Estimation Of Soil Erosion In Andhale Watershed Using USLE And GIS

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Abstract:-

To Estimate, the soil erosion in the Andhale watershed an integrated approach has been adopted using Universal Soil Loss Equation (USLE) model and geographic information system (GIS) techniques. Supporting agricultural production and resource management requires knowledge of soil loss [8]. Soil erosion has been accelerated as a result of deforestation, bad farming practices, and unrestrained grazing. The USLE model required the integration of thematic factor maps, including those for rainfall erosivity, slope length and steepness, vegetation cover, soil erodibility, and erosion control. Practices differ significantly across various climatic zones, soil properties, slopes, land cover, and crop phases. This study's objectives included identifying the spatial distribution of soil loss, analyzing the impact of land use and slope exposure on soil erosion, and assessing the use of GIS and USLE to identify soil loss.

The annual rainfall data for the research area had been used to calculate the rainfall erosivity factor. Topographic factors (LS) were created using the DEM of the study area. The land uses land cover map was used to determine the value of the cover management factor and the support practice factor. The soil erodibility map was then created by assigning K-factor values to the various soil types based on soil texture and electrical conductivity.

KEYWORDS:

Q-GIS, USLE, Andhale Watershed, Landsat, Soil erosion, GIS .

1 INTRODUCTION

One of the biggest issues on the planet is soil erosion, which has an impact on agricultural land by reducing its top fertility [2]. Most of the development depends on industrialization and agriculture [2]. The impact of water detaches and removes soil particles over time, causing the soil to deteriorate gradually [3]. The hydrologic cycle is connected to the naturally occurring process of soil erosion, which is a common geological event [3]. Soil is under threat of erosion, it is one of the most essential resources of humankind [7]. It depends on a variety of elements, including the slope's steepness, the climate, the use and cover of the land, and ecological disasters like forest fires [7]. The status of the soil is mostly determined by erosivity, erodibility, and land use management strategies [7]. Areas with a high percentage of vegetation are less likely to experience soil erosion because topography regulates soil movement in a watershed [7]. Land deterioration brought on by soil erosion affects more than 50% of India's total land area [5]. Every year, more than 75 billion tons of soil are lost to erosion from agricultural land around the world [5]. Two models, a physical model, and an empirical model, are used to calculate the quantity of soil erosion. The spatial input data for the empirical model is provided by GIS and remote sensing (RS), which also forecasts the probable soil erosion rate. Several experts throughout the world have studied soil erosion using various types of models. The Universal Soil Loss Equation (USLE), created by Wischmeier and Smith in 1965 for assessing soil erosion, is the most widely used empirical model [7]. Using the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation, the mean annual soil loss information per unit of the land area may be determined (RUSLE) [8]. The goal of the current study is to use the USLE model to estimate soil erosion in andhale village.

2. STUDY AREA

Andhale watershed, a rural watershed in the Maharashtra state of India, with a total watershed area of about 54.78 KM SQ. The landscape of the area is undulating, with occasional hills, straight ridges, and plains. The watershed is located in the tropical wet and dry climate zone between latitudes 5^0 to 20^0 [5]. Rainfall primarily occurs in one season (i.e., this sort of climatic zone) whereas the other seasons are dry.

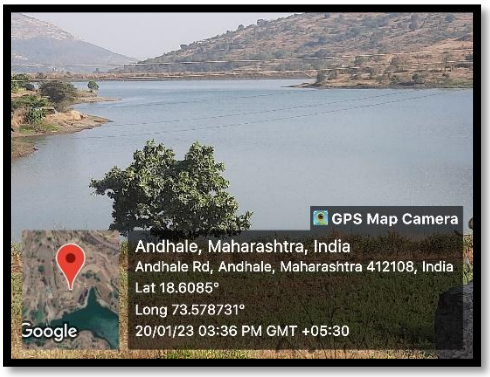

Table-1: Data Collection

Rainfall Data	https://power.larc.nasa.gov/data-access-viewer	Rainfall data for a period of 30 years.
Soil Data	Collecting Soil Samples	Soil Data
Satellite Images	https://bhuvan.nrsc.gov.in/	Carto DEM(30m Resolution)
Digital Elevation Model	https://bhuvan.nrsc.gov.in/	Carto-DEM (30m Resolution)

3. EXPERIMENTATION

3.1 Soil Erosion Estimation Model

To calculate annual soil loss, The USLE model has been used and the equation is as follows:-

A= R*K*LS*C*P

Where,

A= Average annual soil loss (ton/ha/year)

R= Rainfall erosivity factor

K= Soil erodibility factor

LS= Slope and length factor

C= Land cover and land use factor

P= Support and conservation practices factor

3.2 Rainfall erosivity (R)

The erosive strength of runoff that causes soil erosion is expressed quantitatively as the "R-factor." Using the kinetic energy of the rain as a foundation, the erosivity of rainfall is measured. The value of the R factor likewise rises as rainfall intensity and duration increase. According to the rainfall erosivity value, R-value is higher where rainfall intensity is observed to be greater and vice versa. The Excel file with the R factor value and the latitude and longitude of the rain gauge station has been created in order to create an R factor map.

The NASA data access portal was used to collect the 30-year historical monthly rainfall data. The R-factor calculates how much rain contributes to erosion.

The Andhale watershed experiences less rainfall because it is located in a tropical wet and dry environment between 5 and 20 degrees latitude. Rainfall typically occurs in one season in this type of climate zone, but the other seasons are dry. Hurni (1985) adopted a model based on the easily accessible information on that region's yearly average rainfall [4]. The equation is written as follows:

$R = -8.12 + (0.562 \times P)$

Where,

R= Rainfall Erosivity Factor

P= Average annual rainfall intensity.

3.3 Crop Management Factor (C)

According to the situation, the primary factors that directly affect human action and determine whether erosion will increase or decrease are plant cover and farming methods [3]. The ratio of soil loss from a field with a particular vegetation cover to the corresponding soil loss from continuous fallow with the same rainfall is what determines how much soil is lost (Wischmeier & Smith). The land use and land cover classification map was thus utilized in this investigation. The study region displays thorough classification of land use and land cover. The recommended C-factor values were assigned using the categorized map for various land use and land cover classes. The crop management factor (C) is dependent on data about the research area's land use and cover [1]. The study region has been divided into four different land use classifications, including aquatic bodies, vegetated areas, and bare ground.

3.4 Conservation Practice Factor (P)

The conservation practice factor (P) measures the difference between soil loss caused by certain support practices and soil loss caused by uphill and downhill cropping. There are no significant conservation efforts in the study region [1]. According on the region's greatest length and slope, different researchers have assigned different values for P. based on maximum length and the percentage of slope. P-factor values were set at 0.6 for paddy agriculture areas and 0.9 for other areas [1]. The figures are based on those recommended by the overview of the RUSLE model [4].

3.5 Soil Erodibility (K) Factor

The physical information needed to estimate soil erodibility was gathered by taking soil samples from the study region. The texture of the soil samples was examined. electrical conductivity and (sand, silt, and clay concentrations). Then, based on soil texture and electrical conductivity, the K-factor values of the various soil types were assigned, creating the soil erodibility map [3].

The soil erodibility factor (K-factor) measures both the rate of flow and the susceptibility of the soil to erosion. In 1978, Wischmeier and Smith created a formula to calculate the K-factor. The following formula is used to calculate the K-factor:

Soil Erodibility:- $K = 311.63 - 4.48 \times (SG\% + S\%) + 613.4 + 6.45 \times EC$

Where,

SG = C Coarse sand content (%)

S = Sand content (%)

EC = Electrical conductivity.

3.6 Topographic factor (LS)

According to the length and steepness of the slope, erosion is influenced by topography and is indicated by the LS factor [3]. Using the DEM as a starting point, the Q-GIS software created the LS-factor map [3]. By reformulating its topographic factor, the RUSLE model can be used to analyze the susceptibility of soils to erosion on a broad scale, such as those in basins. This will improve its representation in the scale of the basin, and the DEM can be utilized to obtain the accumulated flow and slope map.

4.RESULTS AND DISCUSSION

4.1 Rainfall Erosivity Factor (R) :-

In MJ mm/ha/h/ year, the R-factor calculates the effect of rainfall on erosion. R factor values have been produced by using the IDW interpolation method in the Q-GIS 3.18 software. For the study watershed region, the R-factor values ranged from 904.03 – 928.51 MJ mm/ha/h/ year.

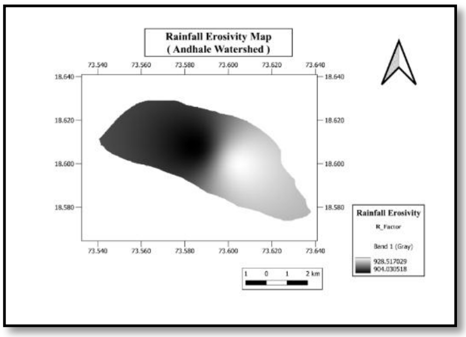

Fig-1.Rainfall Erosivity Map

4.2 Slope and length (Topographic) factor (LS)

The slope of an LS-factor analysis map shows that the higher LS-factor values (34.61) in the study, watershed have been found close to the slope. LS factor values for the study area vary from 0.03 to 34.61.

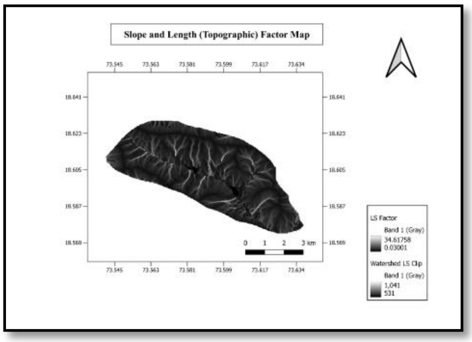

Fig-2. Slope and Length Factor (Topographic Factor) Map

4.3 Crop management factor. (C)

Built-up areas, barren land, vegetation, and water body were the principal land uses and covers of the watershed that were identified via supervised image classification. A large portion of the watershed's lower catchment is made up of barren land. so the watershed's highest C-factor value is found here (1.0) [8]. While a large portion of the watershed's upper catchment is made up primarily of water bodies with a C-value of 0.00.

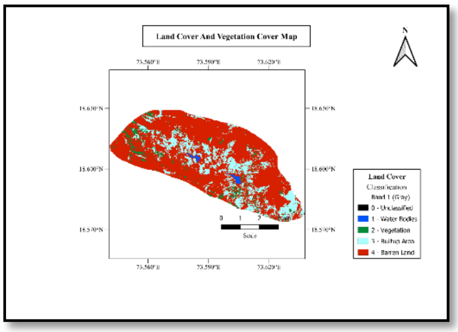

Fig-3. Land Cover / Vegetation Cover Map

Land use and land cover class	C Value
Water Bodies	0.00
Vegetation	0.030
Built up Area	0.00
Barren Land	1.00

Table- 2. C Factor Values

4.4 Conservation practice factor (P)

The value of the P-factor ranges from 0.6 to 0.9 depending on the current land management technique used in the research region. The slope steepness conditions have a significant influence on the P-factor values.

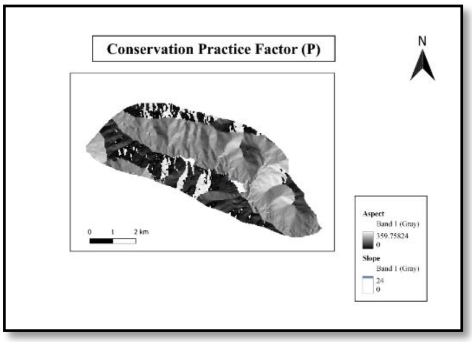

Fig-4. Conservation practice factor map.

Land Slope Percentage (%)	P value
1-2	0.6
3-5	0.5
6-8	0.5
9-12	0.6
13-16	0.7
17-20	0.8
21-25	0.9

Table- 3 P values

4.5 Soil Erodibility Factor (K).

As a result, the watershed's K-factor erodibility varied between 0.174 and 0.264. It was higher in the watershed's downstream region, where runaway and arid lands were located. Arable ground without any tree cover is visible in the watershed's upstream portion. Therefore, soil erosion has a significant impact on these soils.

4.6 Average Annual Soil Loss (A)

Using Q-GIS spatial analyzer, the five USLE factor maps were overlaid to perform the erosion risk assessment in the Andhale watershed. In the Andhale watershed, annual soil loss ranged from 11.16 to 60.11 tons/ha/year.

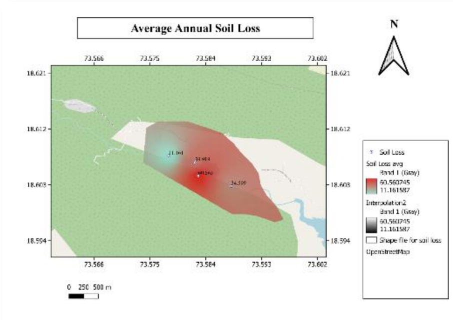

Fig. 5 Soil Erosion Map of Andhale Watershed.

5. CONCLUSION

Humanity is at risk from soil erosion, which is also expected to have an impact on the overall economy of nations with an agriculture-based economy, such as India. Although it is exceedingly challenging to completely halt soil erosion, it is possible to lessen it if the reasons and the rate of erosion are understood. The conservation of soil and water in the watershed may be aided by decreased erosion. This study aims to investigate, quantify, and pinpoint the major causes of erosion. The USLE model has been used to estimate soil erosion from the research region in the current study. In Q-GIS, various maps depicting the spatial distribution of various components R, LS, P, and C have been created, and K has been manually estimated.

1. The Topographic/Slope and Length (LS) factor ranges from 0.030 to 34.617, the Rainfall erosivity (R) factor ranges from 928.51 to 904.03 MJ mm/ha/h/year, and the C factor ranges from 0.00 to 1.00.

2. The support and practice factor (P) ranges from 0.6 to 0.9, and the soil erodibility factor (K) ranges from 0.174 to 0.264 tons h/MJ/mm.

3. The range of the annual average soil loss is from 11.1611 to 60.5650 tons/h.

4. The 11 t/h/year soil loss tolerance upper limit. The seriously impacted area, on the other hand, exhibits a soil loss rate of greater than 50 t/h/year. In our example, the yearly soil loss ranges from 11.161 to 60.565 t/h/year on average

The Andhale watershed's soil erosion has been targeted with the following necessary actions.

• Keeping up a robust perennial plant cover.

• Spreading wood chips, crushed stone, and other such materials in heavily trafficked areas where it is difficult to develop and sustain vegetation.

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