GISSA Research Presentation

Research Topic:

Spatial Prediction of Soil Erosion Using RUSLE Model, GIS, and Remote Sensing; Case Study Eastern Cape Province South Africa.

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Introduction

Soil erosion as defined by FAO (food and agriculture organization) is the accelerated removal of top soil from land surface through water, wind and tillage. So, the process of erosion occurs naturally under all climatic conditions and all continents, but it is significantly increased and accelerated through unsustainable human activities such as intensive agriculture, deforestation, over grazing, and improper land use changes.

According to Garland et at. (2000), he stated that soil erosion has affected more than 70% of the land surface in South Africa. And of this 70%, 20% of the land is being used for agricultural and other land use activities. So among the 70% of land undergoing erosion in South Africa Eastern Cape is amongst the eroded land.

Aim, Objectives, and Research Question

Aim The aim of this study was to spatially predict soil erosion using RUSLE model, GIS, and Remote Sensing techniques to map soil erosion movement.

The objectives of this research were linked with the research question as follows;

Objective 1: To investigate models of soil erosion.

RQ 1.1: What models are available for soil erosion prediction?

RQ 1.2: What are the pros and cons of the different models?

RQ 1.3: What makes the RUSLE model suitable for analysis in this project?

Objective 2: To find a suitable site for testing the RUSLE model of soil erosion prediction.

RQ 2.1: What are the criteria for choosing a test site?

RQ 2.2: Which areas meet these criteria?

RQ 2.3: For which of these areas is data readily available and hence which area will be suitable for the study?

Objective 3: To use the RUSLE model to predict soil erosion in the chosen study area.

RQ 3.1: What does the RUSLE model reveal about soil erosion in the study area?

RQ 3.2: What are the limitations of the RUSLE model?

Objective 4: To make recommendations based on the findings.

RQ 4.1: How could land administrators and policymakers use the findings to combat soil erosion?

Scope of Study

The project was based on using RUSLE model, GIS, & remote sensing techniques to predict soil erosion in Eastern Cape Province. The application of this model is ideal for this project because with the use of remote sensing and GIS the method can be used to track soil erosion over a large area with a reasonable expenditure and better accuracy.

Literature Review

So the RUSLE model was implemented by Wischmeier and Smith in partnership with the United States Government in the late 1960's to calculate the effect of soil erosion. The model was made public in 1965 and with its emergence it was used to predict soil erosion on different land use areas. Originally the model was first referred to as USLE (Universal Soil Loss Equation) model and in 1978 it was changed to RUSLE (Revised Universal Soil Loss Equation) model to make it compatible with other research and technological advancement**.** But the introduction of the change from USLE to RUSLE did not affect the structure of USLE, although there was a significant change in the algorithm that calculated the individual parameters such as, the erodibility factor (K) in the USLE model, calculation was based on soil texture, organic matter content, and permeability while in the Revised equation (RUSLE), the K factor was adjusted to account for seasonal changes such as freezing and thawing. The LS factor in the USLE model was based on length and steepness of slope regardless of land use, while in the revised equation (RUSLE), LS values were assigned according to land use. (Renard et al., 1994**).**

RUSLE Parameters	Symbol
Rainfall Erosivity	R
Soil Erodibility	K
Slope Length and Steepness	LS
Crop or Cover Management	C
Conservation or Support Practices	P

Table 1 showing RUSLE parameters and their symbols.

So based on reviews of soil erosion in South Africa, reviews were seen where other erosion methods was used to spatially mapped soil erosion. For example in Limpopo, remote sensing and conversional surveying techniques were used to predict erosion occurring in Ravine.

Methodology

This section is based on the description of data, resources and techniques that will be used in the research to attain the goals of the study.

In terms of availability of models needed to combat the problem of soil erosion, there a dozen of models that have been developed to help solve the problem of soil erosion which are Water Erosion Prediction Project WEPP, Soil and Water Assessment Tool SWAT, and the European Soil Erosion Model. This research was based on the Revised Universal Soil Loss Equation

RUSLE Parameters

The RUSLE parameters consist of six parameters that was created to predict the effect of soil erosion.

Rainfall Erosivity

This calculates the intensity of rainfall (drops) that courses erosion on the surface of soils. For the parameter to be calculated non-stop precipitation data must be collected for a period of time (Wischmeier and Smith, 1978).

For rainfall erosivity, it is calculated with the help of rainfall data gotten from rain gauges for a g period of 10 years, in which the mean annual precipitation of the rainfall values of the years are calculated. And IDM was used to interpolate the data to get the average rainfall values of the whole study area and with the help of Hurni, H equation (1985) and raster calculator the erosivity factor of the whole study areas Alfred Nzo District is gotten.

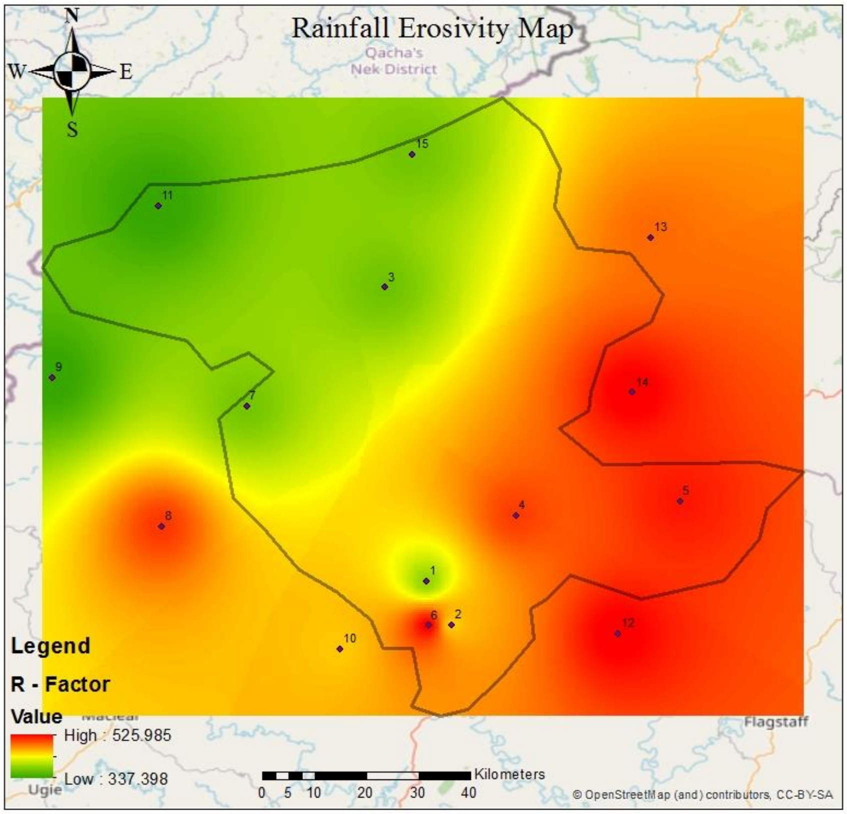

Figure 1 Rainfall Erosivity Map of Alfred Nzo district.

Interpolating the rainfall values, provided an observed values of the R factor that ranged from 372 to 523. From the R factor map the observations was as follows, most of the eastern part and some portions of the north east, south west and south east section of the study area has high erosivity values that are above 400 MJ mm ha-1 year, while areas with low erosivity are the north, north west and some part of the southern part of the study areas.

Soil Erodibility

This refers to the ability of soil to be submissive to erosion caused by water runoff. For this method the digital world soil map is used to extract the soil map of the study area and the top layers values of clay, silt, sand, and organic carbon content is used to calculate the erodibility factor with the help of Williams's equation (1995).

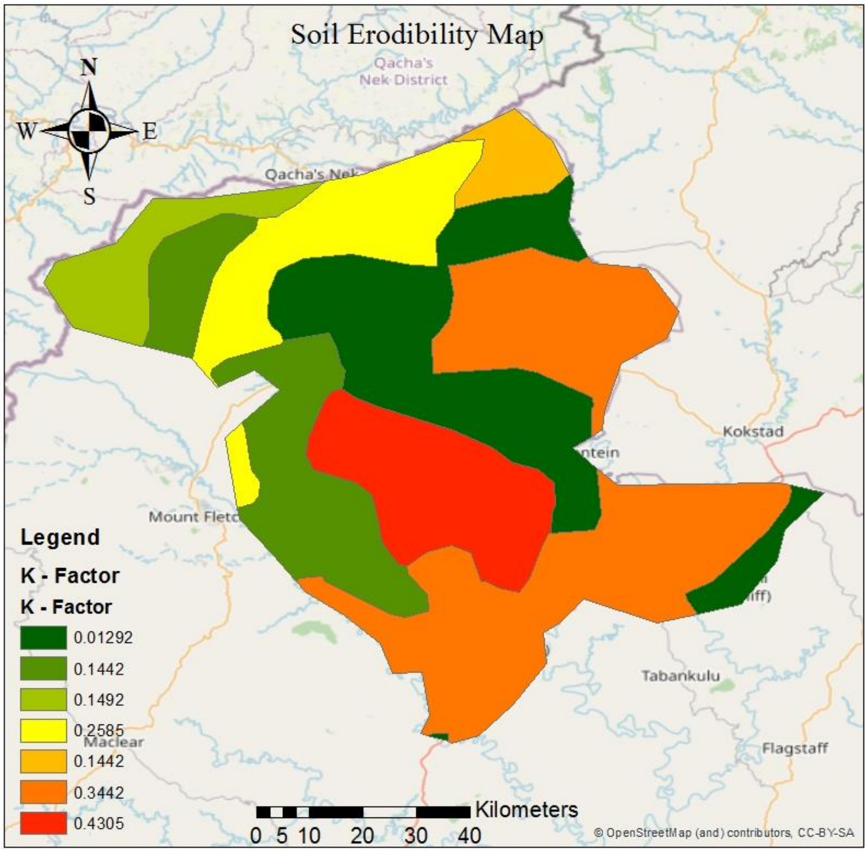

Figure 2 Soil Erodibility Map of Alfred Nzo district

For erodibility factor map the erodibility value had a range of 0.01 – 0.4. The highest erodibility values found in the study area was in the south (western and some parts of the eastern) and north western part of the map in which the erodibility ranged from 0.25 – 0.43. MJ mm ha-1 year. Lower erodibility values indicate low soil permeability which means that the soil are more resistance to erosion.

Slope Length and Steepness

This is caused via the process of erosion occurring in a slope, for slope length and steepness a DEM map of the study area (Alfred Nzo District) with a resolution of 30m is used find the slope angle of the study area. After which a Fill tool, is used to correct sinks that was developed when creating the DEM map, followed by creating a flow direction and flow accumulation map of the study area. Finally the Moore and Burch (1986) equation is used in raster calculator to calculate the slope length and steepness of the study area.

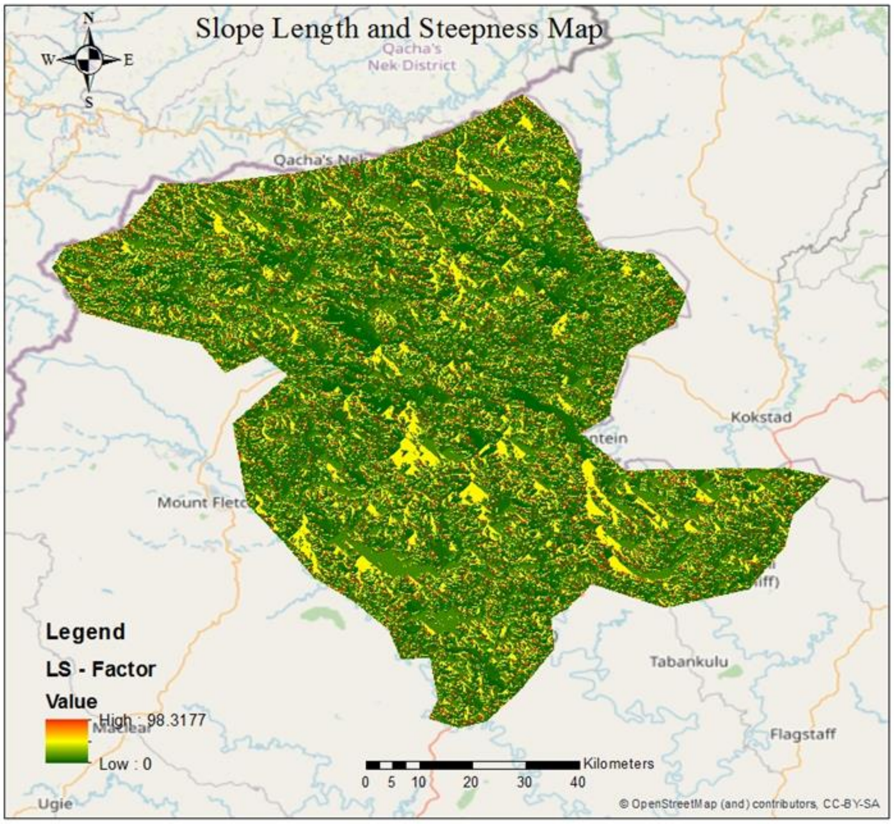

Figure 3 Slope Length & Steepness Map of Alfred Nzo district.

The LS factor values of the study area ranged from 0 – 98.31 degree the reason for this high LS value is due to the uneven topography of the area. Areas with high LS values are found in mountainous areas and are characterized with steep slopes or topography. The low LS values on the map indicate areas that are made up of relatively low elevation and are not subjected to erosion (soil).

Cover Management Factor

This is defined as "the ratio of soil loss from land cropped under specified conditions to the corresponding loss from clean-tilled, continuous fallow" (Wischmeier and Smith, 1978, 17). For this method the Normalization Difference Vegetation Index tool was used to generate the vegetation index of the area followed by using raster calculator to compute the C factor using Vander-Knijff et al., (1999) equation.

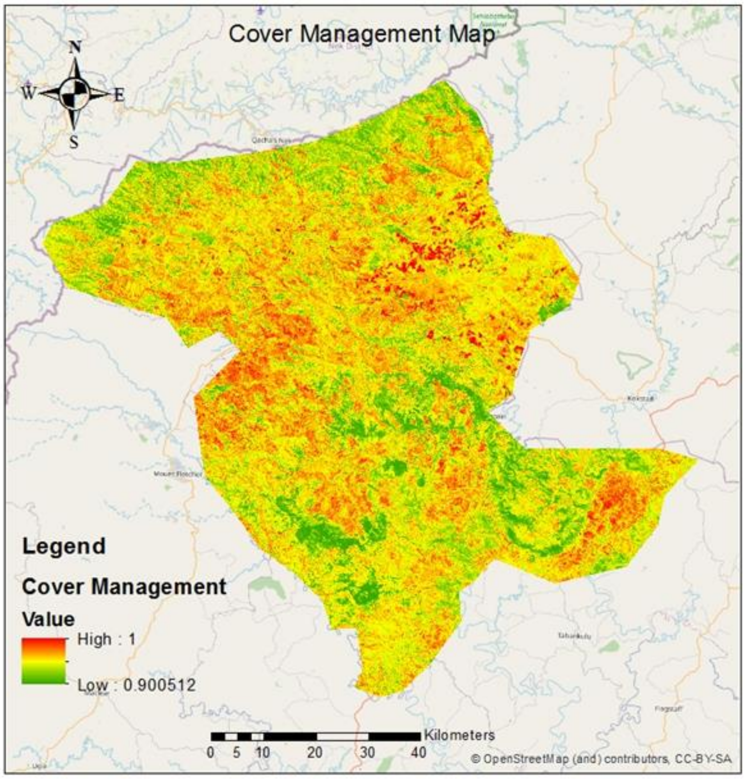

Figure 4 Cover management map of Alfred Nzo district.

A high cover management value of 1 as seen on the map are areas that are vulnerable to erosion as the soil surfaces are unprotected or barren, while for a lower C factor value (0.9) are areas that are more resistance to erosion because they have high vegetative cover which have low soil erosion potentials because of its ability to resist high-intensity rains.

Sopport Practice

This method describes the land activities that reduces the effect and power of runoff from rainfall. For this the Global-Cover map of the world was used to extract the cover map of the study area after which the Stone R.P & Hilborn D, (2012) equation was used to obtain P factor values.

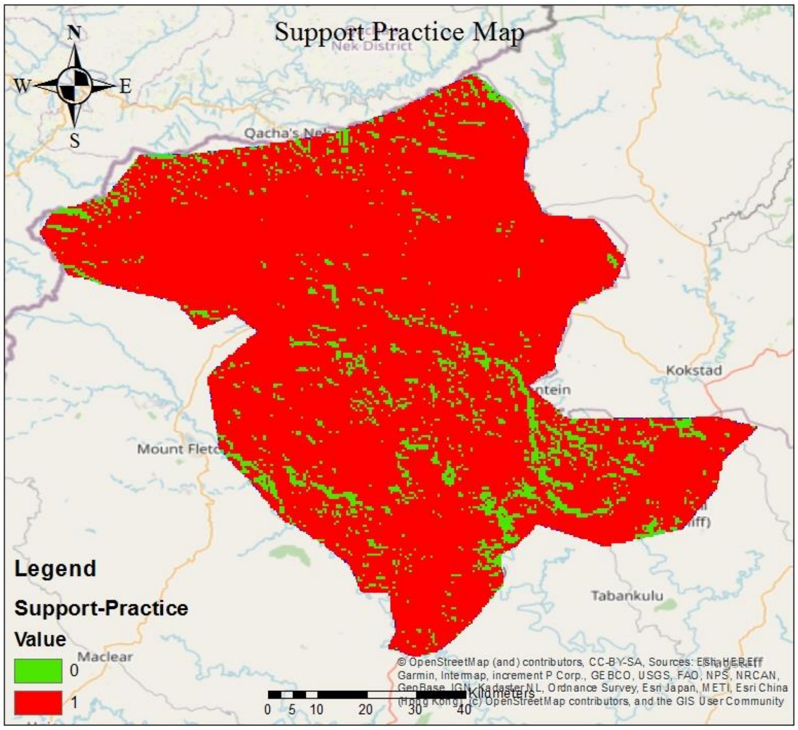

Figure 5 Support Practice Map of Alfred Nzo District

The variation of the support practice values ranges from 0 – 1, which means 0 indicates a good support practice (the practice is said to be reducing the effects of erosion) while 1 means the support practice of the area is poor.

Erosion Probability Zone

To identify of the areas prone to erosion in the district, the different RUSLE parameters layers was merge together to produce the erosion probability zone. This method deals with reclassifying the different parameters and then overlaying the layers according to their causative factors

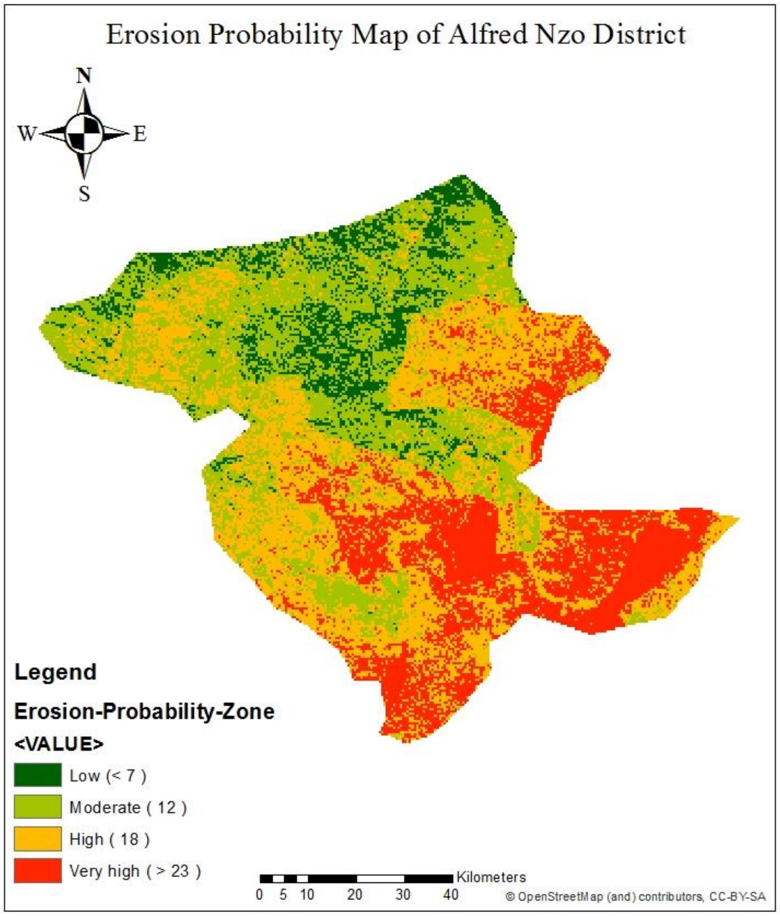

Figure 6 Soil erosion probability zone of Alfred Nzo district.

Ground Truthing

This method was done to compare the soil erosion probability zone generated in this research to other soil erosion probability zone carried out in the study area. So for this method, the Global Soil Erosion Platform Layer for the year 2012 was used with a spatial resolution of 1km.

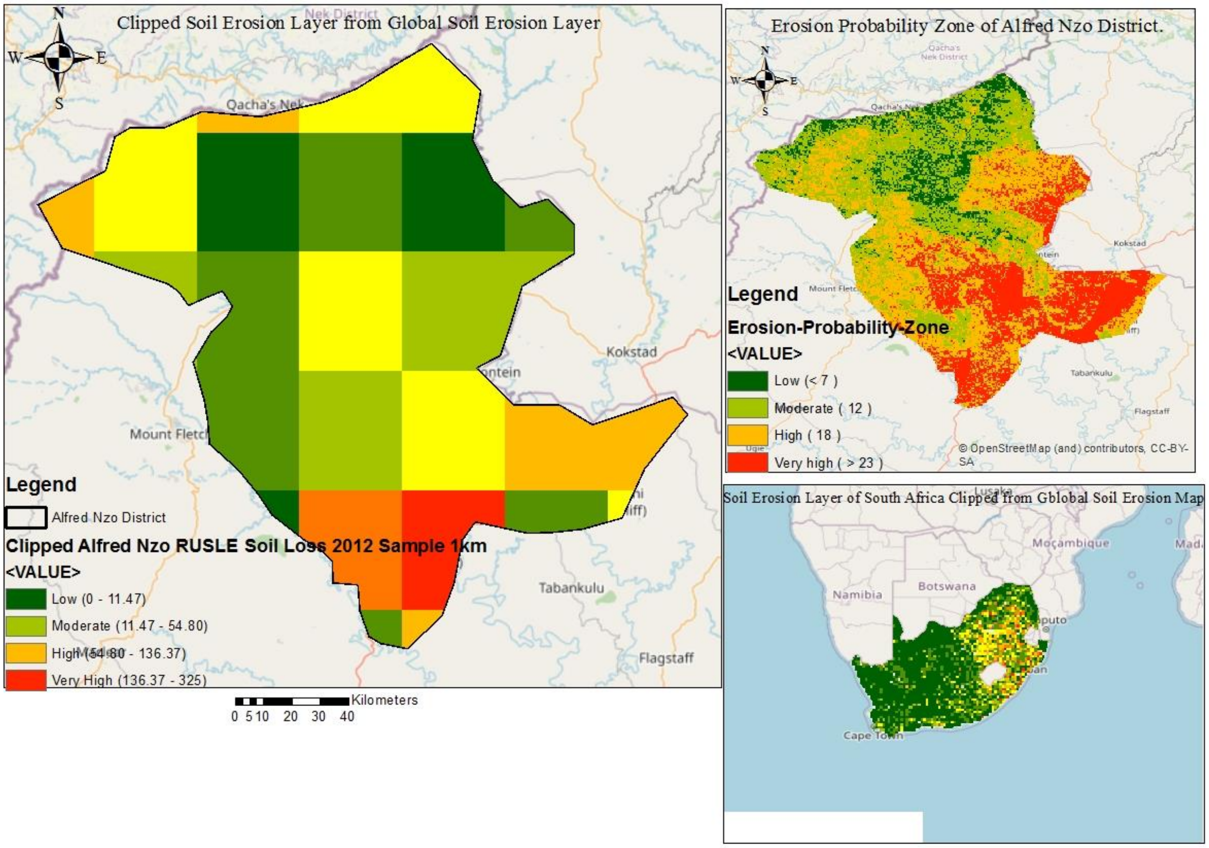

Figure 7 Soil Erosion map of Alfred Nzo District and South Africa Clipped from Global Soil Erosion Map including the Erosion Probability Zone Map of Alfred Nzo District.

Comparing the two layers that is soil erosion probability layer and the global soil erosion layer, the two maps identify a gradient of low to high erosion risk moving from north to south, which suggests the generated soil erosion probability map of the district in the research is correct. Also with regards to the difference in similarity between the two layers is due to the time difference that exist between the maps which is a period of 8 years. This time period between the maps has either increase or maintain the erosion rate of the district.

Limitations As stated by Jahun in 2015, since the model does not predict sediment path-ways from hill slope to water bodies, analyzing the effect of downstream movement is difficult

The model is excellent when it has to do with measuring the vulnerable soil loss of an area because it can be integrated with GIS easily and simple to use but it cannot be used to ascertain complex process necessary for soil erosion loss (Aksoy & Kavvas 2005).

Recommendations The recommendations of this study was bases on research carried out by other researchers on various land use methods that have helped reduce the rate of erosion for example Lesoing and Francis in (1999) stated that Stripped Cropping system can be used to reduce soil erosion by planting stripped crops along a slop. Also Rotation crop system can be practices where a mixture of different crops can be cultivated on a land each year to help reduce soil erosion.

Conclusion The identified areas prone to soil erosion in the district can help policy makers and land administrators to help reduce the rate of erosion occurring in the district by applying the recommendation as listed above.

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