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# Estimation of soil erosion vulnerability in Perambalur Taluk, Tamilnadu using revised universal soil loss equation model (RUSLE) and geo information technology

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## Abstract

*Soil loss is a universal land degradation problem arises from agricultural intensification, land degradation as its economic use, environmental impacts in addition to other anthropogenic activities. A widespread method of RUSEL and Geo information techniques used to make a decision of the soil erosion vulnerability of the study area. The spatial analysis of the annual soil erosion rate was obtained through the integrating of good environmental variables in a GIS based raster method. The present study was five major factors were used are R, K, LS, C and P factors were computed to decide their effect on average annual soil loss. The soil erosion map is reclassified according to the sing et. al. Soil erosion risk classes for Indian condition such as Low (>5), Moderate (5-10), High (10-20), Very high (20-40), Sever (40-80). The study area 68.95 % has low erosion risk and 16.80% moderate erosion risk of the total area. The other erosion risk classes such as high, very high and sever erosion range occurred in the percentage of 7.48 %, 4.52% and 2.26 % of the total area respectively. The resulting of the annual soil erosion map shows a maximum soil loss of 52.25 ton/ha/year, and the mean annual soil loss for the entire study area about 0.16 ton/ha/year. Its consequently the close relation to forests on the steep side slopes along with slope gradient and length followed by soil erodability factor were found to be the main factor of soil erosion.*

**Keywords:** Soil Erosion, RUSLE, LS factor and Geo-information technology.

## Introduction

Soil erosion is one of the most important land degradation problems through the water and critical environmental hazard in the modern time at worldwide. Soil erosion and associated degradation of land resources are highly significant the spatio-temporal phenomena in many countries[1-3]. Soil erosion, normally related to farming practice in humid and semi-arid country, lead to a decline in soil productiveness, obtain a series of negative impact of environmental problem and also risk to sustainable devolvement of agricultural production and water quality in this region. In India soil erosion has a major effect for agricultural land, degradation of the soils and siltation in reservoir etc are formed in the nation. The government has been taken a lot of plans and actions to rectification of this problem and preventing further destruction of the soil layer. In India concerning 16.4 t $ha^{-}1$ (5334 m-tonnes) of soil are detached annually[4-6]. The sheet erosion is the most serious issues in India it is suggested by Narayana and Babu in 1983. Soil erosion critically affected to the gullied land, shifting cultivation region, wasteland and Water-logged area. Soil erosion was born extremely that region has rate of much higher than the sedimentation and also the reservoir and fertility has decreased become an ecological problem of the country[7,8]. The soil erosion related with infiltration rate when an increase infiltration rate and declined the soil erosion. In recent times as part of environmental and land consideration policy to develop agricultural land and productivity level as well as control the soil erosion hazard in hill region[9-11]. USLE model has predicted soil erosion through the water and RUSEL also fallow the same principle but contain a several improvement in calculation for various factor. Soil erosion is a vital and non renewable resource in the earth but in many region people did not consider soil erosion and land degradation problems for that causes vast area economically unproductive so that region consider to give more priority for management and improve soil productivity. Geo information techniques widely use to assess the soil loss intended for all the region and recently availability of high resolution data has used to make a large scale inventory of Digital Elevation Model (DEM), landuse/land cover (LULC) and soil resource maps were effectively used to assessed soil erosion hazard[12,13]. The aim of the present study was, to determine the spatial distribution of annual soil loss and to analyze the effect of Rainfall, landuse, slope exposition and terrace farming on soil erosion using RUSLE model and Geo information technology.

**Study area:** Perambalur taluk is located at Perambalur district in Tamilnadu, province between North Latitude $11^0$ 07' 18'' to $11^0$ 18' 36'' and East Longitude $78^0$ 40' 19'' to $78^0$ 55' 49''. The total geographical area is 33684 hector. In this taluk bounded by Veppanthattai taluk in the North, Kunnam taluk in the South, Alatur taluk in the East and Turaiyur taluk of Thiruchirapalli district on the west (Figure-1). According to the 2011 the total Population of the area has 1, 62,356 with 81,586 males and 80,770 females. The population density of the taluk is 482 inhabitants per square kilometer. The study area has exposed topography is undulating plain and rugged terrain with irregular charnockitic hillocks and hornblende biotite gneissic rocks. The ground elevation ranged from 100 to 620 M above mean sea level and the region slope is toward the east.

The taluk lies in the southern plateau and hill zone of agro-climate region with semi arid climatic characteristics, the maximum rainfall is during Northeast monsoon followed by the Southwest monsoon and the minimum rainfall was noted in winter. April, May and June with the maximum temperature ranging from 38° to 39°C and the cool months being January and February with the minimum temperature ranging from 20°C to 21°C. In many places in this study area where a rough topography is dominant, the parent rocks are visible due to the effect of the slope. Most of the people are engaged in agriculture work, the important crop grown in this taluk is cholam, cotton and maize which are rain fed crop and onion is irrigated crop. The commercial crops like chillies and groundnut and sunflower are also cultivated both in rainfed and irrigated. The major crop such as Paddy, Onion, Groundnut, Tapioca and Sugarcane are cultivated under irrigation with the help of well and tank irrigation.

## Materials and methods

Several soil erosion models and Techniques are available to predict soil hazard zone and risk. In this present study has been estimated soil erosion with the help of RUSLE model and GIS techniques.

**Data source:** The data used for evaluation of RUSLE factor and generation of erosion hazard map were prepared from different data sources like topographic sheets (58 I/11, 12, 15, 16), Landsat8 OLI/TIRS data obtain from the Earth Explorer, CARTO DEM (30 m Resolution) bhuvan website, the rainfall data were collected from IMSD data center, India and the soil data collected from the NBSS and land use planning centre, Tamilnadu (Figure-2). These data were used in processing the maximum possibility classification algorithm in ERDAS imagine and spatial analyst in Arc GIS 10.1.

**RUSLE parameter estimation method:** The RUSLE parameters are generally used for both forest and agricultural region and assess for the average annual soil loss. It is introducing and enhanced the soil erosion factor by Wishmer and Smith 1978[14-16]. The RUSEL model required for five major input factors like R, K, LS, C & P these factors expressed in the calculation is

$$A= R * K * LS * C * P.$$

Where: A is an average annual soil loss for select study area it is represented (ton/$h^1$/yr); R factor is the rainfall runoff erosivity (MJ mm $ha^1$ $h^1$ $y^1$); K factor represents the soil erodability (a ton / ha /h/$ha^1mj^1mm^1$); LS factor is the slope length and steepness of the area; C factor is the cover management factor it is expressed in range of 0 to 1.5 and P factor is the conversion practice it is expressed in the value of 0 and 1.

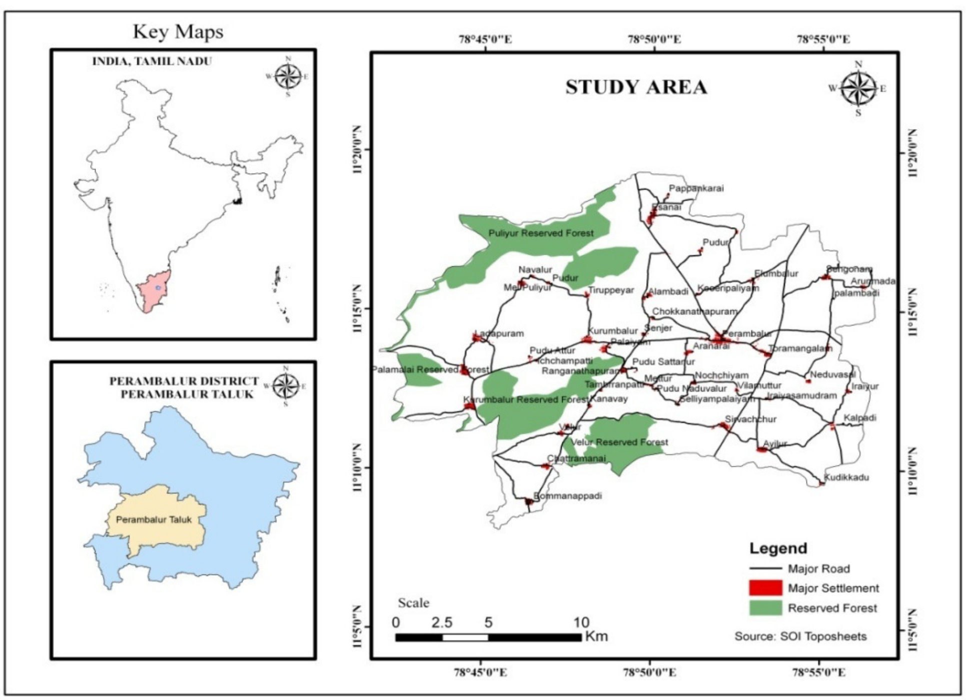


**Figure-1:** Study area location map.

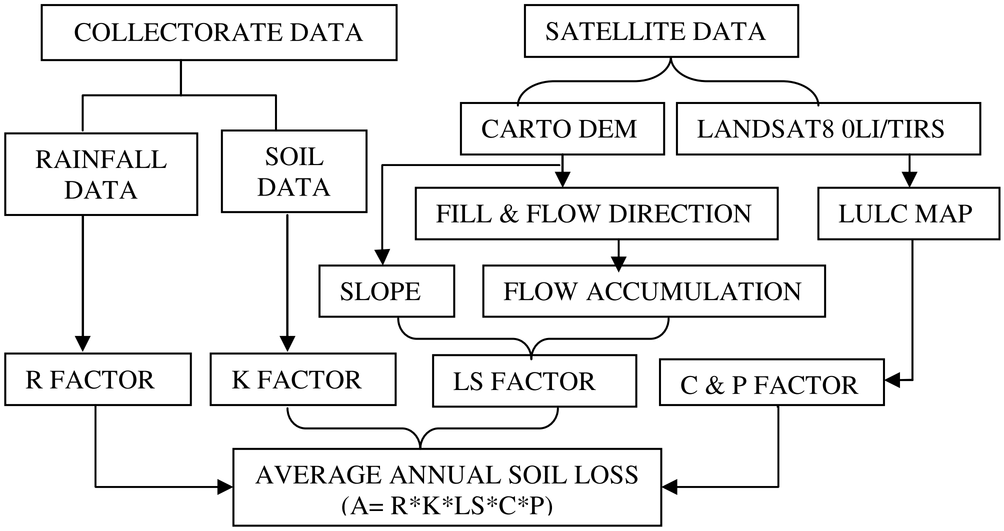


**Figure-2:** Methodology of the flowchart.

**Rainfall erosivity (R) factor:** Rainfall erosivity was estimated with help of Rainfall data and many researchers R factors considered in the long time average annual rainfall. It measures the erosive force in a particular region by the causes of runoff. The R factor was reflected with precipitation pattern among the region, if an area having nearly slope region that area have low erosivity and water ponding were protecting the soil particles from the eroded region by the rainfall. The present study was 5 year annual average rainfall data were used to input of R factor, the R factor has been calculated as

$$R = 79 + 0.363*RN \quad (1)$$

Where: RN is the average annual rainfall in mm.

In this equation developed by Sing et al.[17]. For Indian condition for this equation used to prepare the R factor it is show in Figure-3.

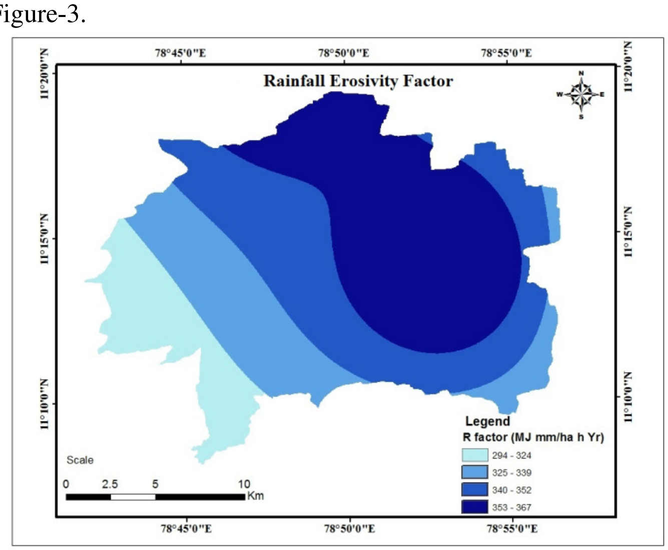


**Figure-3:** Rainfall erosivity factor (R).

**Soil erodibility (K) factor:** The soil erosivity factor is depending on the soil characteristic of natural resistance and susceptible, soil texture, grain size and organic content. The K factor reflects the value of rainfall runoff. The present study area having seven major types of soil were presented are clay, sandy-clay, clay-loam, sandy clay-loam, sandy loam, loamy sand and sand. According to the soil survey manual was represented to the soil erodability factors of susceptibility and rate of runoff, it was calculated in the standard unit plot condition. The soil infiltration capability and structural stability has affected by the K factor and it is ranged from 1 to 0.01 the highest value indicate that region soil is very fine texture for example silt or very fine sand. The present study area has moderate soil of K factor is observed it is shown Figure-4.

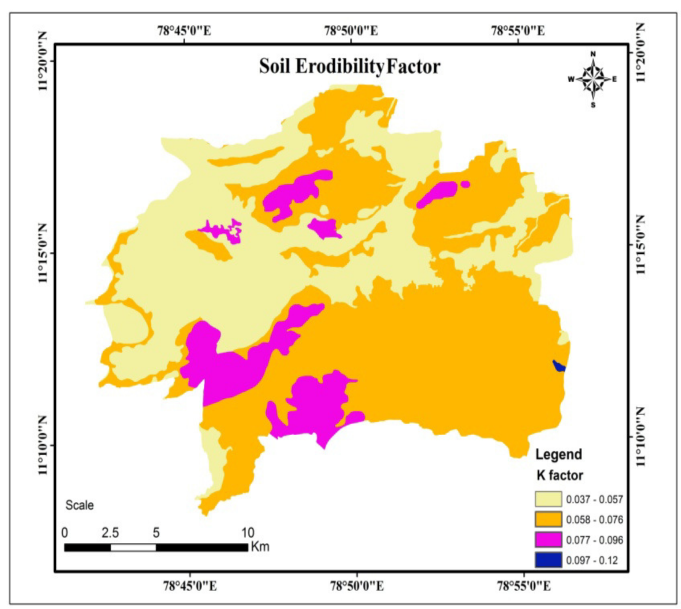


**Figure-4:** Soil Erodibility factor (K).

**Slope length and steepness (LS) factor:** LS factor depends on the slope length and steepness of the area and it has played an important role in soil erosion. They produce for topography on the top soil erosion and its containing the length and steepness of the slope that persuade the surface runoff speed[18,19]. The RUSLE formulate that no separation among the rill and inter rill in the S factor that compute the consequence of slope steepness in the soil loss[20-22]. The study area Ls factor was prepared through a CARTO DEM (30 m Resolution) data its show in Figure-5. There are lots of relationships for the assessment of Ls factor while the best suitable for intergraded with GIS platform it is proposed by Moore et al.[22]. It's based on the unit stream power theory that equation as follows:

$$LS= (A/22.13)^{0.6} + (\sin/0.0896)^{1.3} \quad (2)$$

Where A is a slope length factor, B is the slope steepness factor; 22.13 is the RUSLE unit plot length, 0.6 is the slope length exponent variable (generally it's taken from respective grid).

$$A = (\text{Flow accumulation} \times \text{grid size}) \quad (3)$$
$$B = \text{Slope of DEM} \quad (4)$$

The accuracy which it can be estimated through the digital elevation model (DEM) data resolution. Arc GIS Raster calculator tool used to drive LS factor map it's based on the slope steepness and flow accumulation[23].

$$LS = (\text{Flow accumulation} \times \text{Cell size} / 22.13, 0.6) \times \text{Power} ((\text{Sin} (\text{Slope of DEM} \times 0.01745 / 0.0896, 1.3) \quad (5)$$

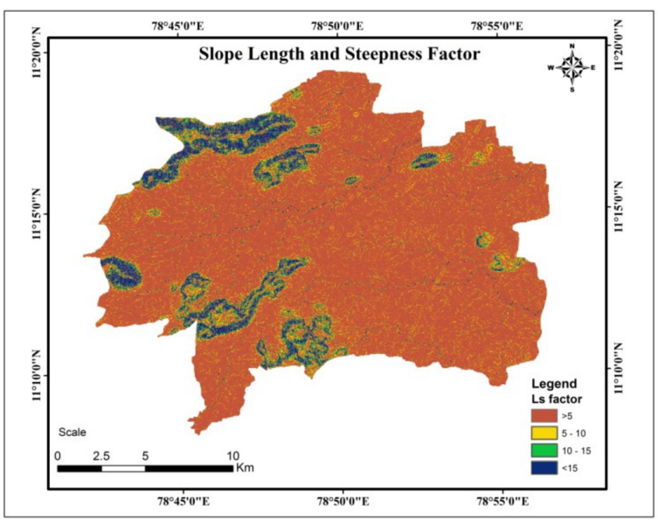


**Figure-5:** Slope length and steepness factor (LS).

**Cover management factor (C):** The Cover management factor was representing the result of soil disturbing activities for plant, crop sequence, productivity level, Soil cover and sub-surface biomass in the soil erosion. This factor is defined as the relation of soil loss from the land under a cropped for specific conditions into the equivalent soil loss from clean tilled and continuous fallow land[24]. Since there are a variety of land covers and spatial and temporal changes, a set of satellite data sets from different periods was used to prepared landuse and land cover map. The cover management factor was prepared on the basis of landuse and land cover condition and the C value assigned based on the (Table-1)[25-27]. Water bodies comprise ponds, river, dry river, canal, swamps will have minimal erosion hence they are assigned a very low value (e.g. 0.003); for built-up area the chances of erosion can be considered null. The landuse- land cover map has re-classified based on C-factor value for that generation of the C factor map its show in Figure-6.

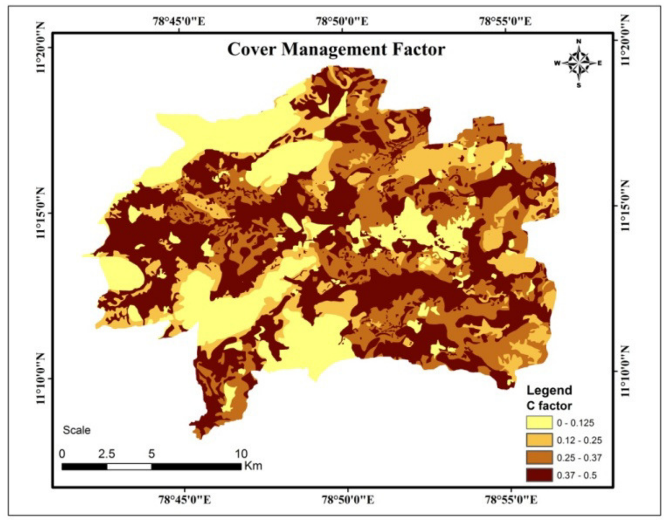


**Figure-6:** Cover management factor (C).

**Table-1:** Cover management factor from the LULC classes.

| LULC | C value |
|---|---|
| Cropland | 0.5 |
| Fallow land | 0.3 |
| Plantation | 0.5 |
| Forest | 0.008 |
| Scrub forest | 0.08 |
| Land with scrub | 0.6 |
| Land without scrub | 0.8 |
| Wasteland (Barren rocky/ stony waste, gullied/ ravenous land) | 0.18 |
| Built up land | 0 |
| Water bodies | 0.003 |

**Conservation practice (P) factor:** The conservation practice (P) factor is the soil loss ratio through a particular support practice to the equivalent of soil loss with up and down slope tillage[28]. The P factor is specific control practices for that reduce soil erosion potential from the runoff by the influence of drainage/flow pattern, contouring and velocity of runoff on the soil[29,30]. This factor was derivative from LULC and support factor of the study area it is shown in Figure-7. The P factor ranges from 0 to 1 and the highest value is assigned that area having no management practice (forest) and the minimum value assigned into the built up land, Plantation area with strip and the contour cropping region. The P value is lower than that area having more effective the management practice.

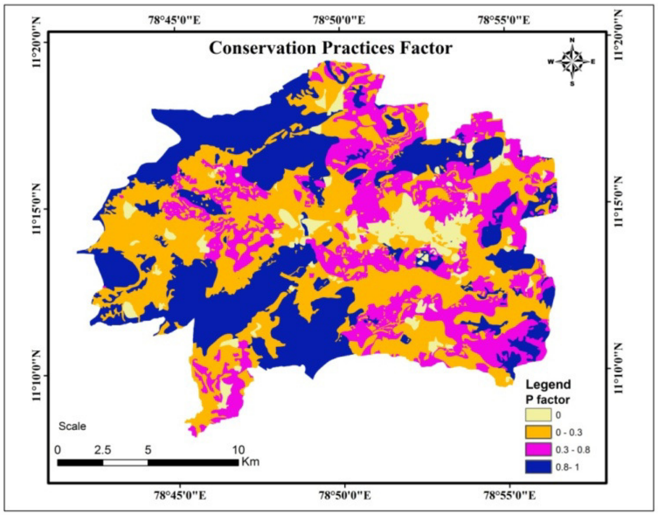


**Figure-7:** Conservation practices factor (P).

## Results and discussion

The soil erosion problems as determined through the RUSEL model using Geo information techniques for evaluating different disturbance, alternative and spatial optimization for conservation measures. The formation of a record through conservative method is the time consuming, tedious and its complex to handle. Therefore RUSEL method has followed with different thematic factors. The average annual rainfall (R) factor value recorded in the range of 294.34 to 367.22 MJ.mm $ha^{-1}$ $h^{-1}$ and the mean value is 330.78 MJ.mm $ha^{-1}$ $h^{-1}$ observed in this study area (Figure-3), K factor is recorded in the range of 0.037 to 0.12 (Figure-4). Several researches indicate that LS factor plays a very important function in RUSEL model while finding the soil erosion rate in Perambalur taluk was observed in the range of 0 to 118.12 and the mean value is 1.58 its show in Figure-5. The C factor value has been observed from the range of 0 to 0.56 (Figure-6) and support practice P factor value ranged in between 0 to 1 its show in Figure-7. The Average annual soil loss (A) is computed through multiplying the developed raster data from the RUSEL method it expressed for $A = R \times K \times LS \times C \times P$. The Perambalur taluk is 52.25 ton/ha/yr of average annual soil losses were observed in the forest and barren land it shows in Figure-8. The mean annual soil loss for the entire study area about 0.16 ton/ha/yr. When the improper cultivation method followed and ploughed in the farmland that area having removed topsoil during the wind and rain seasons.

The study area having gentle slope region as a result of low soil erosion and the Soil erosion map is reclassified according to erosion risk classes suggested by Singh et al[31] for Indian condition. According to the erosion risk classes it is observed that 23,223.88 ha area is under low erosion class whereas 761.599 ha area is under severe class as shown in Table-2.

**Table-2:** Soil loss classification according to the erosion risk classes.

| Class | Area (ha.) | Area (%) |
|---|---|---|
| Low | 23223.88 | 68.95 |
| Moderate | 5657.72 | 16.80 |
| High | 2517.92 | 7.48 |
| Very high | 1522.88 | 4.52 |
| Severe | 761.60 | 2.26 |

## Conclusion

The soil erosion has been estimated and spatially distributed in the Perambalur taluk using RSULE and GIS technique and the soil loss map is classified into five different erosion risk classes. According to that 23223.88 hector (68.95%) land of the study area has low erosion risk and 5657.72 hector (16.80%) lands are moderate erosion risk category it is highly occurred in the fallow land. The high and very high erosion risk is observed about 4040.8 hector of the total study area (Table-2). The severe erosion mainly 761.60 hector (2.26%) occurred in forest and barren rocky land it show in Figure-8. The average annual soil loss map is very helpful to predicting soil conservation measure checking the soil loss effectively. The local farmers should adopt soil conservation and protective method in his farming land and the local planner and decision maker have to apply both long and short term natural resource management system including the forest laws.

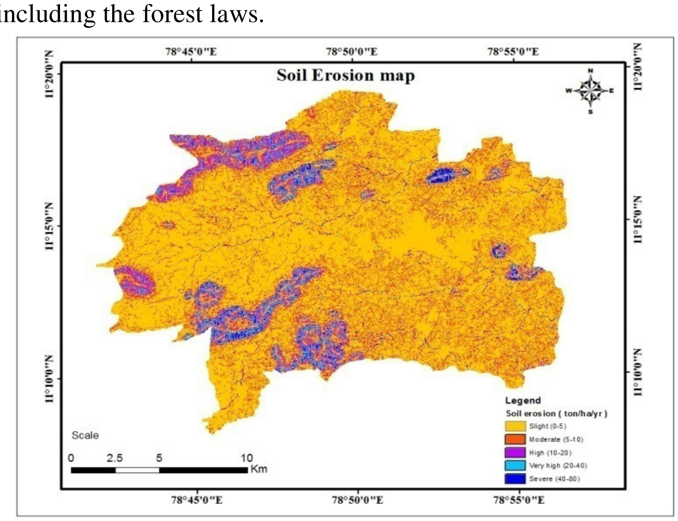


**Figure-8:** Soil erosion map.

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