 3, 2 of the LansSAT TM image acquired in the year 1999 and classified into the land use classes (C- Cover management factor and P- support practice factor) within the study area, the support practice (P), Soil factor (K) and R- rainfall pattern factor were also digitized and converted to raster.**

The digitized maps and the classified images were reclassified by assigning the index factors value onto each, as slated in RUSLE handbook, Data such as (R), (K), topography (DEM), (C) and (P) were utilized for soil modeling using the integration of RUSLE and Geographic Information System (GIS), the average annual soil loss of the upper Yedzaram was predict to be 2381.87 tons/acre/year for 1999. From this study and this prediction, the soil loss is expected to increase with time if agricultural activities, deforestation and land clearing continue to take place within the research area.

Keyword: Erosion, Soil loss, Digital Elevation Model, Management Cover, Factors, topology.

I. INTRODUCTION

Erosion is a serious ecological problem affecting valuable land worldwide, and in the recent, Nigeria for instance have a lot of resources released towards controlling the problem by the government. However, the result has not been sufficient. Erosion has great negative impact on the environment, agricultural productivity, lives and property of urban and rural areas. Most human activity that modifies the land or environment enhances soil erosion. Erosion occurs when the amount of runoff originating in a watershed exceeded the carrying capacity of natural constructed drainage system [4]. Population pressure, topography nature of the of soil characteristics, climate variables, urban development and most human activities modifies vegetation cover, thus; leading to increase surface runoff and consequently washes away the top soil especially from the cultivated lands. This runoff reduces the land elevation which increases erosion intensity in an area [2], [7]. When land is not properly managed, the result will be high rate of soil erosion and sediment discharge into a given basin.

STUDY AREA

River Yedzeram is one of the rivers that drain into Lake Chad. It has a total length of about 330 kilometer [8]. It takes it source from the Hudu Hills south-east of Mubi and flows northward into the Chad [1].

The study area is situated in the North and South parts of Mubi Local Government Area, the Northeastern part of Adamawa State, Nigeria and located between latitudes 10° 11 '30" and 10° 22' 30"N and between longitudes 13° 13' 00" and 13° 30' 00" 'E. The drainage basin covers an area of 35.1 kilometer square and falls within the Mubi (North and South) political boundary. However, the section of the channel's middle course studied covered a length 30 km^2 from Va'atita in Mubi south to Mayo Bani in Mubi North Local government area.

METHODOLOGY

The methodology for this research involved the use of RUSLE in a GIS environment. It include the use of Rainfall erosivity factor (R), Soil erodibility factor (K), topographical factor (DEM), Land cover factor (C), Conservation practice factor (P), topographic maps and satellite imagery. Each GIS layer was developed for each factor and combined using the ArcGIS 10 software. The data used for this study includes, a topographic map of the research area which was digitized and converted to form the digital elevation model (DEM) through the Spatial Analyst tool from topo-to-raster.

The land use map of the study area was classified from (Landsat TM, 1999) satellite imagery for information on different land uses of the area, ArcGIS 10 software was used to extract land data using the supervised method of remotely sensed data. By this method, ground truthing was caried to compare the classified image with the real data relatively to the land cover of the study area. Supervised classification was used to control the classes by integrating classified image with the visual interpretation techniques. Meanwhile; the P-factor was also classified by assigning index values to represent the management practice within the area of study while the K, R-factor were digitized and reclassified to match the index values of the soil erodibility and the rainfall erosivity factors. Hence the raster calculator was used to achieve the soil loss map by multiplying these factors using RUSLE equation.

COVER MANAGEMENT (C) FACTOR

Cover Management Factor (C) is the ratio of soil loss of a specific crop to the soil loss under the condition of continuous bare fallow [6]. The amounts of protective coverage of crops on surface soil have great influences on soil erosion rate. The C factor value is equal to 1 for bare fallow land and rock-Outcrop. The erosion effect is more when the C value is lower than when there is more coverage of a crop for the soil surface resulting in less soil erosion. In RUSLE, the values of C factor based on land use classification have been determined by the Department of Agriculture (DOA) as shown in table 1 below.

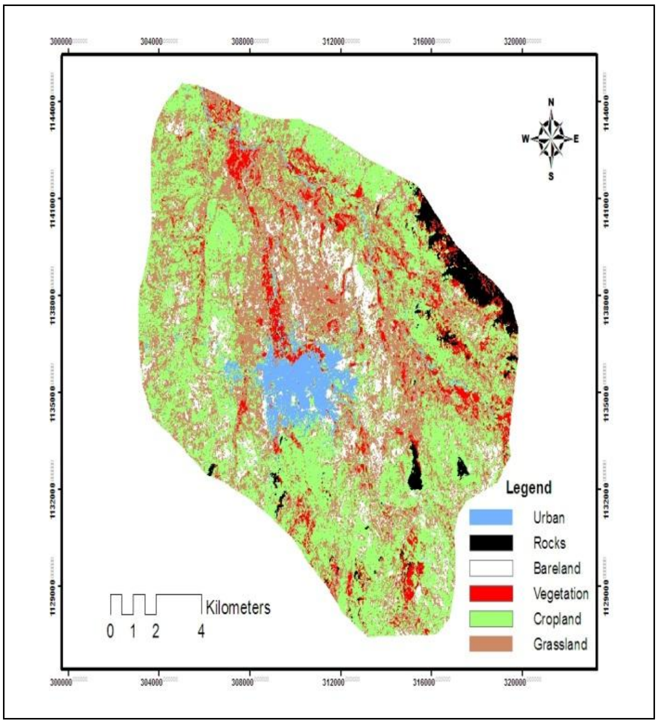

Figure 2: Cover Management Factor map of the study area.

DIGITAL ELEVATION MODEL (DEM)

Digital Elevation Model (DEM) is an ordered array of numbers that represent the spatial distributions of elevations above some arbitrary datum in landscape [5]. A DEM is a numeric representation of the spatial variation in the land surface elevation which represent the land surface as a matrix of elevation value (Z), implicitly located by their geographic coordinates (X,Y). The Digital Terrain Model use for this research was derived from a digitized contour map through GIS surface analysis tools to interpolate the DEM as shown in figure 3.

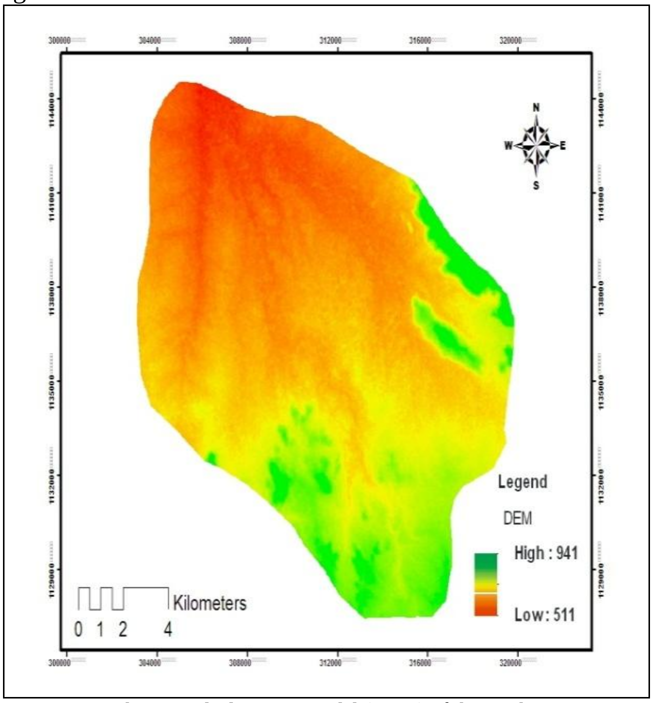

Figure 3: The Digital Elevation Model (DEM) of the catchment Area.

SUPPORT PRACTICE (P) FACTOR

The RUSLE P-factor reflects the impact of support practices as the average annual erosion rate. It is the ratio of soil loss with contouring and or strip cropping to that with straight row farming up-and-down slope. As with the other factors, the P-factor differentiates between cropland and rangeland or permanent pasture (figure 4); thus, the values are analyzed below in table 1.

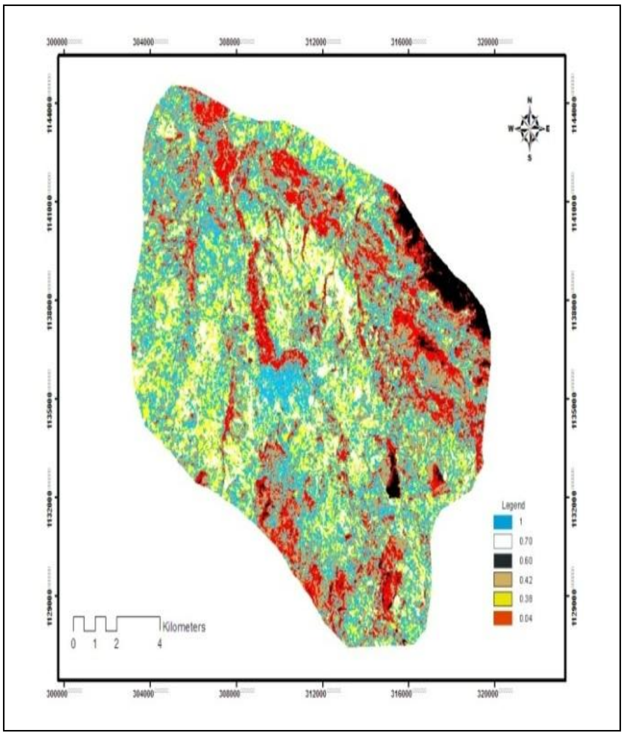

Figure 4: Support Practice Factor map of the catchment area.

Table 1: C and P factor of Yedzeram Catchment. (Determined using Agric. Handbook 537and 703)

Classes	C-factor index	P-factor index	Percentage Cover%
Urban Area	0.01	1.00	3.401
Bare land	1.00	0.70	10.564
Rock- Outcrop	0.90	0.60	2.011
Vegetation	0.03	0.04	40.094
Crop land	0.24	0.38	25.264
Grass land	0.12	0.42	18.666

RAIN EROSIVITY (R) FACTOR

The rainfall-runoff erosivity factor (F); It is the average annual summation (EI) values in a normal year's rain. The erosion-index is a measure of the erosion force of specific rainfall. When other factors are constant, storm losses from rainfall are directly proportional to the product of the total kinetic energy of the storm (E) multiply its maximum 30-minute intensity (I). Storms less than 0.5 inches are not included in the erosivity computations because these storms generally add little to the total R value. R factors represent the average storm EI values over a 10-year record. R is an indication of the two most important characteristics of a storm determining its erosivity: amount of rainfall and peak intensity sustained over a long period of time.
The erosivity of rainfall varies greatly by location (figure 5). The total annual R factor in upper Yedzaram ranges from 750mm to 1050mm with the average annual rainfall index to be constant at 122.7 mm. Approximately 70 percent of the erosivity occurs in the months of May, June, July, August and September in Upper Yedzaram catchment. .

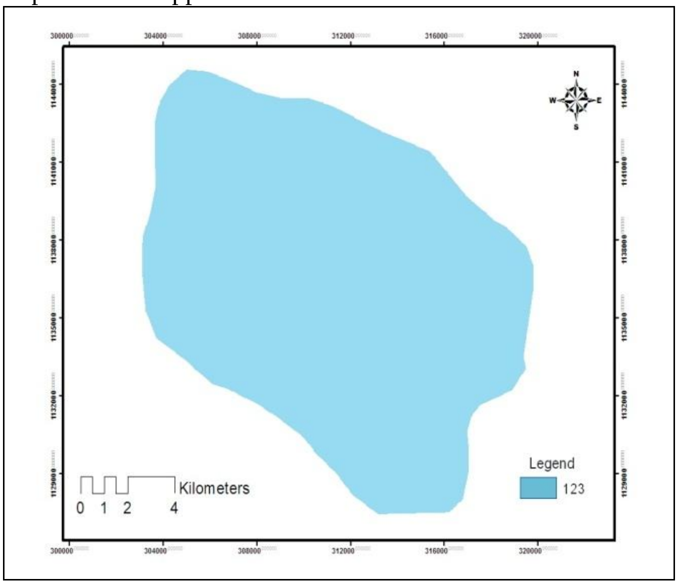

Figure 5: Rainfall Erosivity Factor map of the catchment Area.

SOIL (K) FACTOR

The soil factor erodibility factor (K) represents susceptibility of soil to erosion, the rate of runoff as measured under the standard unit plot environment. Soils with high clay content have low (K) values. Therefore the K value selected for yedzaram catchment is constant 0.43mm because the soil characteristics over the catchment are evenly distributed. Organic matter reduces erodibility because it reduces the susceptibility of the soil to detachment, and it increases infiltration, which reduce runoff and a constant K factor value is mostly used for an environment except in some special cases where the soil factor changes relatively.

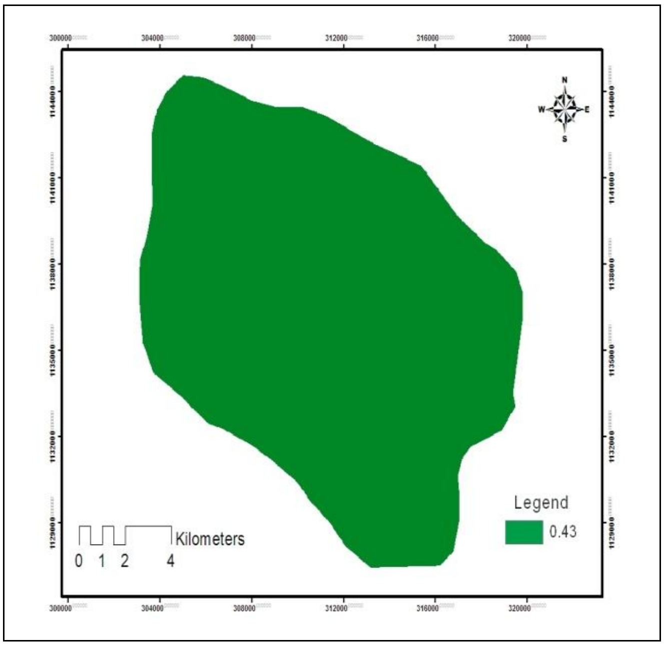

Figure 6: Soil Erodibility Factor map of the Catchment Area.

RESULTS

The RUSLE equation which stated that A= C*P*LS*K*R was used to calculate the annual average soil loss rate (A) in ton/ha/year. In order to predict the annual average soil loss rate in the upper catchment of Yedzeram, the R, K, LS, C and P factors from the earlier chapters were multiplied using the raster calculator function tool of ArcGIS 10 as shown in Figure 7. The multiplication of the images using RUSLE model resulted into an image showing different classes of vulnerability intensity rate of the catchment. For ease of interpretation, the intensity of erosion vulnerability was divided into four (4) classes as shown in figure 7 below. The Upper Yedzaram Catchment in 1999 showed an increase in green, white, black, and Red, which depicts an increase from low, severe, extreme and exeptional to erosion in the year 1999 with their quantified values in tons/acre/year.

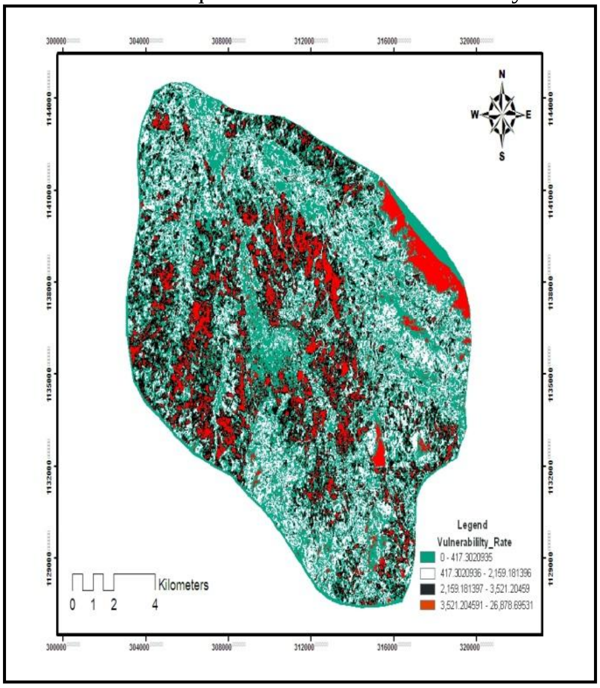

Figure 7: Intensity Map showing area vulnerable to erosion

Annual Soil Loss of Yedzaram catchment estimation

The analysis of the data shows that the average soil loss rate of the catchment is estimated at 2381.87 tons/acre/year and the maximum soil loss rate which is 26878.70 tons/acre/year which occur at the dried crop field area of the catchment. This result is based on the spatial distribution pattern of soil loss rate. Figure 8 combine the interpretation of annual soil loss rate and the average annual soil loss, from the statistical histogram below, the actual maximum soil loss is calculated to be 26878.70 tons/acre/year and the mean annual soil loss is estimated to be 2381.87 tons/acre/year using Customized layer property for image histogram in identifying the maximum soil loss and the average annual soil loss. The histogram explains the statistical analysis of the RUSLE; the lowest soil loss is 83.10 tons/acre/year while the standard deviation for the RUSLE analysis is 8391.68.

A customized layer property for image histogram was used in identifying the maximum soil loss and the average soil loss. The histogram explains the statistical analysis of RUSLE; the average soil loss is 2381.87 tons/acre/year and the maximum soil loss was estimated to 26878.70 tons/acre/year.

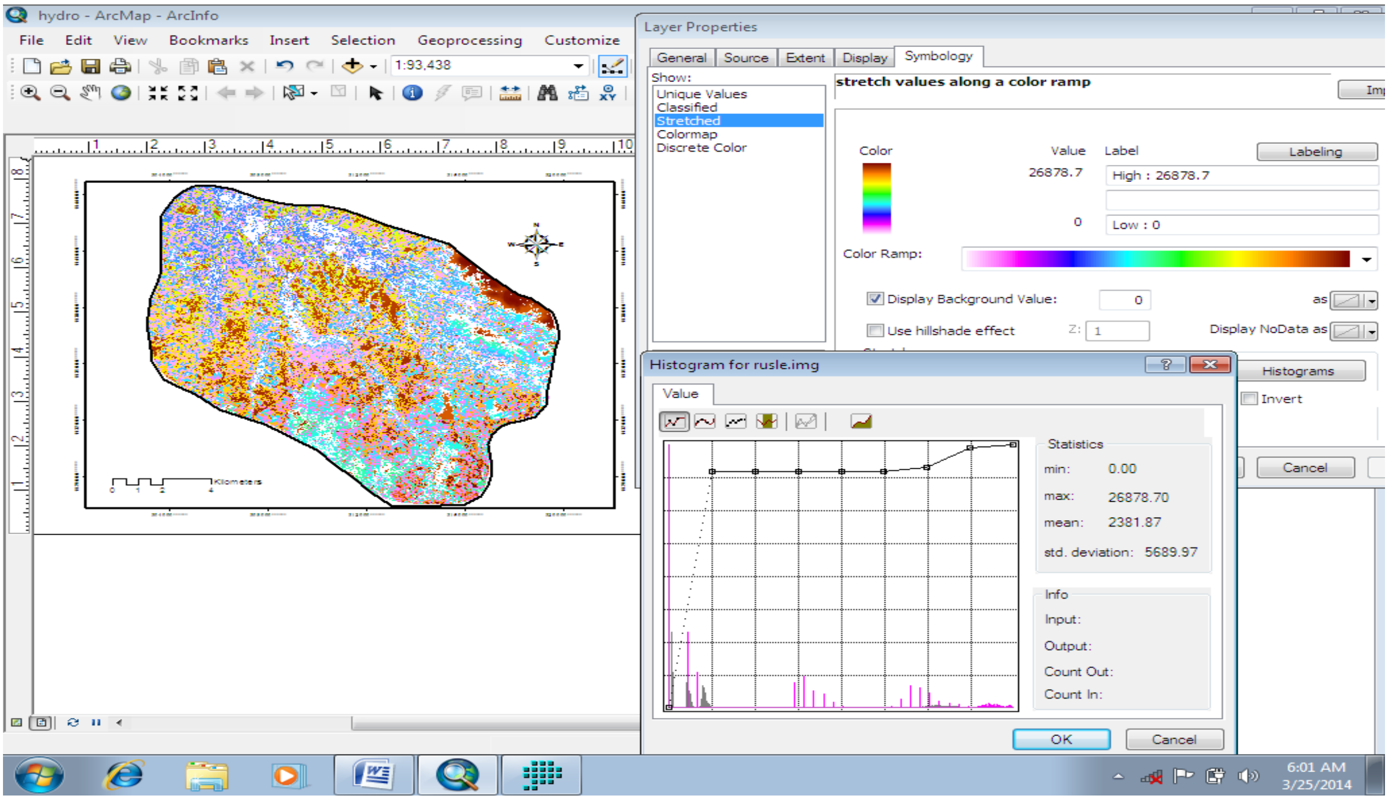

Figure 8: average Soil Loss rates based on the Land cover Using ArcGIS 10 Histogram

SUMMARY

The use of RUSLE as a technique in assessment of soil erosion vulnerability in the upper Yedzeram catchment covering an area of about 35.1 km^2 was carried out and the objectives of this research include an average annual soil loss estimate.. The result was therefore used to design strategies for preventing and mitigating soil erosion within the studied area.

The result of RUSLE depicts the quantity of soil loss within the study area caused by the factor that enhanced soil erosion in the year 1999, the annual average soil loss was estimated to be 2381.87 tons/acre/year. The factors responsible for soil erosion in the catchment area are (topography, rainfall, and soil type and management practice) within the study area, and the strategy for the prevention and the control of soil erosion are (Reforestation and afforestation, trenches and drainage system) in the area was investigated.

CONCLUSION

Soil erosion involves complex and heterogeneous hydrological processes. The RUSLE has been the official calculation algorithm used by researchers. This method has been widely used to calculate erosion at any point in a landscape that experiences erosion. It is simple to use and conceptually easy to understand. The DEM is a fundamental input for spatially distributed models and can provide primary spatial information on elevation, slope and watershed aspect in the modeling process. The DEM can be integrated within the watershed system to model the effects of these parameters upon soil erosion over the entire watershed. This study successfully introduced a simple method for automated spatial distribution extraction for overland flows in conjunction with the RUSLE to produce a reasonable estimation for soil erosion.

In view of the findings, the following recommendations were made; on the effect of global warming, the amount of rainfall is bound to increase in the subsequent years therefore the need for urgent response in trenches excavation around the mountains to collect runoff water from the hill will be of good assistance in reducing gully formation in the studied area. In addition, revegetation is the answer to deforestation, the use of bye word by government putting measures in place to check the policies (Four trees should be replace with one fell tree).

Finally, a standard drainage system should be in place to channel the runoff water to the river to prevent gully erosion within the catchment of this research and there is a serious need to educate the public on the effects of their activities on the environment and the importance of the measure put in place to mitigate the effects of gully erosion on the studied area. All these depend on the ability of the government and the town planning department of the local and state authority.

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