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Review Article

USLE and RUSLE Approach- Important Tools for Soil Erosion Risk Assessment: A Review

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Abstract: Gullies and development other forms of erosion have become the greatest environmental hazard and disaster rampant in the wide world. soil loss equations have been initiated since the 1940s and their focus over time has shifted to land conservation. The overall current soil erosion rates are highly variable and gully erosion is the dominant processes. In addition, The influence of human activities on the landscape. Through a productive review of existing research, this paper presents a comprehensive review of the USLE and RUSLE approach for soil erosion risk assessment causes and effects of soil erosion as well as control measures aimed at reducing.

Keywords: USLE, RUSLE, Soil Erosion, GIS, RS.

INTRODUCTION:

Began developing equations to calculate field soil loss about 1940 in the Corn Belt. Then, between 1940 and 1956 soil loss estimating procedure was referred to as the slope-practice method. The report(Browning *et al.*,1947), designed soil management factors for a set of tables to facilitate field use of the equation in Iowa. A diagrammatic of the equation was published in 1952, where it was used by Soil Conservation Service (SCS) in the Northeastern States (Lloyd *et al.*, 1952).

The Universal Soil Loss Equation (USLE) was developed initially as a tool to support soil conservationists, where conservationist used the USLE to assessment soil loss on specific slopes in particular fields. Also, The USLE has guided the farmer in choosing practices that would control erosion adequately If soil loss exceeded acceptable limits. Important an erosion model designed to compute longtime average soil losses from rill erosion and sheet under specified conditions. also, useful for construction sites and other non-agricultural conditions(Wischmeier *et al.*, 1978). The USLE has been widely applied for simulating soil loss using annual and average annual data in semi-arid and sub-humid regions of India. Nash and Sutcliffe model efficiency was (0.95 and 0.90) an average annual basis and when predicted on annual basis respectively. Also, model efficiency based on annual data series was (0.46 and 0.76) in a semi-arid region and sub-humid region respectively. While the coefficient of determination (R2) between measured and simulated soil loss values was (0.88 and 0.91), (0.93 and 0.94) on annual basis, and an average annual basis for a semi-arid and sub-humid region, respectively. Due to attributed to the erratic and uneven distribution of rainfall the Observed soil loss values registered higher variation in semi-arid region compared to sub-humid region for both annual and average annual data sets(Ali & Sharda, 2005). While (Fistikoglu & Harmancioglu, 2002). A GIS has been integrated with the USLE the purpose of the study is to distinguish the gross erosion, sediment loads, and organic N loads to the Gediz River, Turkey. Also, presented here reflects the difficulties in applying the methodology when the required data deficient in both quantity and quality.

In 1980, it was established that original USLE should be revised to include additional update research information to increase its applicability to different sites worldwide, where Revised Universal Soil Loss Equation(RUSLE) developed as a temporary advance,

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is intended to bridge the gap between what is now ancient technology (USLE). Also, The RUSLE utilizes the same empirical equation used in the USLE. RUSLE model is computer-based, normally used for a variety of vegetation types and slope and on steeper longer. The RUSLE Widespread use and proved usefulness and validity, where it retains the six factors of Agriculture Handbook No. 537 to calculate A from a hills lope. Then, soil-loss evaluations included in the previous handbook using fundamental information available in three databases: CITY,CROP, and OPERATION(Renard *et al.*,1997). RUSLE can be used to compute soil loss in areas where important overland flow occurs but is not designed for lands where no overland flow occurs (Dissmeyer & Foster , 1980).

The Erosion Consequences Traditional

Genetically, palynological, geomorphological, and sedimentological studies have explained close relationships between land use/land cover (LU/LC) changes. Also, the studies propose that soil erosion on the sedimentation and hill slopes in the valley floors were already present during the Bronze Age, pre-Middle Ages, during the Roman, and post-Roman periods. Erosive influences of traditional land-uses from steppes in very degraded states and hill slopes covered by open shrubs, an increase in soil stoniness, changes in soil structure, soils without upper horizons, infiltration and field capacity(García-Ruiz, 2010). The report (García-Ruiz *et al.*, 1995) aims to compare the traditional land uses with the present ones, to explain some of the landscape characteristics (soil conservation).The results obtained refer to the traditional cereal agriculture they respond rapidly to precipitation and soil erosion, due to a state of damage of many soils used for cereal cultivation over many centuries. Also, Meadows and dense shrub cover yield much water and few sediments, and very little water and very few sediments respectively. Finally, The burning of the dense shrub cover results in a sudden increase in erosion and runoff.

Process of Erosion

The detachment, transport, and deposition of soil particles due to one energy provide by water, wind, and gravity drives, where detachment exists when the forces holding a soil particle by one energy provide. This study (Gilley & Finker, 1985) an attempt to evaluate the performance of several soil detachment relations, where detachment equation use with raindrops influence at terminal velocity and define the rainfall detachment factor. The rainfall factors included: kinetic energy, kinetic energy times for unit of drop area and circumference, kinetic energy per unit of drop area and circumference, momentum, momentum times unit of drop area and circumference, momentum per unit of drop area and circumference. The reliability of assessment obtained using this factor varied safely between soil materials. an equation relating soil detachment to rainfall intensity was acquired from information available in the literature. During a rain erosion test, detachability was safely affected by surface water content changes but, transportability was not. Transportability was negatively linked to grain size, where this relation could appear by a power function. For the sediments, detachability variations were more significant than variations in transportability. While the coarse sediments, transportation by raindrop effected was a selective process(Savat & Poesen, 1981). The third and final step in the erosion process and occurs simultaneously with two steps is Deposition (Huang et al. 1999).Deposition occurs moving water is greater than its transport capacity (Foster & Meyer 1972).

Universal Soil Loss Equation (USLE) and Revised Universal Soil Loss Equation (RUSLE):

A brief history:

Universal Soil Loss Equation (USLE):

In1965 was depended on the analysis of 10,000 plot-years of data under natural rainfall conditions collected mostly on agricultural plots, where rainfall data are used to design soil erodibility and supply values for the effectiveness of preservation tillage and construction practices. Therefore, The term "universal" was given to the USLE to distinguish it from earlier erosion prediction equations. It was applied on agricultural lands throughout the United States and non-agricultural situations such as construction sites and undisturbed lands including rangelands and forests. The following description of the USLE basic USLE (Wischmeier & Smith, 1965, 1978) is:

$$\mathbf{A = RK\,(LS)CP} \qquad (1)$$

Where:

A: Soil loss in tons/acre for the time period selected for R (usually 1 year).

R: A rainfall erosivity factor for a specific area.

$$\mathbf{R}=\frac{\sum_i^n EI_i}{n} \qquad (2)$$

Where:

E: The kinetic energy per inch of rainfall (ft-tons/acre).

I: The rainfall intensity in each rainfall intensity period of the storm (in./h).

K: A soil erodibility factor for a specific soil, expressed in tons/acre per unit of R. This nomograph (Figure 1) is currently used to obtain the K factor.

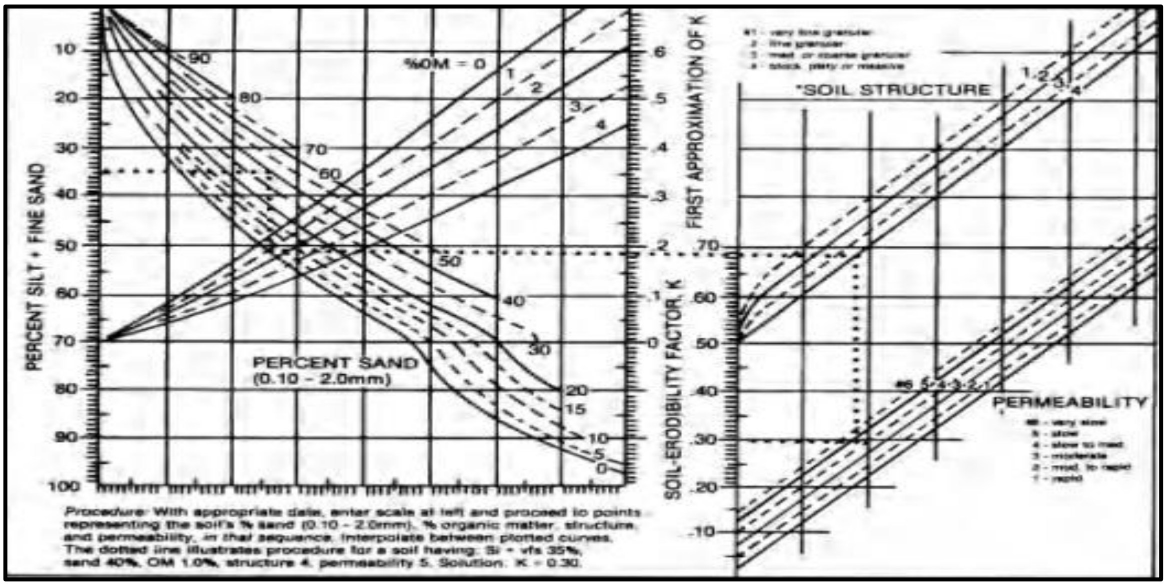

Figure 1: Nomograph for determining the soil erodibility factor (K) (Wischmeier *et al.*, 1971)

LS: The topographic factor, where **L** is the ratio of soil loss from a given field slope length to soil loss and **S** is the slope gradient factor.

The slope length factor (L) is defined as:

$$\mathbf{L}=\left(\frac{\lambda}{72.6}\right)^{m} \qquad \textbf{(3)}$$

Where:

λ: The field slope length (ft).

m: Affected by the interaction of slope length with gradient, soil properties, type of vegetation, etc.

The slope gradient factor (S) is defined as:

$$\mathbf{S}=\frac{0.43+0.30s+0.04s^{2}}{6.613} \qquad \textbf{(4)}$$

Where **s** is slope (%)

C: A dimensionless cropping management factor. The value of C should be established experimentally.

P: An erosion control practice factor.

Note: Equation (1) supply an estimate of sheet and rill erosion from rainfall events on upland areas. Also, it does not include eroded soil deposited at the base of slopes, snowmelt runoff, or wind. In addition, It does not include erosion from stream banks (Brooks *et al.*, 2012).

Revised Universal Soil Loss Equation (RUSLE):

RUSLE predicts average-annual soil erosion by water for farming, mining, conservation, construction sites, and other areas. The ARS and their cooperators initiated the development of RUSLE in the 1980s. The report (Weltz *et al.*,1998) developed Revised Universal Soil Loss Equation (RUSLE) to address deficiencies in the USLE by accounting for temporal changes in soil erodibility and plant factors which were not originally considered. Also, improvements were made to the rainfall, slope, and length of the original USLE model. In addition, RUSLE can be applied to single events for a snowmelt-erosion component. Finally, The RUSLE technology is computer-based and not need to replace the tables, figures, and often tedious USLE.

REVIEW:

The report (Foster *et al.*,1981) application of the USLE and adoption of the International System of Units (SI) in the United States, where Conversion factors were derived by considering the dimensions of each variable of the USLE factors. The values for the USLE factors can be computed directly in SI units without conversion from U.S. customary units.

The work of (Essa, 2004), to assess the impacts of changing the land cover on soil, a GIS-based erosion model has been developed to predict annual soil loss, where the RUSLE model was used. Spatially distributed static parameters for this model are extracted from a regional GIS and the dynamic parameter is estimated from the land cover maps, derived by Landsat MSS and TM for(1972 1992 respectively), where The image difference technique was used in the change detection analysis. The result shows the erosion model predicts an increase from 1972 to 1992, as a result of land cover changes.

The report (Fu *et al.,* 2006), the RUSLE, the sediment delivery distributed (SEDD) model, and GIS was used to estimate the impacts of no-till practice on soil erosion and sediment yield in southeastern Washington. The results showed that the average soil loss decreased from (11.09 to 3.10 t/ha yr and 17.67 to 3.89 t/ha yr)for the whole watershed and the croplands under the no-till respectively. Also, average sediment yield decreased from (4.71 to 1.49 t/ha yr and 7.11 to 1.55 t/ha yr)for the entire watershed and the croplands under no-till. Finally, the no-till practice can significantly reduce the soil erosion and sediment yield.

The report of (Al-Alawi & Abujamous, 2009), USLE was used to predict the annual soil loss of a representative area of about 108 ha in Balqa district, where soil survey reports, land capability, site information, erosion hazard in a soil base map for the area. The map contains six themes. In addition, Before constructing SCS about (32%, 7%, 61% of total area were characterized slight, moderate and high respectively).Finally, twenty years after constructing SCS about (58%, 34%, 8% of the total land area were characterized slight, moderate and high respectively).

The purpose of (Bahadur, 2009), produce erosion susceptibility maps for an area that has suffered because of shifting cultivation in Northern Thailand, where approach using RS and GIS-based methods is proposed. imagine image processor has been used for the digital analysis of satellite data and topographical analysis of the contour data for deriving the land use/land cover and the topographical data of the watershed were ARCInfo and ARCView have been used for carrying out geographical data analysis. The USLE within each pixel was calculated by carefully determining its various parameters and classifying the watershed into different levels, where Results show most of the areas under shifting cultivation fell in the highest severity.

The study of (Pandey *et al.,* 2009), using the remote sensing (RS) and geographical information system (GIS) to an assessment of sediment yield in Arunachal Pradesh, India. The Morgan-Morgan Finney (MMF) model and USLE have been utilized for prediction of soil erosion at a spatial grid scale of 100 m × 100 m. The results showed average annual soil loss from (75.66 and 57.06 t ha−1 year−1) using MMF and USLE models, respectively.

The study of (Kouli *et al.,* 2009), to predict potential annual soil loss has been conducted, where RUSLE has been adopted in a GIS framework. The RUSLE factors were calculated for the nine major watersheds as raster layers. The results show that an extended part of the area is undergoing severe erosion, where The mean annual soil loss is predicted up to ~200 (t/ha year−1).

The study of (Eltaif *et al.,* 2010) aims to investigate the spatial distribution of annual rainfall erosivity in North Jordan, where done use erosivity factor R values to correlate in both the universal soil loss equation (USLE) and the revised universal soil loss equation (RUSLE) with annual rainfall amount or modified Fournier index (Fmod). The result appears he annual values of erosivity ranged between 86–779 MJ mm ha−1 h−1 year−1. therefore, the northeastern regions showed the lowest annual erosivity values, while The northwest regions of Jordan showed the highest annual erosivity values.

In this study (Bonilla *et al.,* 2010), RUSLE was integrated into GIS and used to estimate the effects of vegetative cover on soil erosion rates, where require an integral description of the county's soils, topography, climate, and current land use/ land cover in Central Chile. The results appeared 39.7%, 39.8%, and10.4% have low erosion rates (< 0.1 t ha-1 yr-1), intermediate rates (0.1-1.0 t ha-1 yr-1), and high erosion rates (> 1.1 t ha-1 yr-1) respectively. While 10.2% from a remainder of the surface is not subject to erosion.

The research of (Prasannakumar *et al.,* 2011), Testing RUSLE methodology in conjunction with remote sensing and GIS for soil loss prediction in Attapady valley, Kerala, where The RUSLE factors (R, K, LS, C, and P) were computed from local rainfall, topographic, soil classification and remote sensing data. The results of annual soil erosion shows a maximum soil loss of 14.917 t h−1 year−1 .The dominant high soil erosion areas are located in the central and southern portion of the watershed due to attributed to the shifting cultivation, and forest degradation along. Finally, The RUSLE, GIS, and remote sensing techniques also enable the assessment of pixel-based soil erosion rate.

This paper (Mhangara *et al.,* 2012), examines the soil loss spatial patterns using the GIS-based Sediment Assessment Tool for Effective Erosion Control (SATEEC), where SATEEC estimates soil loss and sediment yield within Revised Universal Soil Loss Equation (RUSLE) .the resulting soil erosion risk assessment offers that (35% and 65%) of the catchment is higher than 25 ton ha−1 year−1 and still soil loss of less than 25 ton ha−1 year−1 respectively.

The paper (Prasannakumar et al, 2012), aims integrates RUSLE model and GIS techniques to determine the soil erosion vulnerability in Kerala, India. Rainfall erosivity (R), soil erodability (K), slope length and steepness (LS), cover management (C) and conservation practice (P) factors were computed to determine as GIS data layers. The results of annual soil erosion show a maximum soil loss of 17.73 t h-1 y-1 . Finally, RUSLE method and GIS can serve as active inputs in deriving strategies for land planning and management in the environmentally sensitive mountainous areas.

The research of (Farhan & Al-Bakri, 2012).The aim to perform a GIS-based approach to map and assess land declination with combine water, soil, climate, land use/cover, and remote sensing data, where soil loss with water was assessed using Universal Soil Loss Erosion (USLE). The results showed high soil loss rate that reached 5, 5-25, and 25 ton/ha/yr for 60%, 34 %, and 4% of the study area. Also, the USLE map offered that the study area was suffering from high degradation and facing a high risk of soil erosion.

In this study(Farhan, *et al.*, 2013), aims to estimate annual soil loss using the Revised Universal Soil Loss Equation (RUSLE) with a geographic information system (GIS) and remote sensing (RS).RUSLE contain factors (R, K, LS, C, and P) were calculated and given as raster layers. The result each factor multiplied together to predict soil erosion. potential average annual soil loss is 10 ton·ha−1·year−1 for the catchment, with the potential erosion rates from 0.0 to 1850 ton·ha−1·year−1. About 42.1% (5317.23 ha) of the catchment area was predicted to have a moderate risk of erosion, with soil loss between 5 - 25 ton·ha−1·year−1.In addition, a risk of erosion is heavy to over 31.2% (3940.56 ha) of the catchment, with calculated soil loss is 25 - 50 and >50 ton·ha−1·year−1. Finally, High terrain, slope steepness, removal of vegetation, and poor conservation practices are the most prominent causes of soil erosion.

This work of (Alexakis *et al.*, 2013) objective to develop a comprehensive methodology for assessing erosion rate in a catchment area with the integrated use of RS, GIS and precipitation data in Cyprus, where two models include: The first is a quantitative empirical multi-parametric model and the second is the Revised Universal Soil Loss Equation (RUSLE) model. For the application of the two different models, high resolution GeoEye-1 satellite images and specific parameters such as precipitation data, topography, soil erodibility, erosivity, and runoff were used for a study area. The results indicate that using RS and GIS technologies simultaneously with precipitation data were an effective and accurate assessment of soil erosion in considerable short time and low cost.

The work of (Farhan *et al.*, 2015), to calculated and mapped using the Revised Universal Soil Loss Equation (RUSLE), within a GIS/RS environment in Wadi Kufranja catchment, northern Jordan. The estimated average annual soil loss is 10 ton·ha-1 year for the watershed. Also, 42.1% (5317. 23 ha) ,31.2% (3940.56 ha) of the watershed area and catchment were estimated (5 - 25 ton·ha-1·years -1) and 25 - 50 and >50 ton·ha-1·year-1.The collected household socioeconomic/conservation data have been subjected to multivariate statistical analysis. Stepwise multiple regression analysis appeared (R = 0.765, R2 = 0.585) and F-value for forest clearance, fallow land, and land use/land cover are significant at 0.1% level.

In this study (Ramzi *et al.*, 2017), the actual occurrences of USLE and RUSLE in Jordan were explored, where RUSLE portrayed a product adaptation of a significantly enhanced USLE. Found the soil experimental models stand to be mere demonstrating procedures or structures, instead of being the punctual robotic portrayals of the framework. although, these identified weaknesses, sub-models were found to be utilized in order to give the best practical gauges the spatial index circulation of the soil misfortune of the USLE is viewed as a valuable model that separate regions of a high and low disintegration of the erosion potential, where perceives there is still a need to further enhanced a check of the RUSLE and USLE outcomes in Jordan. In addition, this study benefit of the most adaptable and element structure of RUSLE against the strict exact structures of the USLE.

CONCLUSION:

- Provide the RUSLE over the USLE more data from different locations, cropping systems and different crops, also for forest and rangeland erosion.
- soil erosion has become profuse and prevalent, Therefore required more study, effective policy, and mitigation efforts.
- Corrections of errors in the USLE analysis of soil erosion have been made and gaps in the original data filled.
- Field measurements (direct measurements) of rainfall erosion (simulated rainfall) are highly recommended.
- The increased flexibility of the RUSLE lets for predicting soil erosion for watershed management alternatives and a greater variety of ecosystems.
- The current investigation has demonstrated that a geographical information system (GIS) and remote sensing (RS) techniques are simple and low-cost tools for modeling soil erosion.

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