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Utilizing remote sensing and GIS to characterize watersheds and evaluate soil loss in Dehradun, Garhwal Himalaya

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ABSTRACT

The most crucial aspect of watershed management is watershed characterization, which includes soil loss. Soil loss assessment uses geospatial tools like remote sensing and GIS to show the amount of soil loss or erosion in tons per hectare per year. Both natural and man-made factors contribute to the loss of agricultural land, whereas human factors hasten soil erosion. It is a global phenomena that results in decreased plant water table availability, increased runoff from the more impermeable subsoil, and soil nutrient loss. Planning and better management in a watershed and planning units benefit most from watershed management and soil loss assessment. The satellite image-based model technique combined with remote sensing and GIS provides a scientific, quantitative, and useful outcome. Under all climatic conditions, it can calculate a consistent result of soil erosion and sediment yield for a variety of locations. The Tons watershed, which spans 97.02 km² (9,702 hectares) under the sub-tropical climate region of Uttarakhand, is located between 77°56'05" E to 78°01'01" East longitude and 30° 21'05" N to 30°26'51" North latitude. The Revised Universal Soil Loss Equation (RUSLE) applies to soil loss and GIS. A = is the calculated soil loss per unit area, R = is the rainfall erosivity, K = is the soil erodibility factor, L = is the slope-length factor, C = is the cover and management factor, and P = is the support practice factor. These are the results of the current case study, which is based on computational software and geospatial technologies. Rainfall erosivity ($R=87.5 + 0.375 \times R$), C P is within the range of 0.006-0.8, and the range of soil erosion risk is between 51.40% and 0.85% for the whole research region. In 2016, the open woodland had the largest soil loss (56.58 tons/ha/year) and the riverbed had the lowest (0.17 tons/ha/year) according to several land-use classifications. Part of the research region falls into a moderate and moderate-high zone, while the remainder falls into a low likelihood zone. The case study is highly recommended and will aid in the adoption of soil conservation and loss control practices in the Himalayan areas and the Tons watershed.

Keywords: RUSLE, Garhwal Himalaya, Remote Sensing & GIS, Tons Watershed, Soil Loss.

INTRODUCTION

In terms of shape, physical elements, chemical elements, structure, and biological aspects, soil is a naturally occurring form of mineral and organic components. (Birkeland, 1974, 1999; Jofie, 1936). According to Desmet and G. Govers (1996), natural geological erosion is the erosion of land in its natural form, even when it is not caused by human activity. Running water, wind, ice, and other geological processes continuously erode uneven terrain surfaces. After then, the eroded materials end up in alluvial plains and valleys. Soil formation and removal occur concurrently. While soil development is a long process, erosion may occur at different rates and in different amounts. Nature, however, strikes a balance between the two. The most significant natural resource that humans have access to is soil. It acts as a storehouse for plant nutrients and an anchor for the plants. Forestry and agriculture depend on the soils. Therefore, using soils in a systematic way to improve human standards is unavoidable (Soil and Water Conservation Society, 1993). Soil is one of the key fundamental resources in this rapidly evolving function. Planning for agriculture, forestry, and other development programs benefits from a detailed understanding of the soils. Standard soil surveys are used to gather scientific data on soils. An efficient agricultural research and advice program must include a soil survey. The upgrading of soil survey techniques is receiving a lot of attention and emphasis. Over the earth's surface, soil erosion is a common and widely spread problem. A risk level area map is created to address significant problems caused by wind or water. In particular, soil erosion models highlight the presence of residue and vibrant green plants on the soil (Berk Ustun, 2008). Soil erosion is often lessened during periods of high rainfall when the soil is covered with plant and agricultural leftovers. Doidato, N. (2004). In order to minimize soil erosion and preserve their agricultural property, farmers may play a significant role. Farmers are ultimately responsible for lowering the amount of erosion sediment on their farmland. It is well acknowledged

that agricultural activities on sloping terrain would always result in soil erosion due to water runoff (Shown, Frickel et al., 1981 & Gary C, et al., 1914). Erosion and runoff losses are not unavoidable. By using site-specific and tailored agricultural methods and management techniques, the farmer may efficiently limit erosion, decrease runoff, and increase the quantity of water on his field. While plants can successfully utilize irrigation and blocked water, which is crucial for thriving in arid conditions, runoff water is not known to be used for agriculture. (DD Smith and W.H. Wischmeier, 1965 & 1978). In agricultural systems, managing soil erosion is crucial. Humus is a component of topsoil, which is made up of biotic elements and dirt. The earth becomes very unproductive for growing crops if this layer is removed by wind and water. Loose soils from flat or hilly terrain may be carried away by strong winds. Only slopes experience water erosion, depending on how steep the slope is. In many regions of the globe, wind erosion mostly happens in the winter, when the topmost layer of soil is dry and loose but the ground is frozen. As the snow thaws and melts in the spring, water erosion takes place. The removal of dirt from the surface of the ground is referred to by a number of words. The following definitions are used in this study even though there is some disagreement over the meanings associated with these words. A variety of processes that entrain and move earth materials over a surface are together referred to as erosion. According to SK Saha et al. (1992), soil loss is the actual removal of material from a specific hill slope or hill slope section. Because of on-site deposition in micro-topographic depressions on the hillside, soil loss may be less than erosion. RUSLE calculates soil loss from a hillside due to rill erosion as well as raindrop impact and overland flow, which together are referred to be "in Terrill" erosion (C.C. Truman and J.M. Bradford, 1995). Gully and stream-channel erosion are not estimated by it.

MATERIALS AND METHODS

The case study was conducted using primary and secondary data combined with GIS computation and remote sensing, other geospatial technologies, RS-GIS software, and an SOI Topo map to validate the research region. IIRS Lab Dehradun has performed all computational algorithmic analysis. Rainfall data, soil data, LISS-III satellite photos, and other information gathered from secondary sources. Primary data, such as soil samples, physiographic surveys, visits to agricultural plots, etc., has been gathered and examined for validation. Utilized Satellite Data: Remote Sensing Data; Sensor-LISS-III, Satellite-IRS-P6

LISS-III image	DATE	PATH NO.	ROW NO.
1	15-March,2016	096	049

Software Used ERDAS Imagine 10.0

ERDAS IMAGINE is a very helpful tool that provides access to a large geographic data store. It gives us the ability to decide in a variety of circumstances. EEDAS Imagine has the ability to record and follow certain locations and times, as well as track changes that have happened. With its facilities for creating, managing, and analyzing images, the application is among the finest options. It will provide us valuable geographic data. By combining GIS and remote sensing methods, the tool allows us to handle geographical data and extract necessary information. Arc GIS 10.0 Arc GIS is a Geographic Information System (GIS) that facilitates the use of maps and geographic data. Making maps, gathering spatial and non-spatial data, sharing and finding data, analyzing and using maps, even geographic and non-spatial information applications, and database management systems are all done with software. GIS offers a fundamental foundation for making maps and geographic data accessible both online and offline. Version 3.3 of ILWIS Up to its 3.3 version in 2005, ITC created the PC-based GIS and remote sensing software known as the Integrated Land and Water Information System. ILWIS is a comprehensive suite that includes digital mapping, geographical analysis, and picture processing. It is simple to use and learn. Additionally, it includes 25 case studies from different fields, comprehensive tutorials for direct usage in the courses, and complete online assistance.

Erosion Risk Assessment Using RUSLE Model

The quantity of soil eroded within a certain time period that results in pure soil loss is known as soil loss. Mass per ton, per hectare, and per year (ton / ha / year) are used to represent it. (Kuldeep Pareta & Upasana Pareta, 2012) (ton/ha/year). The current study is based on the RUSLE (Revised Universal Soil Loss Equation) to forecast annual soil loss from the study area. Wishmeier and Smith introduced the USLE (Universal Soil Loss Equation) in 1965. This equation was later revised as RUSLE and modified as MUSLE version (Wishmeier and Smith, et al., 1978). The following is an expression for the RUSLE:

$$A = R \times K \times L \times S \times C \times P$$

Where,

A = Computed soil loss per unit area. R = Rainfall erosivity.

K = Soil erodibility factor.

L = Slope-length factor.

C = cover and management factor.

P = support practice factor (assumed to be one) Rainfall Erosivity (R)

The average yearly rainfall over the previous seven years is used to compute the rainfall erosivity factor. The rainy erosivity calculation formula is as follows:

$$R = 1686 + 0.329 * DEM$$

R Factor = $87.5 + 0.375 * R$ is the Ram Babu equation for soil rainfall erosivity. Under normal unit plot circumstances, soil erosion susceptibility and runoff rate are measured by Soil Erodibility (K). A soil's erodibility is influenced by its texture, organic matter content, and permeability (M.P. Tripathi, Panda, S R.K, Pradhan, and S Sudhakar, 2002). Laboratory analysis and soil profile investigation were used to estimate soil erodibility and K values for various physiographic soil units. The Slope Length (L) component in the K factor map illustrates how slope length affects erosion. The slope's length is the distance between the land flow's source and the deposition site along its flow path. The LISS-III data in this case study were measured using the ILWIS software utility button field width across the slope, which gages slope length. S.K. Saha, M. Kudrat, and SK Bhan (1990) measured the slope length of many fields, created a length, and found homogenous field sections.

Slope Steepness (S)

The influence of slope steepness on erosion is represented by the S factor; soil loss increases more quickly with slope length. Soil particle size and plant cover density have an impact on the relationship between soil loss and gradient (Dutta. Pradip, 1999). In this case study, a terrain slope map in % was created using a DEM map created from CARTOSAT data. This equation is used to derive the LS factor from the

CARTOSAT DEM:

$$LS = \text{pow}((\text{flowaccumulation} * 30 / 22.1), 0.14) * \text{pow}(\sin(\text{Slope_rad} / 0.09), 0.6)$$

Crop Cover Management and Assistance Techniques (C and P) The impact of cropping and management techniques in a unit area that are related to erosion rates is represented by the C factor (Crop Cover Management). When comparing soil erosion, this crop cover management is the most often utilized aspect.

impacts that will have an impact on soil conservation planning, average yearly soil loss, and the inclusion of different activities such crop rotation or other management plans (B Bhushan, K.L. Khera, Rajkumar, 2002).

Table 1: Areal extent of Physiographic Units

Physiographic Unit	PH Unit	Area (Sq. Km)	Area (%)
River Bed	R	1.41	1.64
Steep Himalayas Dense Forest	H11	3.44	4.02
Steep Himalayas Open Forest	H12	33.87	39.48
Moderate Sloping open Forest	H22	0.98	1.14
Settlement	S	4.99	2.79
Lower Piedmont (Scrub)	P24	9.73	1.34
Lower Piedmont (Fellow Land)	P25	1.97	2.29
Lower Piedmont (Agriculture)	P23	0.22	0.26
Residual Hill (Dense Forest)	RH1	5.94	6.92
Upper Piedmont (Dense Forest)	P11	1.82	2.12
Upper Piedmont (Scrub)	P14	11.98	13.97
Upper Piedmont (Agriculture)	P13	3.34	3.89
Moderate Sloping (Dense Forest)	H21	15.95	18.59
Moderate Sloping (Agriculture)	H23	0.30	0.35
Steep Sloping (Agriculture)	H13	1.01	1.18

Total	96.97	100.00
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The influence of support practices on the average annual erosion rate in tons/ha/year is represented by the Support Practices (P)P factor (Support Practice). This study's assessment and delineation of various management methods were based on visual interpretation of the FCC and field survey. After preparing and rasterizing the polygon map, the management practice values were allocated based on the literature to create an attribute class map that displayed the P value in the region. In the end, a P factor map was created. Satellite photos and the study area's Topo sheet have been used to create a variety of maps, including LULC maps, physiographic maps, slope maps, and soil maps. Identification of many components is necessary for soil mapping (S.K. Bhattacharya, 2000). The following factors are crucial for soil survey and land type: vegetation, land use, slope, relief, drainage pattern and condition. Three round approaches make up the technique (Fig. 1);

Study AreaThe Dehradun district of Uttaranchal is where the study area is situated. The Tons Watershed is situated between latitudes 30°19'51.26" and 30°27'57.03 N and longitudes 77°53'21" and 78°02'56" E. The watershed spans 97.02 km² (9702 hectares) and is located between 77°56'05"E and 78°01'01"E longitude and 30°21'05"N and 30°26'51"N latitude in the Dehradun district of Uttarakhand state, India. It is located in the Indian state of Uttarakhand's Dehradun district. The research area is located between the Tons River in the southwest, the Forest Research Institute and Tapakeshwar in the east, the agricultural region of Badshahibagh in the east, the Bakarna reserved forest in the northeast, the Batoli Block Sal forest in the northwest, and the thick Sal forest of Donga Block in the west. The region has pleasant to hot summers and very frigid winters due to its subtropical climate. The region receives 2051.4 mm of rain annually. The region is made up of the piedmont and mountains, which make up the major scenery (Fig. 2&3). Our research region does not include any alluvial plains. Mountains dominate the northern and northwestern areas, while piedmont plains around the Darer, Ghulatia, and Nimi rivers dominate the southern and eastern regions. The area's primary land uses are forestry, agriculture, and habitation. It is bordered to the south by the Siwaliks and to the north by the Lesser Himalayan range. It creates a synclinal valley that is asymmetrical. The Asan River, which flows northwest and merges with the Yamuna River, occupies this watershed. These physiographic units are all stretched from NW-SE to ENE-WSW. Parallel to sub-parallel, sub-dendritic, trellis, angular, rectangular, intermittent, and braided drainage are the main types seen in the region (Fig. 2).

RESULTS AND DISCUSSION

Physiographic Features Physiographic units are separated into sixteen sections in the physiographic map. Slope steepness is the foundation for dividing these units. The river terraces and hills cover the watershed. Because of the soil, vegetation, and slope, each unit has unique features. Each physiographic unit has a distinct area, with a total size of 97.02 square kilometers. A physiographic map looks at a variety of soil characteristics, including soil depth, texture, drainage, slope, coarse fragment, and erosion (SK Saha et al., 1992). The watershed's texture varies depending on the map unit. For example, the Hills have silt loam and coarse sandy loam textures. Loam and silt loam make up river terraces. The top slopes have very shallow to very shallow soil. It is deep, extremely deep, and somewhat deep in the agricultural field. The coarse fragment is quite severe in the higher slopes and relatively minor in the agricultural land (SK Saha et al., 1992). Additionally, erosion is quite high in the hills where there is very little land cover, moderate in the upper river terraces, and modest in the agricultural fields in watershed drainage owing to slope steepness (Table 2 & 3).

Table 2: Soil Characteristics of Various Physiographic-Soil Units

Physiographic Units	Slope (%)	Drainage	Coarse fragments (%)	Texture	erosion
H1	15-25	Excessive	40-75	Sl	e1/e2
H2	15-25	Excessive	40-75	Sl	e2/e3
H3	60-70	Excessive	40-75	Sl	e2
UP1	10-15	well	15-40	Sil	e1
UP2	7-10	Excessive	15-40	Sl	e2/e3
UP3	5-7	Moderate well	<15	L	e1
MP1	5-8	well	<15	Sil	e2
MP2	1-2	well	<15	Sil	e1
MP3	2-3	well	<15	Sil	e1
MP4	5-8	well	<15	L	e1
LP1	5-8	well	<15	Sil	E2/e3
LP2	3-5	well	<15	Sil	e1
LP3	1-2	well	<15	Sil	e1
RH	7-10	well	<15	Sil	e1
RT	1-2	Well	<15	sl	e1
River	-	-	-	-	-

and Cover and Land UseThe research area's primary land cover and land use include riverbed, forest, agricultural, and scrub land. The forest is made up of both thick and degraded vegetation. There are two types of scrub: open and thick. Terrace and bonding techniques are used in agricultural fields (Table 3 & Fig. 5).The average rainfall over a 25-year period is used to determine the Rainfall Erosivity Factor (R). The 25-year average rainfall is 2051.4 mm. The rainfall erosivity is computed using the equation.

$$R = 1686 + 0.329 * \text{DEM (cell size of raster image)}$$

$$R_Factor = 87.5 + 0.375 * R \text{ (Ram Babu equation for Rainfall erosivity)}$$

Ram Babu (1978) calculated rainfall erosivity, which is particularly advantageous for the Indian subcontinent. Results show that the rainfall erosivity range value in the research area ranges from 791.801 to 988.831 (Fig. 8). Although the length of rainfall is most important for soil erosion, slope and rainfall intensity are connected for soil loss (KG Renard, and JR Freimund, 1994). According to the observed range of values, runoff from agricultural areas is often greater in the spring when the soils are wet, and certain patches are under high rainfall erosivity in the research region. The study region's maximum area falls within the moderate R factor, whereas areas with low to moderate rainfall intensity fall under this range. Soil Erodibility Factor (K)The intrinsic erodibility of the soil or surface material at a specific location under typical experimental circumstances is expressed by the K factor (JK Mitchell et al., 1983). The soil or surface material's structure, permeability, organic matter content, and particle size distribution all affect K's value (J.V. Bonta and W.R. Hamon, 1980). The National Resource Conservation Service (NRCS) frequently provides values of K for undisturbed soils through soil surveys; for disturbed soils, the Nomograph equations built into the RUSLE program are used to calculate suitable erodibility values (W.R. Curtis and Superfeskys, 1977). Although structure, organic matter, and permeability all play a role, soil texture is the primary element influencing the K factor. A map of soil attributes is used to calculate soil erodibility. Thirty soil samples were taken from the field (Table 2).

Table 3: Areal extent of Land Use Land Cover

LULC Classes	Area(Sq. Km)	Area (%)
Settlement	5.152790106	5.310783
Dense Forest	19.14404139	19.73103
Open Scrub	1.312710808	1.352961
River Bed	1.411090578	1.454357
Fellow Land	1.968439706	2.028795
Dense Scrub	21.72384443	22.38993
Agriculture	4.858516631	5.007487
Open Forest	41.45361252	42.72465
Total	97.02504616	100

Table 4: Distribution of Slope in Study Area

Slope (%)	Area(h)	Area (%)
<2	463.35	3.668
2-8	3536.79	27.999
8-15	2773.48	21.956
15-30	3329.53	26.358
30-50	1757.99	13.917
50-70	454.67	3.599
>70	315.92	2.501
Total	12631.7	100

Table 5: C and P factor

UNIT	C Factor	P Factor
Orchards	0.05	0.5
Forest	0.006	0.5
Fallow	-	-
Scrub	0.05	0.5
Settlement	-	-
Riverbed	-	-
Agriculture	0.5	0.8

Table 6: Extent of Soil Erosion Risk Class in Tons Watershed

Classes	Soil Loss (t/ha/yr)	Area (Sq. Km)	Area (%)
Slight	0-10	49.7439	51.40
Moderate	10-25	4.7151	4.87
Moderate High	25-50	14.9643	15.46
High	50-100	26.5356	27.42
Very High	100-200	0.819	0.85
Total		96.7779	100.00

Table 7: Average Soil Loss in Study Area (2016)

LULC	Average Soil Loss (t/ha/yr)
Settlement	1.99
Dense Forest	0.49
Open Scrub	27.37
River Bed	0.17
Fellow Land	19.53
Scrub	2.18
Agriculture	18.88
Open Forest	56.58

The soil erodibility value in the research region varies from 0.01 to 0.065 based on the physical and chemical investigation of soil samples (Fig. 9). The K factor displays a number between 0 and 1. Few areas are impacted by high soil erodibility, which is shown by the red color. A value closer to 0 indicates low soil erosion or less prone, while a value closer to 1 indicates significant erosion or high prone (Fig. 9). Flow Accumulation For each pixel in the Digital Elevation Model (DEM), the flow direction determines the natural drainage direction. Following the Flow accumulation process, the output flow direction map displays the total number of pixels that will drain into the outlet point (Dissmeyer and Foster, 1980) (Fig. 10). Drainage Density and Stream Frequency Drainage density, which is measured in km/sq.km, is calculated by dividing the total length of all rivers and streams in a basin by the entire area of the drainage area, indicating the amount of water that will

penetrate. The stream order and flow accumulation map, which is divided into five stream orders, is shown in Figs. 10 and 11. Runoff would increase with the number of streams per square kilometer of drainage density. Therefore, the drainage density describes the runoff in the region, or, to put it another way, the amount of precipitation that might have penetrated. The largest chance of groundwater recharge occurs when the drainage density is low since the drainage density in the region was determined after the digitization of the full drainage pattern. The total number of streams in a region indicates the amount of orders, streams, and patterns present in that region. This is known as stream frequency. More groundwater is recharged when stream frequency is lower. Thus, on a square km grid or area, medium (5–10 number stream) and high (10). 20 flows per square kilometer enrichment) and very high (more than 20 flows per square kilometer enrichment) are regarded as accurate. (Figure 11).The Topographic Factor (LS) Slope steepness (S) and slope length (L), which are linked to an accelerated rate of soil erosion, make up the topographic factor. While length of slope is defined as the distance of slope with moderate soil creep toward down slope, steeper slope is associated with more erosion (Desmet and Govers, 1996). The LS factor shows how LS affects the erosion process. The topographic factor is calculated using the proportion of slope and flow accumulation with RS calculation. The most severe erosion events occur in the range of slope percentages between 10 and 25. The following formula is used to calculate the topographic factor:

$$S = \left[\frac{(Q_a M)}{22.13} \right]^y \times (0.65 + 0.045 \times S_g + 0.0065 \times X S)$$

Where

LS = Topographical Factor; Q_a = Flow Accumulation grid S_g = Grid slope in percentage M =

Grid size (X x Y), y = dimensionless value of 0.2–0.5

The range 0.00917–59.1787 is shown on map Fig. 12 as the result of calculation about the LS factor in the research region. The topographic factor's value grows as the research area's slope and flow accumulation do. Crop Cover and Management Factor (CP) There are eight classifications in the study area; the maximum area covered by dense forest and open scrub is 42.72% and 22.38%, respectively (Table 3 and Fig. 5). The crop cover and management factor (CP) shows land utilization practices, such as cropping pattern, settlement, dense forest, open scrub, river bed, fellow land, agricultural land, and open forest. The prepared map and LULC map have calculated the CP factor (Fig. 13 & 14). The CP factor value ranges from 0 to 1, where a value close to 0 indicates less erosion or soil loss and a value close to 1 indicates greater erosion. Each land use and land cover type in the research area has been shown to have a CP value of 0.05 and 0.5 for orchards, 0.006 and 0.5 for forests, 0.05 and 0.5 for scrub, and 0.5 and 0.8 for agriculture. River beds, settlements, and fallow land are worthless (Table 5). There is just one agricultural class with a P factor of 0.8, which is closer to 1, meaning that soil erosion is moderate to high. Additionally, the CP value in the other LULC classes is less than 0.5 for agricultural land, indicating little soil loss or reduced erosion. Soil Erosion Risk Following the derivation of all RUSLE soil erosion risk map factors. The soil risk map and the table (JE Gilley et al., 1977) illustrate the breadth of soil erosion risk class in the Tons watershed. Here is the formula to calculate the risk of soil erosion: $A = R \times K \times L \times S \times C \times P$. 0.85% of the watershed has very high erosion, 27.42% has high erosion, 15.46% has moderate-high erosion, 4.87% has moderate erosion, and 51.47% has modest erosion. Five indexes—Slight 1–10, moderate 10–25, moderate-high 25–50, high 50–100, and very high 100–200—have been developed specifically for the research region to measure the risk of soil erosion. The research area's soil erosion risk, as determined by t/h/y under five index values, was found to be 49.7439 hours under mild, 4.7151 hours under moderate, 14.9643 hours under moderate-high, 26.5356 hours under high, and 0.819 hours under soil erosion risk-prone (Table 5 & Fig. 15). The average soil loss in each class of LULC in tons per hectare per year was found to be 1.99 for Settlement, 0.49 for Dense Forest, 27.37 for Open Scrub, 0.17 for River Bed, 19.53 for Fellow Land, 2.18 for Scrub, 18.88 for Agriculture, and 56.58 for Open Forest (Table 7, Fig. 15 & 16). The research location was located in a portion of Uttarakhand's Dehradun district with the intention of employing remote sensing and GIS methods to evaluate the danger of soil erosion in the Tons watershed. Using the RUSLE model with remote sensing and GIS, soil erosion has been assessed. Because the model's primary input parameters can be obtained from remote sensing data and the modeling process can be completed with ease in the GIS environment, GIS integration with remote sensing is a peaceful method for modeling soil erosion. According to the study's findings, the Tons watershed has an average yearly soil loss of 63 tons per hectare. The examination of soil erosion in the Tons watershed makes it evident that slope, excessive rainfall, and partial deforestation are the main causes of soil erosion. Scrubland, present fallow, barren land, and low cultivation intensity are the areas with the most soil loss. The thick forest has the least amount of soil loss. Dense woodland covers the most of the region. It has been recommended to restore

vegetation cover on bare ground, particularly by planting trees. The conservation approach may be used within distinct stages of the erosion process since the RUSLE model made it possible to describe the erosion process. The study's findings lead to the following conservation recommendations for high and very high priority classifications of scrubland, agricultural, and barren land. The research approved and suggested preventing soil erosion and loss in the Himalayan areas. Users may locate the Tons watershed's soil erosion-affected regions with the use of RS and GIS. The Tons watershed's severe patch management and soil loss conservation will benefit from the observations and conclusions. The results will help prepare hazard zonation and natural catastrophe management plans more effectively. Because the Tons watershed is located in a mountainous area and often experiences natural disasters including cloud bursts, flash floods, high rainfall, landslides, etc., this article will be useful for improving Tons watershed management. Instead of using empirical approaches, remote sensing and GIS are the most effective tools for calculating and computing such large and complex data. The term "advanced techniques" refers to obtaining trustworthy findings and outcomes in addition to the necessary validation using primary data and concurrent ground-truthing.

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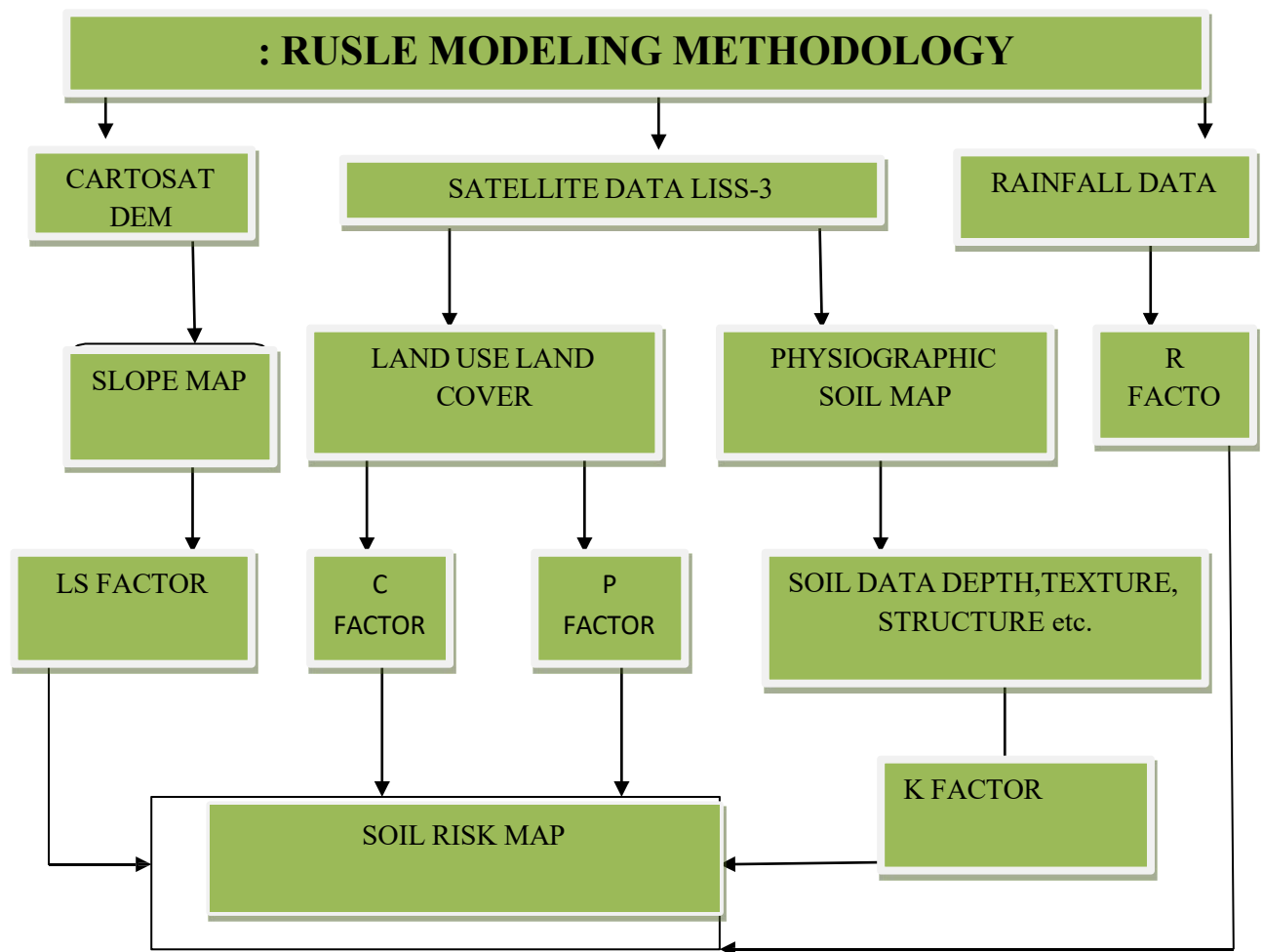


Fig. 1: Methodology

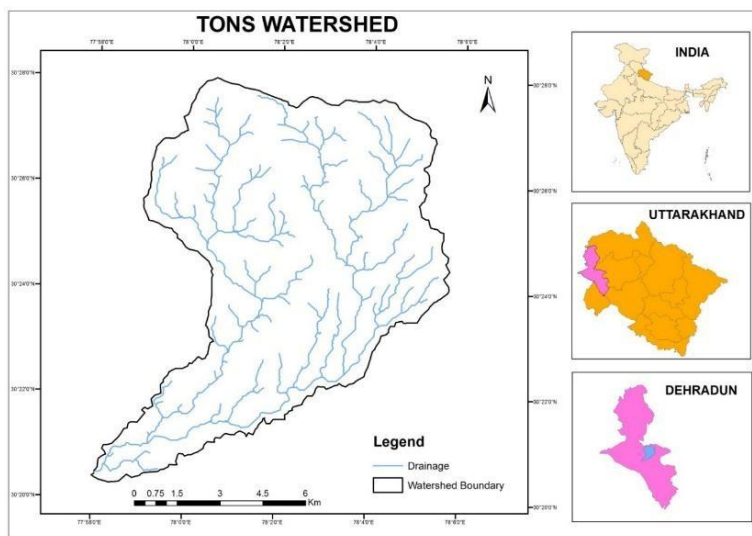


Fig. 2: Study Area, Tons Watershed

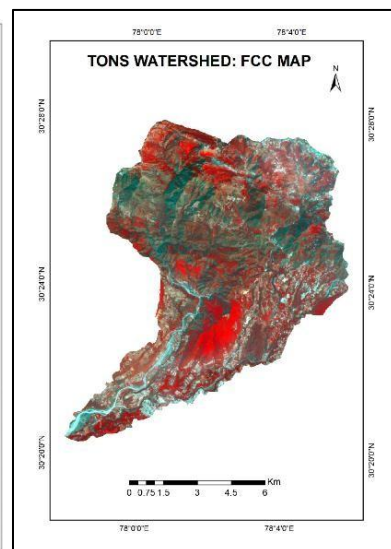


Fig. 3: FCC Map of the Study Area

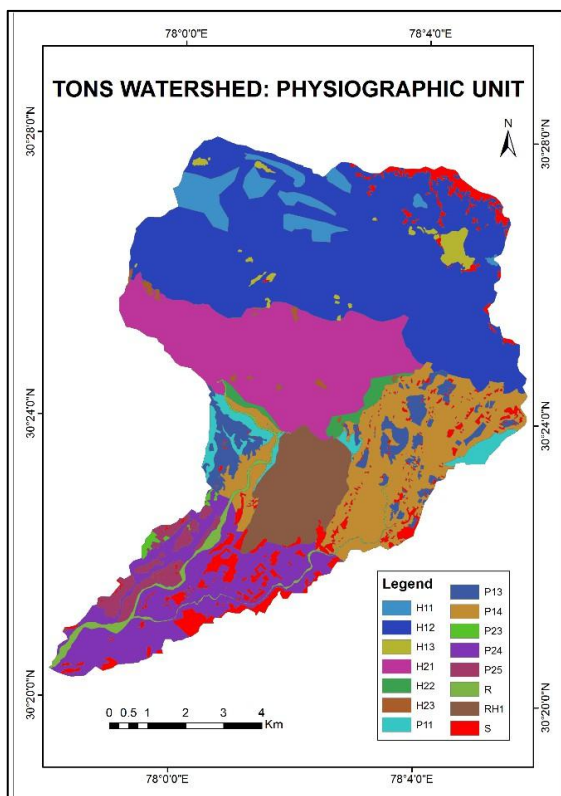


Fig. 4: Physiographic Units

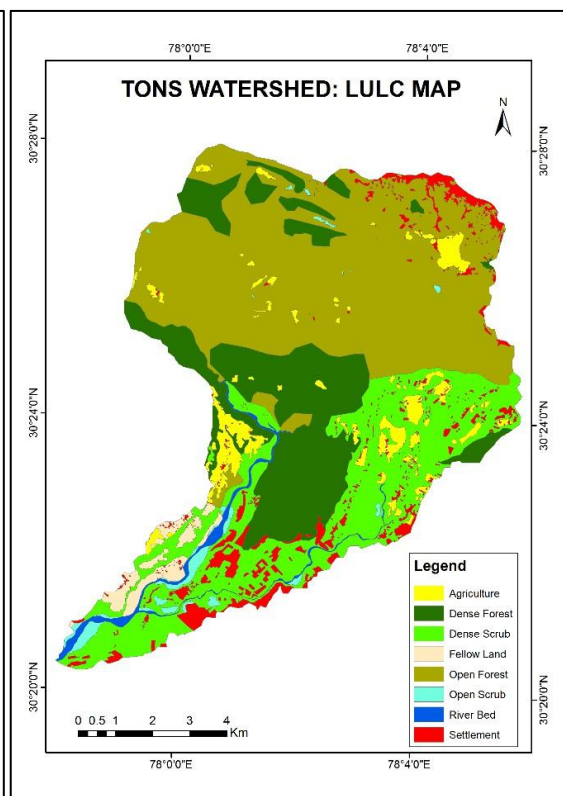


Fig.5: LULC

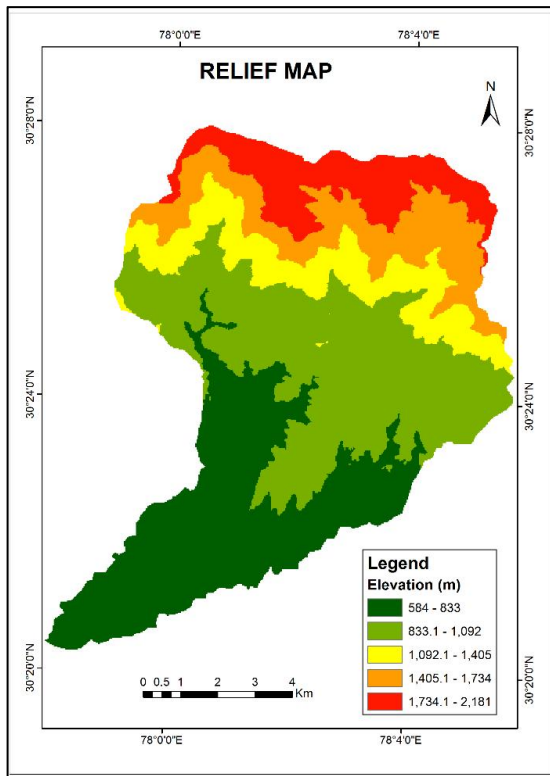


Fig. 6: Relief

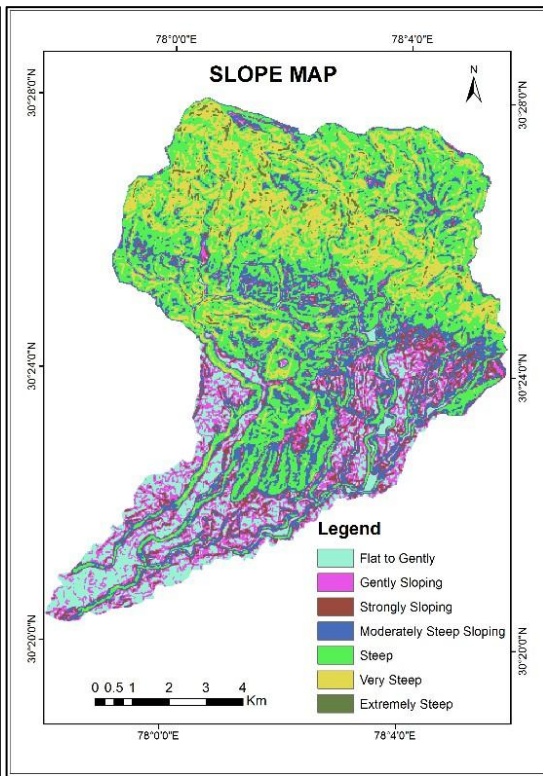


Fig. 7: Slope

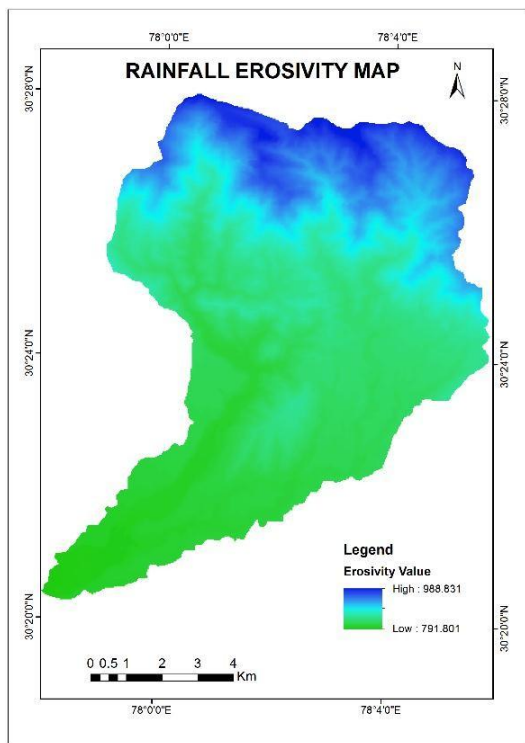


Fig. 8: Rainfall Erosivity (R)

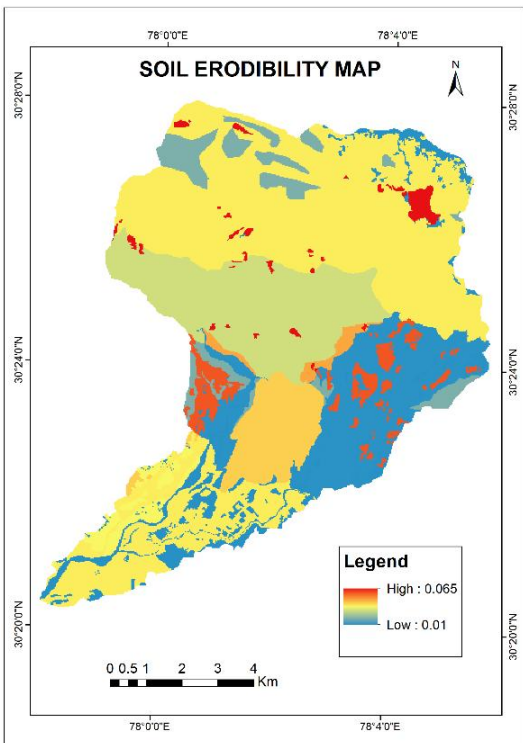


Fig. 9 Soil Erodibility (K)

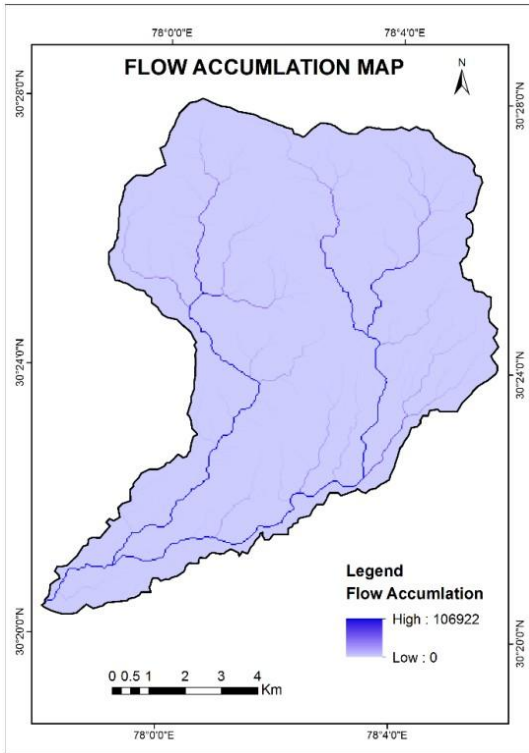


Fig. 10: Flow Accumulation

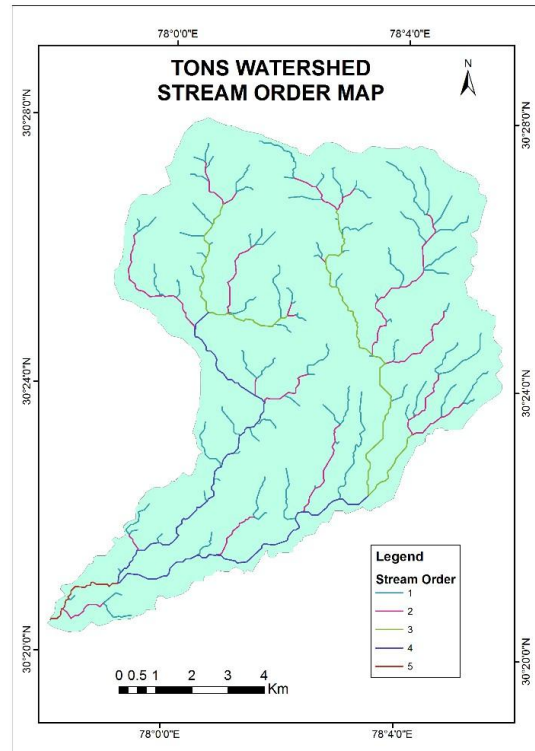


Fig. 11: Stream Order

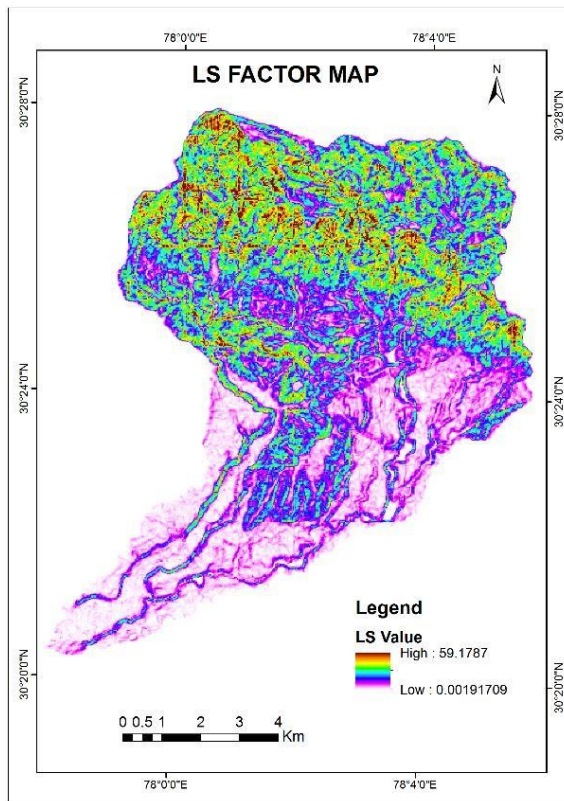
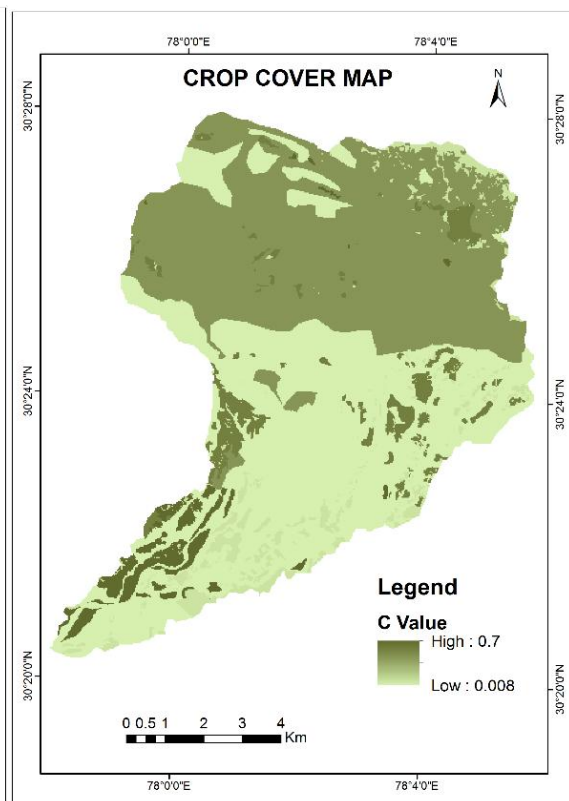


Fig. 12: Topographic (LS)



Factor Fig. 13: C Factor

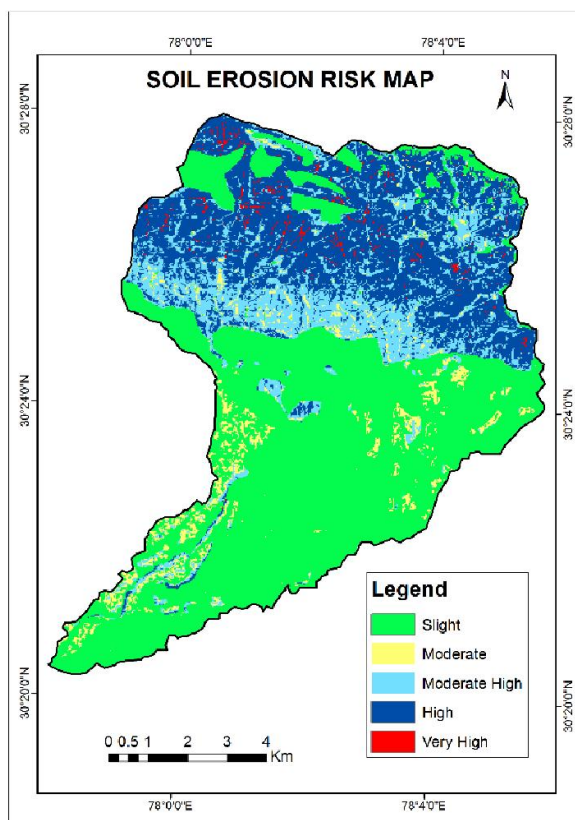


Fig. 14: P Factor

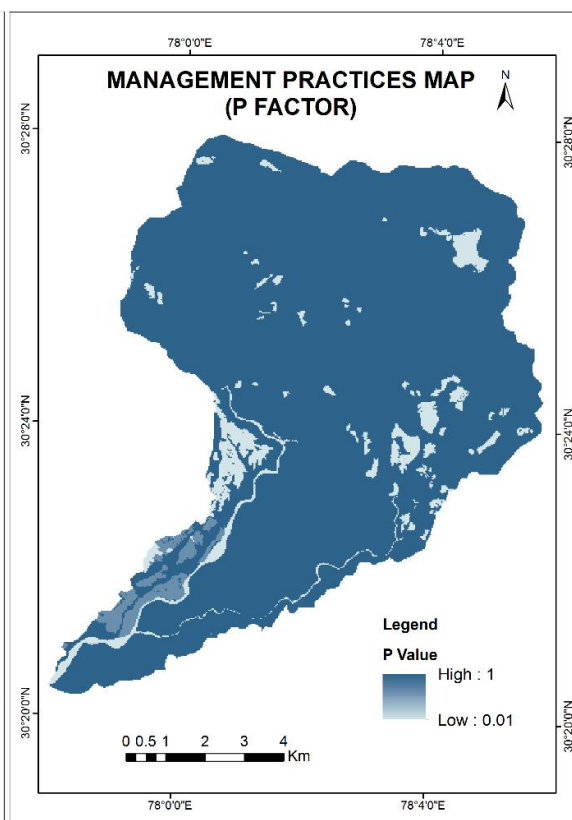


Fig. 15: Soil Erosion Risk

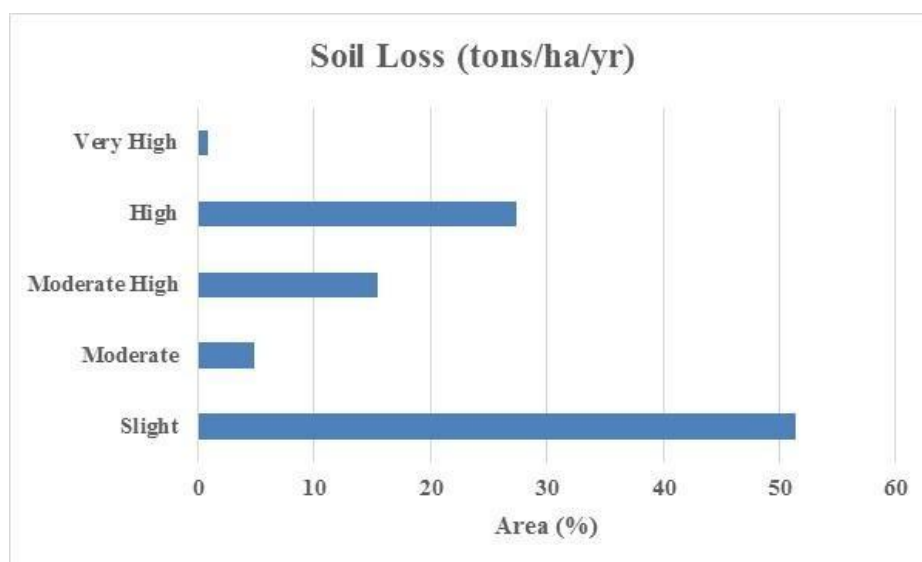


Fig. 17