Spatial Estimation of Soil Erosion Using RUSLE Model: A Case Study of Sangareddy Telangna State

ABSTRACT: This study uses the Revised Universal Soil Loss Equation (RUSLE) model to assess the likelihood of erosion in the Sangareddy district. Erosion calculations require specific data from numerous sources that are available at various scales and forms.When screening the effects of each component causing soil erosion, a geographic information system (QGIS) was employed, which allowed for significant time savings in the processing of spatial data.Topography, rainfall, soil characteristics, and soil conservation techniques were considered in the study among other erosion factors.These variables were multiplied to determine the average soil loss. They are(>80 t/h/year),(20-40 t/h/year), (10-20 t/h/year), (5-10 t/h/year) and (0-5 t/h/year), falls under the severity levels of extremely severe, severe, very high, moderate, and low, respectively.High slope length (LS) factor areas erode more quickly.The spatial distribution of soil erosion in the Sangareddy district was determined as a result, and this information can be used to manage and reduce erosion.

Key words: RUSLE, Sangareddy, GIS, Spatial distribution, Soil Erosion,

INTRODUCTION

The most frequent kind of land degradation is probably runoff-induced erosion in sparsely vegetated areas since it is both widespread and irreversible, inflicting significant harm to the environment (Chadli 2016).The complicated phenomena of soil erosion is studied using a variety of methods, one of which is the prevalent use of spatial data fusion.This strategy makes use of the Revised Universal Soil Loss Equation (RUSLE) model.

Recent decades have seen significant global attention paid to soil and water issues.The soil resources and agricultural output are severely hampered on approximately 549-1094 million acres of land (Govers et al. 2017).According to the FAO (2015), the global average rate of erosion is between 12 and 15 t/h/ year, or 0.90-0.95 mm of soil are lost annually.More than 1 billion ha of agricultural land are in a zone that is sensitive to water erosion, and 550 million ha are in a zone that is vulnerable to wind erosion (Wawer et al. 2005).

The spatial distribution of soil erosion in Sangareddy was measured using the RUSLE model.RUSLE, however, is only suitable for the assessment of sheet erosion and rill erosion; gully erosion is not included.The model integrates a number of characteristics to provide accurate estimates of soil erosion despite its limitations.The study may provide a benchmark for the entire Sangareddy district and add to the body of knowledge regarding soil erosion.

MATERIALS AND METHODS

Study Area:

The Study area was carried out in the Sangareddy district covering an area of 4996km^2 with a population of 1,97,860 and located in the Central region of the Telangana state with 17^{o}31'50.4" N and 78^{o}1'6.96" E. The district is one of the most industrialized regions in Telangana state. This province is characterized by an arid climate being cold and semi-humid in the northern areas and cold with long winters in the higher regions. The boundary of the study area was chosen in a way that could well represent a complex landscape and involved densely built-up area, wet lands, forests, water bodies, croplands, shrubs, and barren lands.

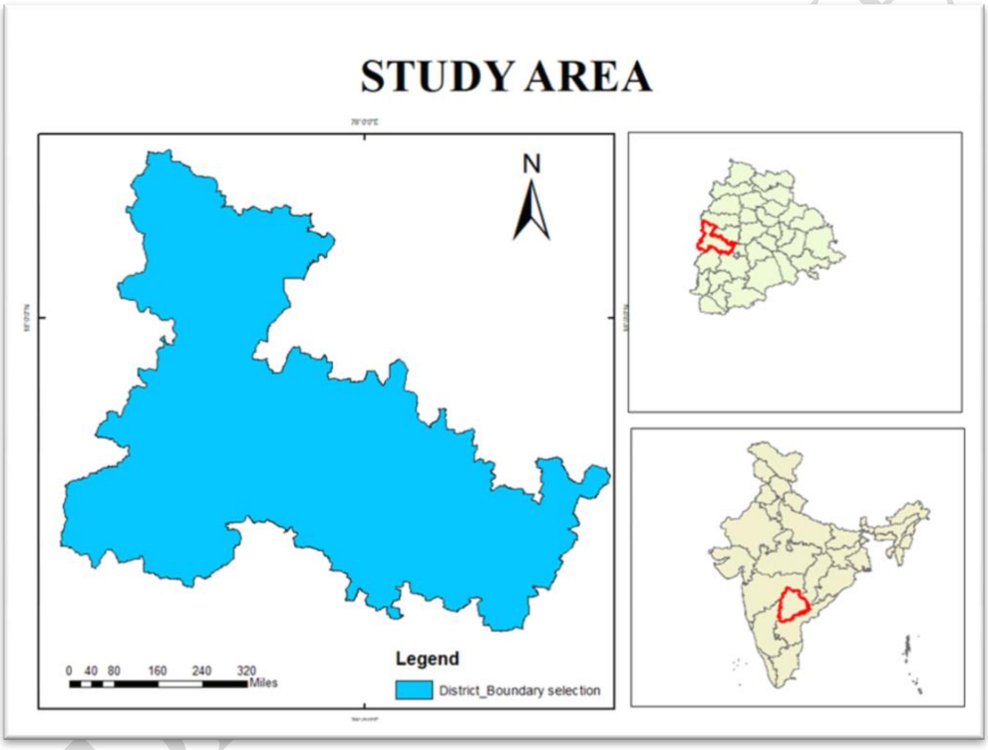


Fig. 1. Study Area Map

Data Collection

Table. 1.The spatial datasets for this research

Datasets	Data Source
DEM	https://earthexplorer.usgs.gov/
Soil Map	Digital soil map of the World www.fao.org/geonetwork/srv/en/metadata.show
LULC map	Lansat-8 https://earthexplorer.usgs.gov/
Rainfall data	Collected data from District office

M ETHODS

The Revised Universal Soil Loss Equation is a powerful tool and used for estimate the soil loss. The RUSLE model can be used to estimate the yearly soil loss value and the intensity of soil erosion in a catchment area. The Wischmeier& Smith (1978) developed USLE erosion model's framework is the foundation for the RUSLE model, which Renard et al. (1997) enhanced and modified.

$$A= [R]*[K]*[LS]*[C]*[P]\ldots\ldots\ldots\ldots(1)$$

Where A = Annual soil loss (t ha−1 year−1), R = Rainfall erosivity factor (MJ mm ha−1 h−1 year−1), K = Soil erodibility factor (t ha h ha−1 MJ−1 mm−1), LS = Slope length factor (dimensionless), C = Crop cover management factor (dimensionless), P = Conservation practices factor (dimensionless)

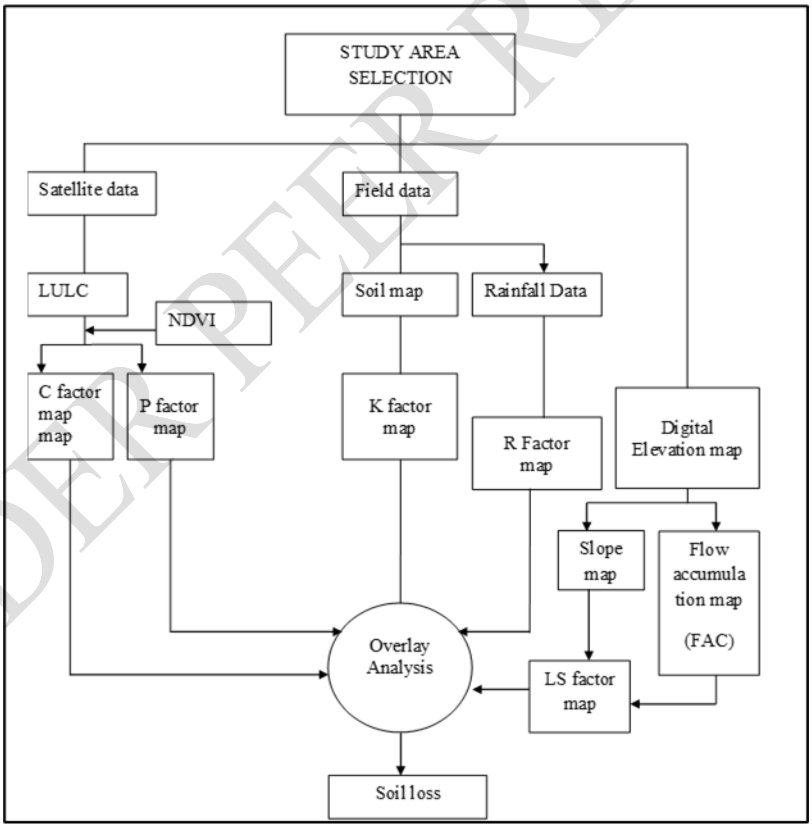


Fig. 2. Flow chart for estimation of soil erosion

Rainfall Erosivity Factor (R)

The ability of rain to affect or separate soil particles based on the amount of rainfall is known as the rainfall erosivity factor (R).The RUSLE's erosivity criteria must take into account the influence that raindrops have on the soil as well as the amount of runoff that results from rainfall.In current study, the rainfall data was collected from Chief planning office, Collectorate Sangareddy, Telangana. The rainfall map that was created represents the district of Sangareddy's average yearly precipitation.Given equation is used to calculate R-factor given by (Koirala et al. 2019)

$$R = 38.5 + 0.35P \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where R= Rainfall erosivity factor, P= Mean Annual Rainfall (mm)

Soil Erodibility Factor (K)

The soil erodibility factor (K) gauges how easily soil particles can separate and be carried away by rain and runoff.According to Erencin et al. (2000), the soil profile's permeability, organic content, and texture all affect the K factor.To calculate the soil loss, an equation from the reference is employed (Kouli et al. 2009).

$$K = Fcsand * Fsi\text{-}cl * Forgc * Fhisand * 0.1317 \ldots\ldots(3)$$

WhereFcsand=low soil erodibility factor for soil Fsi-cl=low soil credibility factor with high clay to silt ratio. Forgc=factor that reduces soil erodibility for soil with high organic content. Fhisand=factor that reduces soil erodibility for soil with high sand content.

Table 2. K Factor Data (Erencin et al. 2000)

Textural Class	K Factor (tons/acre)
Clay loam	0.67
Sandy clay loam	0.45
Clay	0.2

Topographic Factor (LS)

Topographic factor is the function of slope length (L) and slope steepness (S). It represents the effect of topography on erosion. In the present study, the LS factor maps were generated from thematic layers of slope and flow accumulation maps derived from ASTER DEM using the following equation (4) (Tirkey et al., 2013):

$$LS = \left(\frac{flow\ accumulation * cell\ value}{22\cdot 1}\right)^m (0.065 + 0.045s + 0.0065s^2)\ldots(4)$$

Cover Management Factor (C)

According to Chalise et al. (2019), the cover management factor (C) accounts for the impact of cropping and other practises on erosion rates.It is the most spatiotemporally sensitive because it tracks the dynamics of plant development and rainfall (Nearing et al. 2004).This factor is described as a non-dimensional number between 0 and 1 that compares the comparable loss from continuous bare fallow to the soil loss due to rainwater erosion under certain land and vegetation conditions (Wischmeier and Smith 1978).The study examined nine different forms of land use, which were converted from a raster map to a polygon using the raster to polygon tool and combined into a single class using ArcGIS 10.8 software (Table 3).Each land-use example has a C value assigned by reference that is in the range of 0 to 1, with a lower C value signifying no loss and a larger C value signifying significant odds of soil loss (Erencin et al. 2000; Panagos et al. 2015).

Table. 3 Land use land cover and C factor

S. No	LULU	C Factor
1	Water bodies	0.00
2	Forest	0.03
3	Floddedvegitation	0.01
4	Crop land	0.21
5	Build up area	0.70
6	Barren land	0.45
7	Scrub land	0.03

Conservation practice factor (P)

According to agricultural practise, the support practise component shows the rate of soil erosion. In order to control erosion, three techniquescontours, cropping, and terracesare essential (Park et al. 2005).According to Table 4 of Kouli et al. (2009), the contouring approach utilised with P values runs from 0 to 1, with 0 denoting proper anthropogenic erosion and 1 denoting a non-anthropogenic erosion facility.

Table.4 P factor values for slope (Kumar and Kushwaha 2013)

S. No	Slope %	P Factor
1	0.0-7.0	0.55
2	7.0-11.3	0.60
3	11.3-17.6	0.80

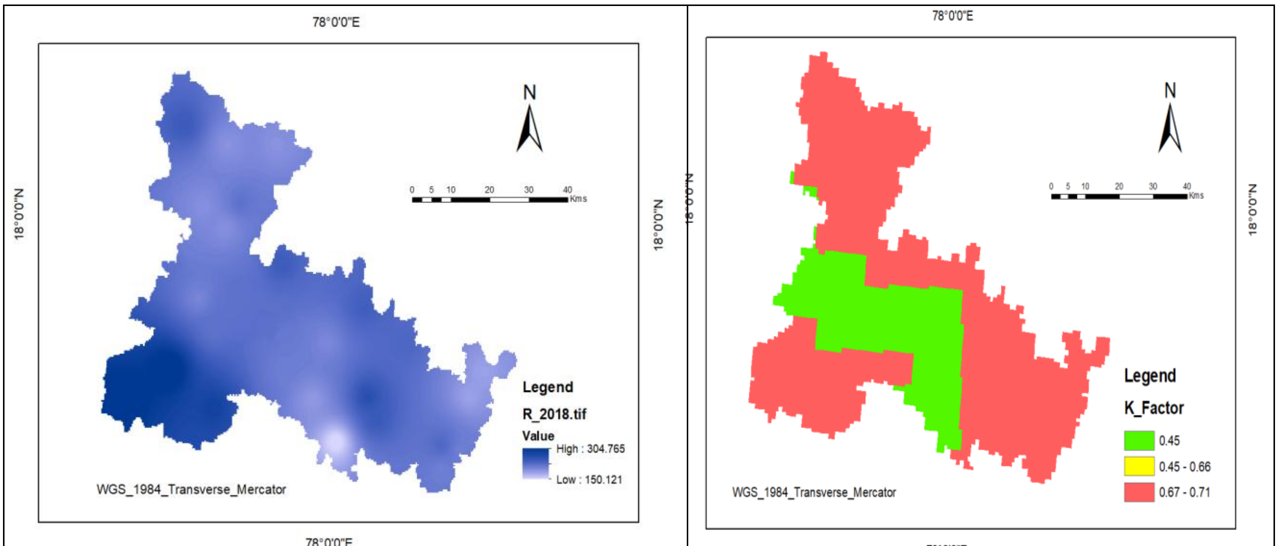
4	17.6-26.8	0.95
5	>26.8	1.0

Results and Discussion

The findings showed that rainfall erosivity factor (R) values ranged from 150.12 to 304.76mm/ha/yr, whereas topographic factor (LS) values ranged from 0 to 6.02. The values of the soil erodibility factor (K) were 0.45 to 0.71. For the entire area, the support practise factor (P) values ranged from 0.55 to 0.95. Values for the cover management factor (C) were between 0.01 and 0.7.

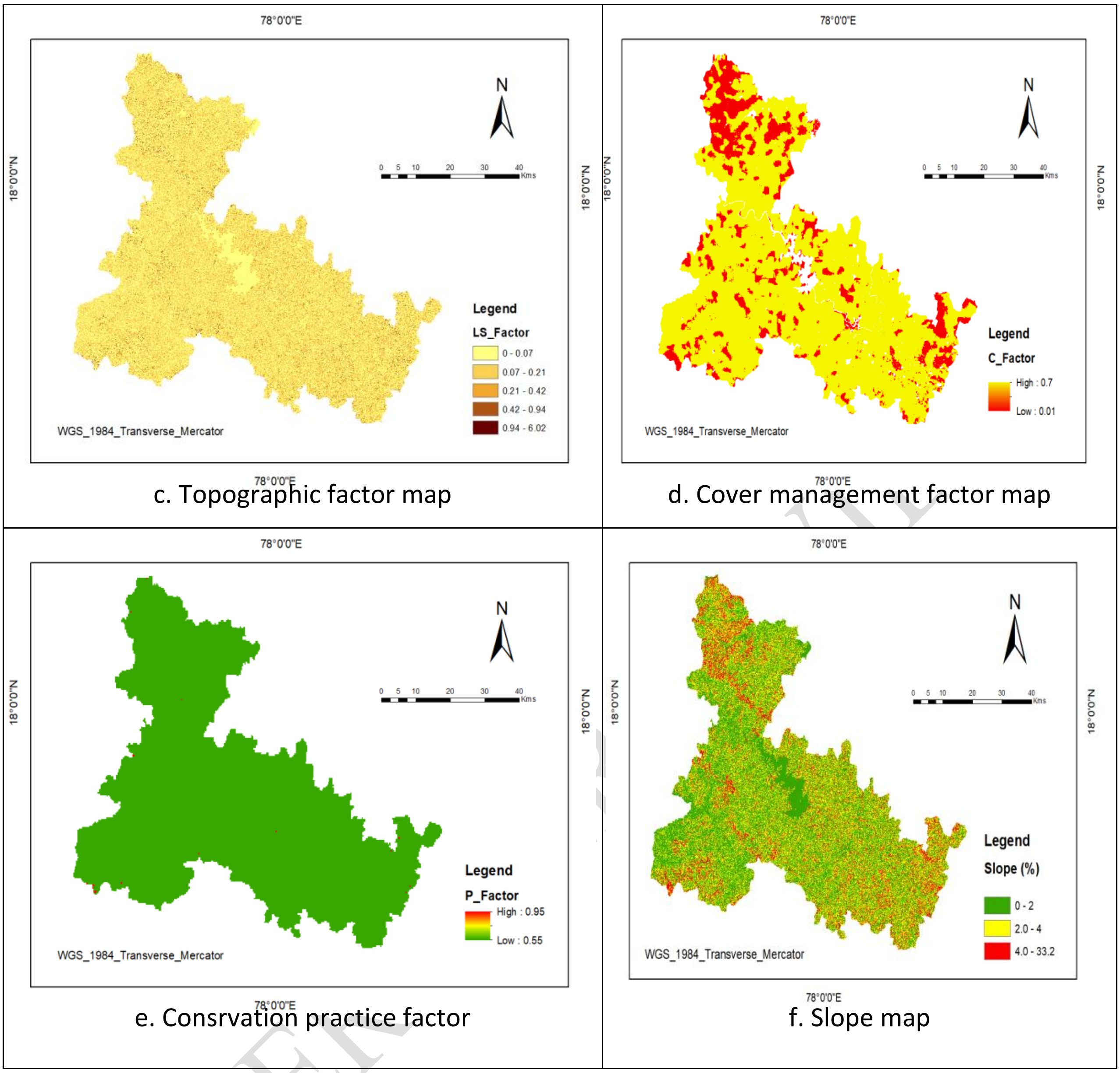
Potential soil erosion rates of Sangareddy District

Using the Arc GIS raster calculator, five factors that exacerbate site erosion were multiplied to create a possible erosion map of the Sangareddy district.The results indicate that majority of land falls under the low erosion hazard zone (0-5 t/h/yr.).



a. Rainfall erosivity factor map

b. soil erodibility factor map



c. Topographic factor map

d. Cover management factor map

e. Consrvation practice factor

f. Slope map

Fig. 3. Five factors maps of soil erosion of the study area

Discussions

The long-term average yearly rate of soil erosion on slopes is predicted using RUSLE, an empirically based modelling approach, employing five variables**.**According to Prasannakumar et al. (2012), it calculates soil loss under comparable topographical and climatic conditions.This study used ArcGIS software to create a possible soil erosion rate map for the Sangareddy district utilising data from several sources.This methodology still has certain drawbacks, but it is the first time that erosion risk has been assessed across an entire mountainous region.It once more identifies key regions for mitigating soil erosion.The same methodology was also applied by other research projects with comparable geographic characteristics (Prasannakumar et al. 2012; Panagos et al. 2015; Kumar and Kushwaha

2013).The uncertainties in an erosion model should be kept to a minimum by properly taking into account the R-factor, LS-factor, K-factor, P-factor, and C-factor.

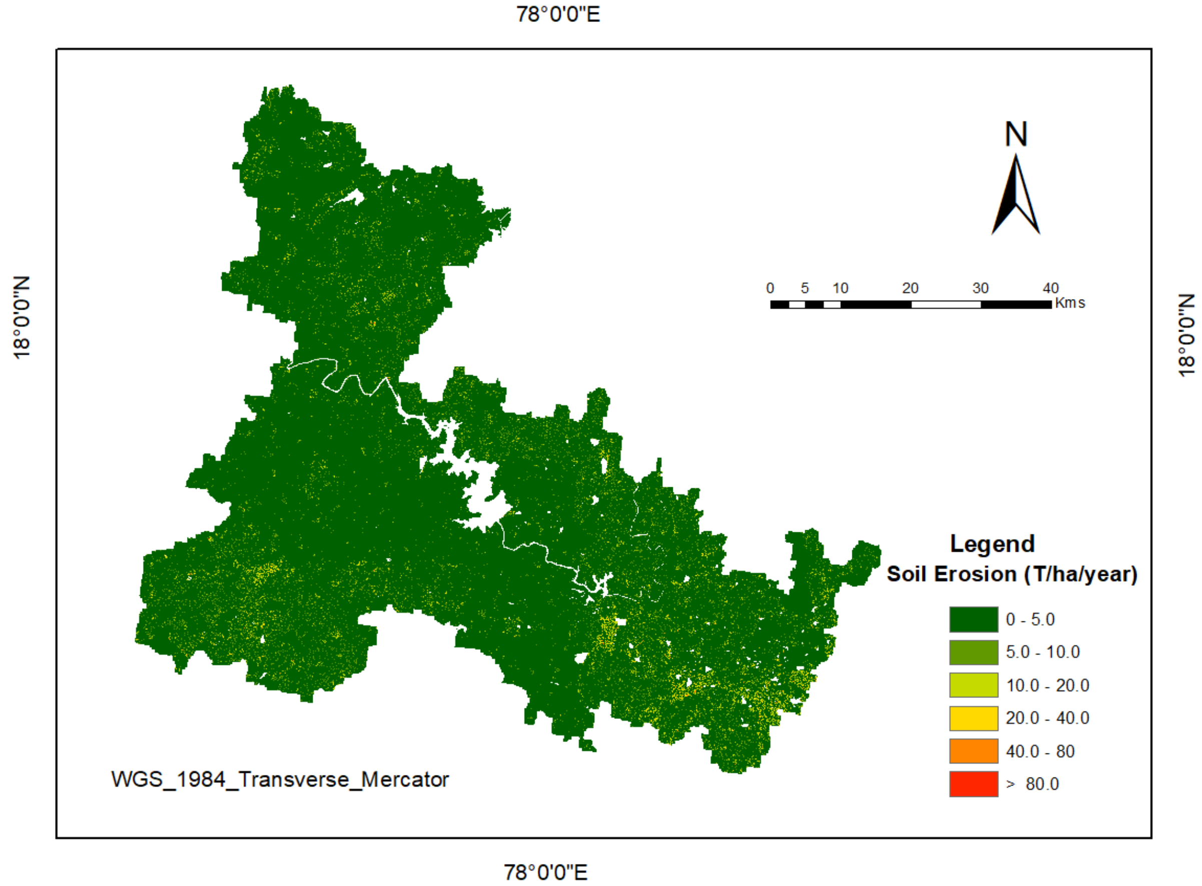


Figure. 4 Potential map of soil erosion rate of Sangareddy district

Table 5. Potential soil erosion rate of Sangareddy district

Class	Rate of Erosion (tons/ha/year)	Severity
1	0.0-5.0	Low
2	5.0-10.0	Moderate
3	10.0-20.0	High
4	20.0-40.0	Very High
5	40.0-80.0	Severe
6	>80.0	Very Severe

Conclusions

The GIS-based RUSLE equation used to calculate the severity of soil erosion takes into account rainfall, soil, DEM, land use, and land cover.Less than 1% of the regions were classified as being at extremely high risk (> 80 t ha per year), while 94.98% of the whole area was classified as being at low risk.This illustration depicts a region susceptible to soil erosion due to its high elevation and frequent rains.The decision-makers' planning and conservation efforts can be supported by the expected severity.The need for special priority and control measures in areas with high to very severe soil erosion.While the foundation of this model is the mapping and prediction of vulnerability zones utilising remote sensing and GIS-based research, such studies are recommended for model conservation and improvement in the future.

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