SOIL EROSION AND RAINFALL-RUNOFF MODELLING USING REMOTE SENSING AND GIS TECHNIQUE OF PAGLADIA WATERSHED IN ASSAM

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By
AKIB JAVED RAHMAN
Roll No: PG/C/23/20
ASTU Registration No: 307909119
ASTU Roll No: 230620061002

Under the Guidance of
DR. UTPAL KUMAR MISRA
Professor, Assam Engineering College
Department of Civil Engineering

ASSAM ENGINEERING COLLEGE
JALUKBARI, GUWAHATI-13, ASSAM

DECLARATION

I hereby declare that the work presented in this report entitled "**SOIL EROSION AND RAINFALL-RUNOFF MODELLING USING REMOTE SENSING AND GIS TECHNIQUE OF PAGLADIA WATERSHED IN ASSAM"** in the partial fulfilment of the requirement for the award of the degree of Master of Technology in Civil Engineering with specialization in Water Resources Engineering submitted in the Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati-13 under Assam science and Technology University, is a real record of my work carried out in the said college under the supervision of Dr Utpal Kumar Misra, professor, Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati-13, Assam.

Do hereby declare that this project report is solemnly done by me and is my effort and that no part of it has been plagiarized without citation.

Date:

Place:

AKIB JAVED RAHMAN
M. Tech 3rd Semester
Roll No: PG/C/23/20
Department of Civil Engineering
Assam Engineering College
Jalukbari, Guwahati-781013

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Date:

Place:

DR. UTPAL KUMAR MISRA
Professor
Department of Civil Engineering
Assam Engineering College
Jalukbari, Guwahati-781013

CERTIFICATE

This is to certify that the work presented in this report entitled "**SOIL EROSION AND RAINFALL-RUNOFF MODELLING USING REMOTE SENSING AND GIS TECHNIQUE OF PAGLADIA WATERSHED IN ASSAM**" is carried out by Akib Javed Rahman, Roll No: PG/C/23/20 , a student of M. Tech 3rd semester, Department of Civil Engineering, Assam Engineering College, under my guidance and supervision and submitted in the partial fulfilment of the requirement for the award of the Degree of Master of Technology in Civil Engineering with specialization in Water Resources Engineering under Assam Science and Technology University.

Date:

Place:

DR. UTPAL KUMAR MISRA
Professor
Department of Civil Engineering
Assam Engineering College
Jalukbari, Guwahati-781013

CERTIFICATE FROM HEAD OF THE DEPARTMENT

This is to certify that the project report entitled "**SOIL EROSION AND RAINFALL-RUNOFF MODELLING USING REMOTE SENSING AND GIS TECHNIQUE OF PAGLADIA WATERSHED IN ASSAM**" has been submitted by AKIB JAVED RAHMAN, bearing Roll No: PG/C/23/20 , a student of M.Tech 3rd Semester, Water Resources Engineering (Civil Engineering Department), Assam Engineering College, in partial fulfilment of the requirements for the award of the degree of Master of Technology in Water Resources Engineering of Assam Science & Technology University.

Date:

Place:

DR. JAYANT A PATHAK
(Professor & Head of the Department)
Department of Civil Engineering
Assam Engineering College
Guwahati-78101

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:

Date

Place:

AKIB JAVED RAHMAN

M.Tech 3rd Semester

Department of Civil Engineering

Assam Engineering College

Jalukbari, Guwahati-781013

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CHAPTER 1

INRODUCTION

1.1 GENERAL

The Brahmaputra, a trans-boundary river that flows through Tibet, northeast India, and Bangladesh and is the ninth-largest river in the world in terms of discharge and the fifteenth-longest river overall, has long been the region's lifeblood. The 220- mile-long Brahmaputra River, is regarded as having the Pagladiya river, known for flash floods and high discharge rate. The northern and southern tributaries differ considerably in their hydro-geomorphologic characteristics owing to different geological, physiographic and climatic conditions.The north bank tributaries flow in shallow braided channels, have steep slopes and carry a heavy silt charge. On the other hand, tributaries on the south bank have a flatter gradient and deep meandering channels with alluvial soils in the bed and bank materials. Consequently, it is essential to investigate the tributaries that, in turn, influence the Brahmaputra River's total discharge.

In the Indian state of Assam, the Pagladiya River flows into the Brahmaputra River from its northern bank. Prior to joining the Brahmaputra River, the Pagladiya river travels through the districts of Baksa and Nalbari after rising in the Bhutanese hills. The Pagladiya River is perennial, extremely shallow, and infamous for its high discharge rates and flash floods.The upper portion of the Pagladiya River is chosen as the study area for the current study taking into consideration the land and data issues. The study region is located between 26°27'01.75"N and 26°45'9.289" N latitude, or 91°27'36.22" E to 91°34'45.757" E longitude. The Pagladiya river is a rainfed river, water flow in the river was very high during monsoon season while the river become almost devoid of water during winter season.

Basin models are essential for assessing water resources, examining streamflow quality and quantity, controlling water distribution systems, safeguarding and developing groundwater systems, protecting against flooding, and forecasting water supply.

The well-known empirical technique, the Revised Universal Soil Loss Equation (RUSLE) when used in conjunction with GIS and remote sensing, may effectively illustrate the geographic variance of long-term average soil loss on both a large and small scale.To use successful management solutions, it is necessary to quantify and thoroughly examine the scope and severity of the soil erosion issues. Additionally, it is crucial to have a map of a watershed or region's soil erosion that is spatially distributed. In order to improve planning for irrigation and soil conservation, it assists in identifying the potential for soil erosion at various places and, consequently, assists in implementing the necessary safety measures to reduce it (Tiwari et al., 2016).

The Pagladiya is a northern bank tributary of the Brahmaputra river in the Indian state of Assam. The perennial, shallow Pagladiya River is renowned for its flash floods and high discharge rates, which result in flooding downstream. The water body investigation was the Pagladiya river, which runs through the lower portion of its annual course but receives very little water during the summer month. Along with the rainfall, the change in land use and land cover that has occurred in the Pagladiya basin has had an impact on deforestation to increase agricultural productivity. This causes the infiltration rate to drop and the surface runoff to rise. Assam has been experiencing floods ever since time in a immemorial. Floods usually happen between June and August due to heavy monsoon rains making the flood situation in places more worse. Water scarcity, hydro meteorological extremes and water pollution are major environmental threats affecting the biotic/abiotic, status of surface and groundwater resources in river basins within them, through the disturbance of the ecosystem services that people rely on. In such a case, to combat environmental problems and mitigate the impact of future climate and socio-economic changes on water resources, hydrologic river basin models are valuable tools.

Thus, to estimate the possible flood problems created by the river, it is essential to develop a proper rainfall runoff model to simulate the runoff from the river. Also soil erosion estimation is important to monitor the effect watershed on river water.

1.2 OBJECTIVE OF THE STUDY

- To estimate the annual soil loss of Pagladia watershed using RUSLE.
- To analyse the impact of land cover change on sheet erosion of Pagladia watershed in Assam.
- To simulate the Runoff of Pagladiya river using HEC-HMS rainfall runoff model.

CHAPTER 2

LITERATURE REVIEW

Arekhi (2012) used the HEC-HMS model to identify the various evaluation techniques for runoff losses (Green and Ampt, Initial and Constant Loss Rate, and Deficit and Constant Loss), taking into account several objective functions (percent error in peaks and volumes). Accordingly, the approach with the smallest difference between the % of observed and simulated discharges is given first preference based on objective functions, while other methods are given second preference. Results indicated that the Initial and Constant Loss Rate approach performed better than the Green and Ampt method in six events, with four events fitting with percent error in peak and five events fitting with percent error in volume.

Fleming et al., (2013) simulated the precipitation-runoff processes in dendritic watershed systems' precipitation-runoff processes by HEC-HMS. It is intended to be useful for solving a wide variety of problems in a wide range of geographical contexts. This encompasses runoff from small urban or natural watersheds to major river basin water supply and flood hydrology. For studies of water availability, urban drainage, flow forecasting, the impact of future urbanization, reservoir spillway design, and flood damage mitigation, floodplain regulation, wetlands hydrology, and system operation, hydrographs generated by the program can be used directly or in conjunction with other software.

Wischmeier & Smith, (1978) (Kinnell, 2010) developed the most popular models for calculating long-term average yearly soil loss and for planning soil and water conservation are the Universal Soil Loss Equation (USLE) and its revised version i.e. Revised Universal Soil Loss Equation (RUSLE).

Beskow et al., (2009) combined USLE and GIS in order to calculate probable soil loss from the Grande River Basin in Brazil (6273 Km^2). The ability to identify the regions most vulnerable to water erosion was made possible by their results, which demonstrated sufficient precision.

Biswas and Pani (2015) combined the Revised Universal Soil Loss Equation model with geographic information systems. The GIS platform's overlay of the factors for soil erodibility, length of slope, steepness of slope, management of cover, and support and conservation techniques leads to a significant amount of soil loss in the research region. High soil loss in the basin's upstream region is closely related to the LS and K factors as well as the drainage density. The capacity of reservoirs has been reduced in both dead and living storage space as a result of soil loss in the upper catchment areas. The influence of soil erosion on plateau fringe areas is concluded, and estimating soil loss is a crucial component of effective land use planning and development plans.

Ganasri and Ramesh (2016) assessed soil loss using the Revised Universal Soil Loss Equation (RUSLE), which was integrated with GIS and used in the Nethravathi Basin in southwest India. Remote sensing data were used to estimate RUSLE model parameters, and GIS was used to identify the zones where erosion is most likely to occur. In order to prevent soil erosion in the Nethravathi Basin, the results can undoubtedly help with the application of soil management and conservation methods.

Jaiswal et al., (1999) examined remote sensing technology for the changes in land use and land cover over a 30-year period in a section of Madhya Pradesh's Shahdol district's Gohparu block. Maps of land usage and land cover were created by visually interpreting data from two time periods from remote sensing. It was discovered that 14 percent of the area had turned into wasteland, while the loss of vegetation cover was estimated to be 22 percent. It was discovered that the overall rate of change throughout this time was 1.8 percent every year.

Shalaby and Tateishi (2007) mapped land cover changes along Egypt's northwestern coast using maximum likelihood supervised classification and post- classification change detection algorithms using landsat data collected in 1987 and 2001, respectively.On each of the two images' six reflecting bands, a supervised classification was carried out using ground truth data. Using auxiliary data, observable interpretation, and expert knowledge of the area through GIS, the categorization results were significantly improved. These modifications to the land cover led to deterioration of the vegetation and water logging in a section of the study area.

Kaul and Sopan (2012) examined a land cover mapping and monitoring project in the research region, the Jalgaon District, in order to preserve the natural resources that are now available and to comprehend the causes and effects of overusing soil and water resources. In this study, the LULC (Land Use/ Land Cover) supervised classification method was applied to satellite photos. Seven LULC classes were chosen in order to classify things.

Jabbaret (2021) studies The Geographic Information System (GIS) to identify the geometric and hydrologist parameters. The Soil Conservation Service-Curve Number (SCS-CN) Method was adopted to estimate the rainfall losses while the Soil Conservation Service-Curve Number (SCS-CN) Method was used to transform the excess rainfall into a direct runoff hydrograph.

Rajput et al., (2021) simulated the rainfall runoff process in the Banjar river watershed, which is located between the Mandla and Balaghat districts of Madhya Pradesh, India, using the Hydrologic Modelling System (HEC-HMS) of the Hydrologic Engineering Centre. The sub-watersheds and river characteristics are generated using the CartoDEM as the input elevation. The Soil Conservation Service Curve Number (SCS-CN) approach simulates the rainfall-runoff process. Using performance evaluation measures such the Nash-Sutcliffe efficiency (NSE), the percent error in the peak, and the coefficient of determination (R2), the model's performance is evaluated. According to calibration and validation results, HEC-HMS can be used to predict the basin's hydrology, which will be useful for a variety of water and soil conservation measures.

CHAPTER 3

STUDY AREA

3.1 DESCRIPTION OF THE STUDY AREA

In the Indian state of Assam, the Pagladiya River flows into the Brahmaputra River from its northern bank. Prior to joining the Brahmaputra river, the Pagladiya river travels through the districts of Baksa and Nalbari after rising in the Bhutanese hills. The Pagladiya River is perennial, extremely shallow, and infamous for its high discharge rates and flash floods. The upper portion of the Pagladiya River is chosen as the study area for the current study taking into consideration the land and data issues.

The research area selected is located in the Assam state, The river has a total length of 196.80 kilometers. It originates in Southern Bhutan and it travels for 19 kilometers in Bhutan territory and then it enters Assam and flows to Nalbari & Baksa district for a length of 170.8 kilometer, before finally joining in the Brahmaputra river. The study region is located between

26°27'01.75"N and 26°45'9.289" N latitude,

91°27'36.22" E to 91°34'45.757" E longitude.

The Pagladiya river watershed has a catchment area of 389.37 km^2.

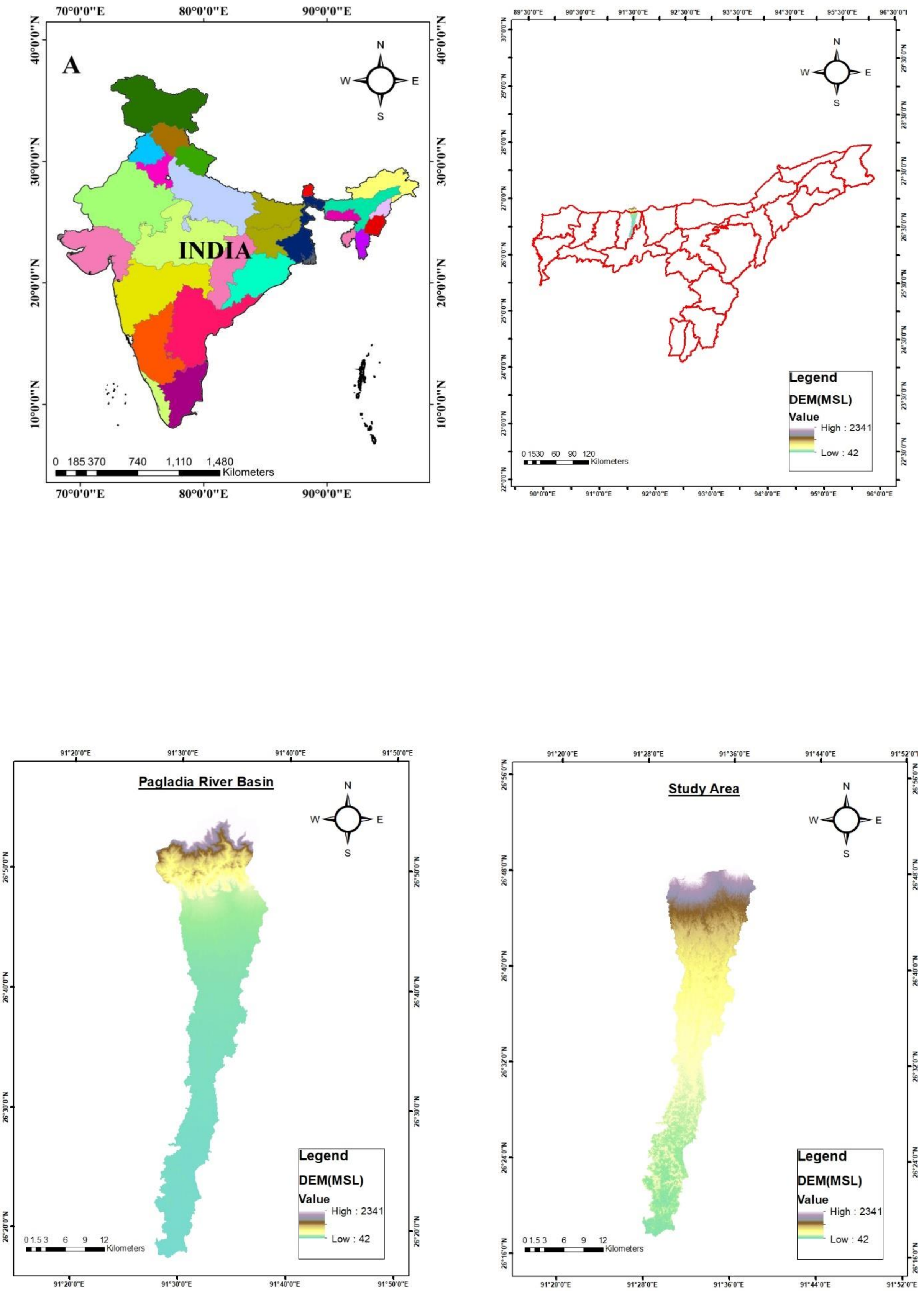


Fig 3.1 : Map Showing geographical location of study area

3.2 CLIMATE

The Pagladiya River is a rained river, water flow in the river was very high during monsoon season while the river become almost devoid of water during winter season.

The study region's mean maximum temperature from 2004 to 2017 was 29.1°C, with a maximum temperature of 34.52°C recorded in April of that year, while its mean minimum temperature from 2004 to 2017 was 20.3°C, with a minimum temperature of 9.56°C in January of that year. The month of April 2016 recorded the greatest mean annual wind speed of 5.78 m/s, while the month of January 2007 recorded the lowest mean annual wind speed of 0.38 m/s. At a height of 2 meters, the region's mean relative humidity has increased from 50.77% to 87.43%. Annual rainfall in the watershed ranges from 1586.07 mm to 2317.6 mm. All these above mentioned data haves been collected from NASA's Prediction of Worldwide Energy Resources (POWER).

3.2 TOPOGRAPHY

The research area's topography is located between 42 and 2341 meters above mean sea level (msl) as shown in Figures 3.2.

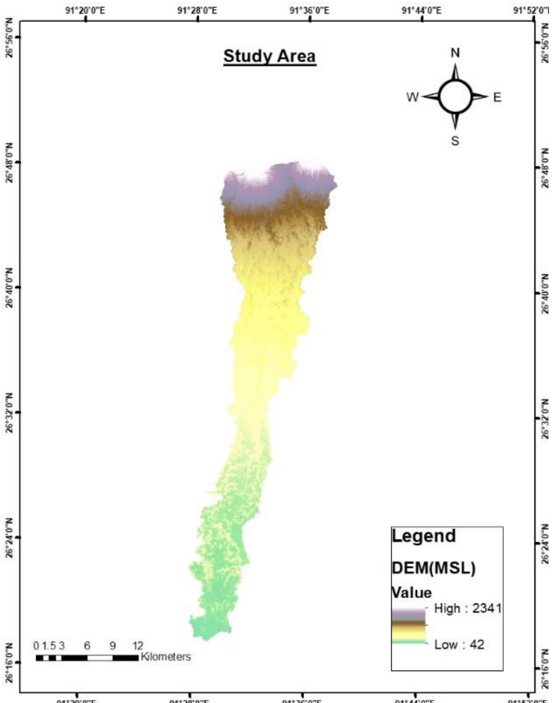


Fig 3.2: Digital elevation model of the study area

CHAPTER 4

METHODOLOGY

4.1 DATA USED AND SOURCE

Table 4.1 : Types of data and their sources used in the study

Sl. No.	Data	Details	Source
1.	Digital Elevation Model	SRTM 30 m resolution	USGS (https://earthexplorer.usgs.gov/)
2.	Rainfall Data	-	-
3.	Discharge Data	Daily Discharge data	-
4.	LULC Map	Landsat	Prepared in Arcgis using supervised classification
5.	Soil Map	1:500000	FAO

4.2 DIGITAL ELEVATION MODEL

Digital Elevation Models (DEMs) served as a representation of the research area's topological features. Depiction of the topographic surface of the Earth's bare ground of any surface structures, trees, or other items. A Digital Elevation Model (DEM) was generated from the shuttle Radar Topography Mission (SRTM) where 90 m resolution was used in this study and downloaded from USGS

4.3 LAND USE LAND COVER (LULC) MAP

Land use land cover (LULC) is also one important input data in any hydrological model. A GIS layer using ArcGIS for the Pagladiya River's land usage has been prepared via supervised classification.

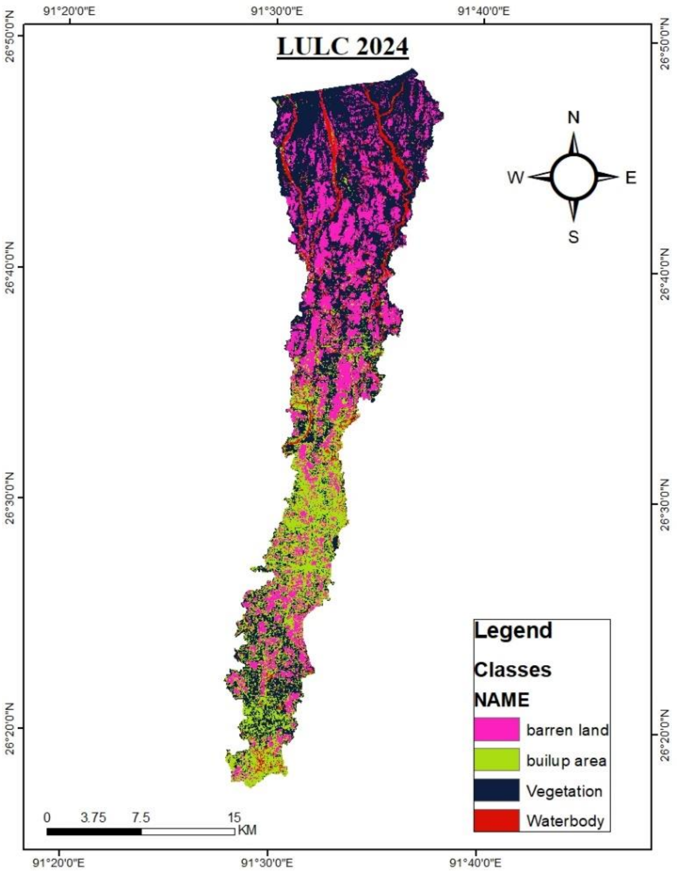


Figure 4.1 : Land use land cover map of Pagladia Watershed

4.4 SOIL CHARACTERISTICS:

In order to further evaluate and classify the types of soil data that was collected using a scale of 1:500000 from the International Food and Irrigation Organization (FAO). The soil map was created as a vector layer in a GIS system. For reclassification of the soil map, user soil database was referred from Map Windows SWAT 2012 interface. The nature of the soil is shown in the figure itself in Figure below. The soil Texture are Sandy Clay Loam , Sandy Loam, Loam in the watershed.

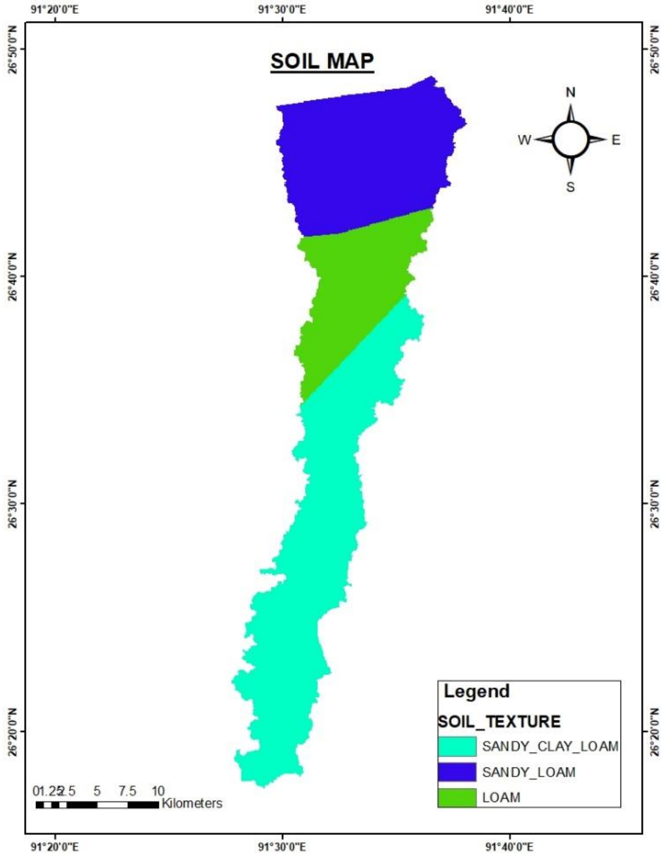


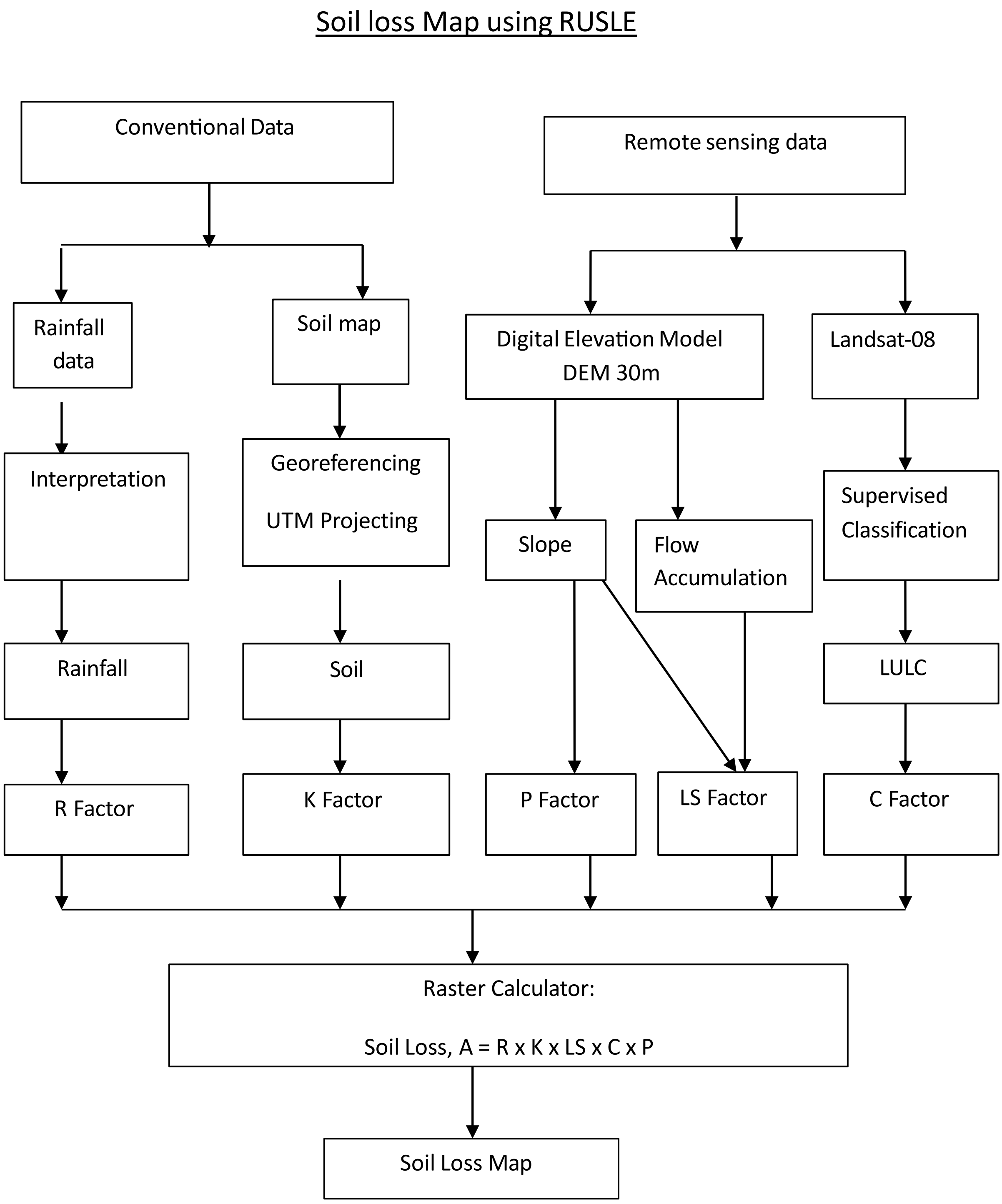
Fig 4.2 : Soil texture map of Pagladiya river basin

4.5 ESTIMATION OF SOIL LOSS FOR PAGLADIYA RIVER BASIN USING REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE)

The one of the popular models for calculating long-term average yearly soil loss and for planning soil and water conservation are the Universal Soil Loss Equation (USLE) and its revised version i.e. Revised Universal Soil Loss Equation (RUSLE) (Wischmeier & Smith, 1978) (Kinnell, 2010). The USLE method of calculating the slope length and steepness factor was originally applied at the unit plot and field scale, and the RUSLE extended this to the one-dimensional hill slope scale, with different Equations depending on whether the slope had a gradient of more than 9 % (Renard et al., 1997). USLE believed that runoff was uniform throughout the catchment whereas RUSLE better takes into account the fact that some runoff is funnelled into rills and gullies, (Renard et al., 1994). To forecast long-term annual averages of soil loss, RUSLE was created. For this purpose we have used methodology used in the estimation of soil loss has been presented in the following Flow Chart.

As the flow rate drops, sedimentation must also take place throughout the hydrograph's retreating section (Kim, 2006). The most effective erosion prediction model now in use that is simple to implement at the local or regional level is RUSLE. Additionally, several factors from DEM and LULC (land use land cover) from satellite images that can be easily linked with RUSLE include slope, aspect, etc. The RUSLE Equation's core structure hasn't altered, however several of the components have undergone changes.

4.5 FLOW CHART SHOWING THE METHODOLOGY OF SOIL LOSS ESTIMATION



4.6 REVISED UNIVERSAL SOIL LOSS EQUATION

The Universal Soil Loss Equation (USLE) determines soil loss at any given point as a function of rainfall energy and intensity, soil erodibility, slope length, slope gradient, soil cover, and conservation practices (Wischmeier and Smith 1978). The Revised Universal Soil Loss Equation (RUSLE) has the same form as the USLE, but includes revisions for slope length and slope gradient calculations, more elaborate calculations for soil cover and conservation practices (Renard et al. 1997). However, RUSLE can estimate only annual average soil loss from rill and interill erosion caused by rainfall splash and overland flow, but not from gully and channel erosion (Renard et al., 1997). Therefore, GIS methods are used to partition the areas into overland and channel types to estimate the soil loss in individual grid cells of overland areas.

The RUSLE is applied to the Pagladiya river Basin by representing the basin as a grid of square cells and calculating soil erosion for each cell. RUSLE (Wischmeier and Smith, 1978) compute the average annual erosion expected on field slopes using GIS, to partition the areas into overland and channel types which is expressed in the Equation as shown below-

$$\mathbf{A = R \times K \times LS \times C \times P} \quad \ldots\ldots\ldots\ldots\ldots\ldots..(4.1)$$

Where,

A= The average annual soil loss, usually on yearly basis (ton/ha-1/yr-1)

R = rainfall-runoff erosivity factor, the rainfall erosion index plus a factor for any significant runoff from snowmelt. (MJ mm/ha-1/h-1/y-1)

K = soil erodibility factor , the soil-loss rate per erosion index unit for a specified soil as measured on a standard plot, which is defined as a 72.6 ft (22.13 m) length of uniform 9% slope in continuous clean-tilled fallow. (t/ha/h/ha-1/MJ-1 mm-1)

LS = slope length factor, the ratio of soil loss from the field slope length to soil loss from a 72.6 ft (22.13 m) length under identical conditions. (dimensionless)

C = cover-management factor, the ratio of soil loss from an area with specified cover and management to soil loss from an identical area in tilled continuous fallow. (dimensionless)

P = support practice factor, the ratio of soil loss with a support practice like contouring, strip-cropping, or terracing to soil loss with straight-row farming up and down the slope. (dimensionless)

The parameters of RUSLE Equation were grouped into three classes, namely erosivity, erodibility and management factors. All these parameters were determined from geomorphological and rainfall characteristics.

Rainfall Runoff Erosivity Factor (R)

The rainfall erosivity factor (R) describes the erosivity of rainfall in an area based on the rainfall amount, intensity and reflects the effect of rainfall intensity on soil erosion. It quantifies the effect of raindrop impact and explains the amount and rate of runoff associate with Rainfall erosivity (R). The value of rainfall erosivity factor used in RUSLE must quantify the effect of raindrop impact and must also reflect the amount and rate of runoff likely to be associated with the rainfall. The rainfall erosivity factor is often determined from rainfall intensity if such data are available. In 1986, Morganh as multiplied the mean yearly rainfall by 0.5 as a general constant.

$$R=P*0.5 \text{ --------------------(4.2)}$$

Where, P = the available mean annual rainfall data.

Morgan and Davidson (1991) used this model once more in Ivory Coast and Burkina Faso for their study. Joshi et al. (2016) employed this model in India for their research in the north of Pune, Maharashtra. Dahe and Borate (2015) also used this approach on Maharashtra's Kaas Plateau.

Singh (1981) created a different R factor model, which is as follows:

$$R=79+0.363\ AAP \text{ ------------------(4.3)}$$

Where,

R=Rainfall erosivity factor,

AAP is the average annual precipitation in mm.

SOIL ERODIBILITY FACTOR (K)

The ease with which soil is separated by splash during rainfall, by surface movement, or by both is referred to as soil erodibility. The soil-erodibility factor (K), also known as soil erodibility, measures the combined impact of rainfall, runoff, and infiltration on soil loss. The influence of soil characteristics on soil loss during storm occurrences on upland areas is taken into consideration by the soil-erodibility factor (K) in RUSLE. The rate of soil loss per rainfall erosion index unit [ton. acre. h (hundreds of acres. ft-ton. in)-1] as measured on a unit plot is known as the soil erodibility factor (K). The unit plot is 72.6 feet (22.1 meters) long, slopes at 9%, and has been continually left in a clean-tilled fallow condition with tillage done both uphill and downhill (Wischrneier and Smith 1978).For situations when the silt fraction does not exceed 70%, the nomograph can be approximated algebraically using (Wischmeier and Smith 1978).

$$K= [2.1 - 10-4(12-OM)\ M1.14+3.25(s-2)+2.5(p-3)] / 100 \text{ -----------(4.4)}$$

OM = Percent Organic Matter where

M is the product of the major fractions of particle sizes. (percentage of modified silt, or the 0.002-0.1 mm size fraction)

s = Structure classes

p = Permeability of the soil

K is represented as ton.acre-1 per erosion index unit using ton.acre.h (hundreds of acre.ft-ton.inch) units that are usual in the United States. Its SI unit is expressed in t.ha.h.ha—1 MJ-1mm-1.

There is also an Equation for estimating K-factor values given by Wiliams (1995)

$$\mathbf{K= f_{csand}*f_{cl\text{-}si}*f_{orgc}*f_{hisand}} \text{ ---------------------------------------(4.5)}$$

where,

f_{csand} is a factor, that lowers the k indicator in soils with high coarse-sand contents and higher for soils with little sand;

$f_{cl\text{-}si}$ gives low soil erodibility factors for soils with high clay-to-silt ratios;

f_{orgc} reduces K values in soils with high organic carbon content, while

f_{hisand} lowers K values for soils with extremely high sand content:

fcsand = {0.2+0.3*EXP[-0.256*ms*(1-m$_{silt}$/100)]}

$$\boldsymbol{f_{cl-si} = (\frac{m_{silt}}{mc+m_{silt}})^{0.3}}$$

$$\boldsymbol{f_{orgc} = \left(1 - \frac{0.25 * orgC}{orgC + \exp[3.72 - 2.95 * orgC]}\right)}$$

$$f_{hisand} = (1 - \frac{0.7 * \left(1 - \frac{m_s}{100}\right)}{\left(1 - \frac{m_s}{100}\right) + \exp\left[-5.51 + 22.9 * (\left(1 - \frac{m_s}{100}\right)\right.}$$

where:

ms– the sand fraction content (0.05-2.00 mm diameter) [%];

msilt – the silt fraction content (0.002-0.05 mm diameter) [%];

mc– the clay fraction content (<0.002 mm diameter) [%];

orgC – the organic carbon (SOC) content [%].

The Equation 4.5 has been used to prepare the Soil Erodibility Factor (K)map for our study area.

The K factor is a number that ranges from 0 to 1, with values closer to 0 being less susceptible to soil erosion.

Slope length and Steepness Factor (LS)

L factor and S factor are usually considered together to combine the effect of slope and slope length, which basically reflects the terrain on a given site. In this study an approach developed by Moore and Burch (1986) is used to compute LS factor. Moore and Burch (1986) proposed a unit stream power based physical LS factor.

According to them if the USLE is to be applied to real-world catchments, whether they are large or small, then it is recommended that the length-slope factor derived from unit stream power theory be used rather than the original Equation given by (Wischmeier and Smith 1978). This allows a greater range of topographic attributes (slope, slope length, and catchment convergence) and rilling to be explicitly accounted for within the soil loss calculations (Moore and Burch, 1986). The LS factor as proposed by them was

$$LS = (\frac{\text{SLOPE LENGTH}}{22.13})^{0.4} * (\frac{0.0174\sin\theta}{0.0896})^{1.4}$$

Where,

slope Length is Flow accumulation *cell resolution (DEM) and

θ is "Slope in Degree"

Flow accumulation can be derived from DEM using spatial analyst tool in ArcGIS. At first the DEM has to be filled and then flow direction has to be performed. Using Flow Direction as an input Flow Accumulation can be derived in ArcGIS. Slope angle θ, for each grid can be found by using the Spatial Analyst tool in ArcGIS.

To compute LS factor using DEM in arc Map following stems were used:-

1. Calculate Fill sinks

2. Calculate flow Direction using Fill sinks data as the input raster

3. Calculate flow accumulation using flow direction data as the input raster

4. Calculate slope of watershed in degree using DEM (Digital Elevation Model)as the input layer(Arc Map spatial Analyst Tools Surface Slope)

5. Write the LS-factor formula below in Arc Map spatial Analyst Tools Map Algebra Raster Calculator

Cover Management Factor (C)

The next crucial element that regulates the risk of soil erosion is vegetation cover.The cover and management (C) factor reflect the effect of LULC, cropping and management practices on the rate of soil erosion, and it is the ratio of soil loss from land covered by vegetation. The cover management element in the Revised Universal Soil Loss Equation takes into account the impact of vegetation cover. According to Wischmeier and Smith (1978), it is the proportion of soil loss from land that has been farmed under certain conditions to the same loss from clean-tilled, continuous fallow. According to Oliveria et al. (2015)b and Wischmeier & Smith (1978), this factor is a non-dimensional number between zero and one that indicates a rainfall erosivity-weighted ratio of soil loss from land under specified, vegetated conditions to the analogous loss from continuous bare fallow.

Rao (1981) then used the USDA-SCS (1972) idea to determine the cover management factor in the context of India. This idea was applied by Tirkey et al. (2013) to the Daltonganj watershed in the Palamu district of Jharkhand. This table was adopted by Chatterjee et al. (2014) for the Upper Subarnarekha River Basin in Jharkhand. The model was utilized by Joshi et al. (2016) for their investigation in the Maharashtrian region of Pune. The C-values were used in the present study proposed by Kim et al., (2005).

Support Practice Factor (P):

Support practice indicates the rate of soil loss according to the various cultivated lands on the earth. There are contour farming, strip cropping and terrace as a method and as an important factor that can control the erosion.

CHAPTER 5

RESULTS AND DISCUSSION

This chapter presents the soil erosion estimation using RUSLE of Pagladiya watershed. Elaborative findings and a discussion of the land use/land cover in the Pagladiya river basin are also included in this chapter.

5.1 Delineation of Watershed

The delineation of watershed is done in ArcMap 10.4 . Shuttle Radar Topography Mission (SRTM) digital elevation model of 30m x 30m resolution was used downloaded from USGS earthexplorer (https://earthexplorer.usgs.gov/) . Then the Tiles is downloaded in which the study area is lied as shown in the figure below.

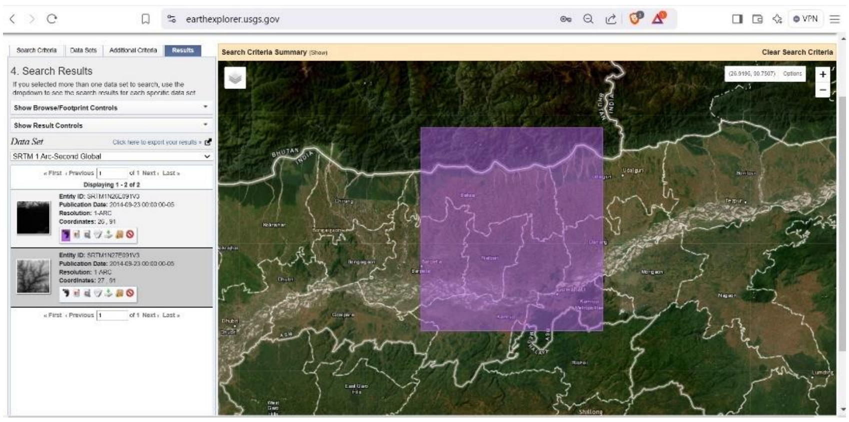


Fig 5.1 : Figure Showing USGS interface

After downloading, import the DEM file in ArcMap and fill it.

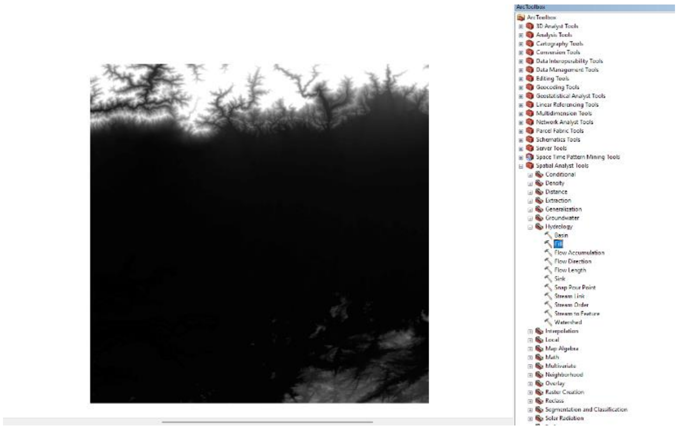


Fig 5.2 Fill of DEM

After filling Flow direction has been done.

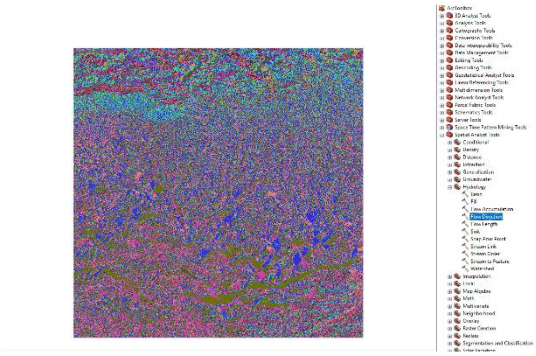


Fig 5.3 Flow direction done in Arctool box

After that Flow Accumulation has been done.

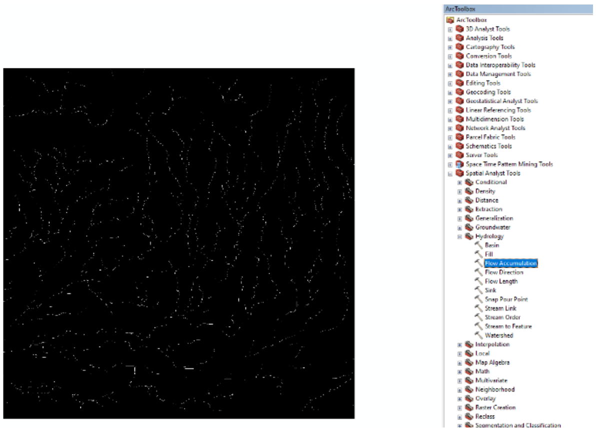


Fig 5.4 Flow Accumulation

After Flow Accumulation identify the outlet point and then go to watershed in arc toolbox.

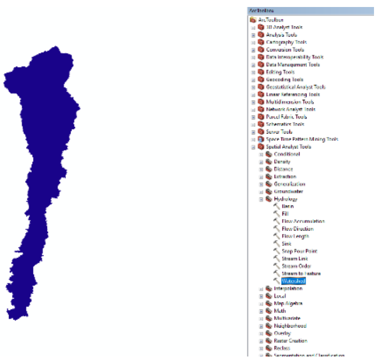


Fig 5.5 : Watershed delineated in raster

The in conversion Convert from rater to polygon.

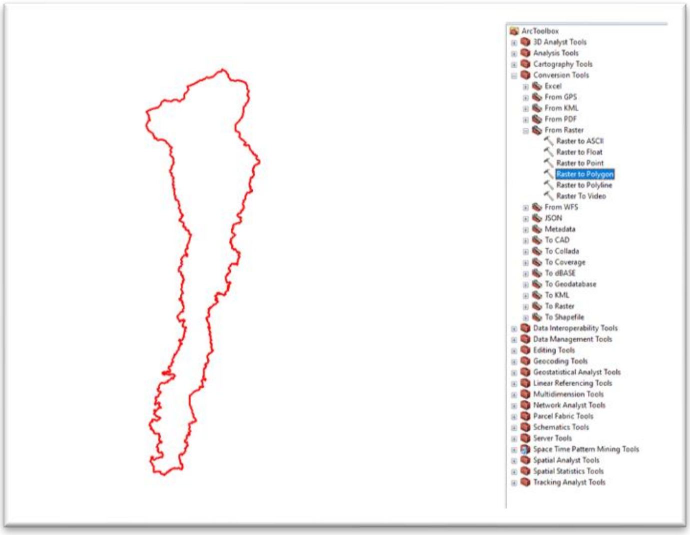


Fig 5.6 : Watershed in polygon form

Fig 5.7 : Clipping the Watershed against Assam

5.2 LAND USE LAND COVER (LULC) MAP

Land use land cover (LULC) is also one important input data in any hydrological model. A GIS layer using ArcGIS for the Pagladiya River's land usage has been prepared via supervised classification.

First two Landsat 8 image has been downloaded from USGS earthexplorer . The landsat image are those as shown in the figure. Our study area is lies in this landsat image.

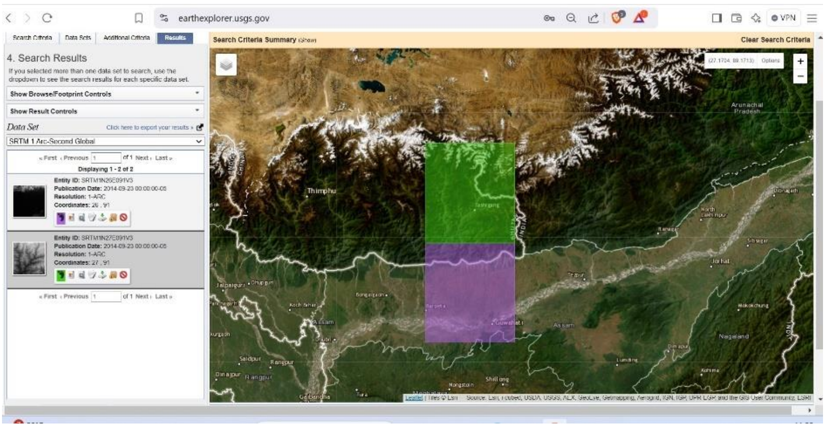


Fig5.8 : Landsat image downloaded from USGS

After downloading the Landsat image those are imported in ArcMap 10.4 . First have to import the 7 bands from one Landsat image.

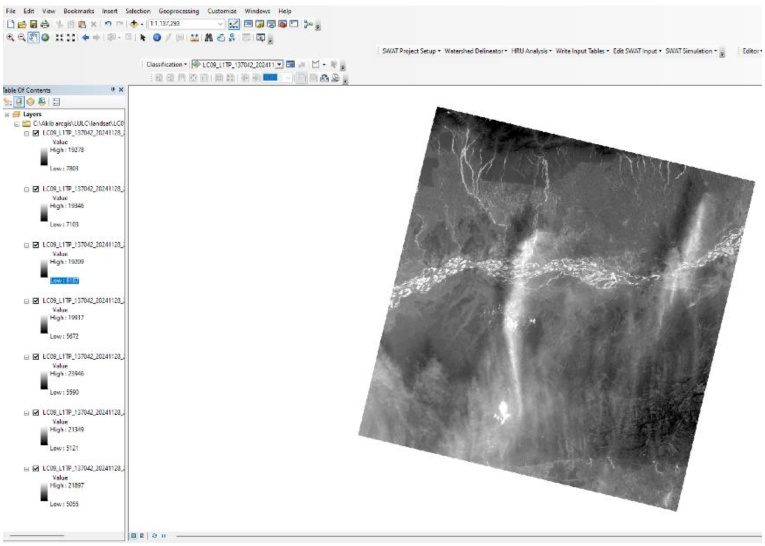


Fig 5.9 : Addition of Bands of first Landsat image in ArcMap

After addition Composite band has been done as shown below-

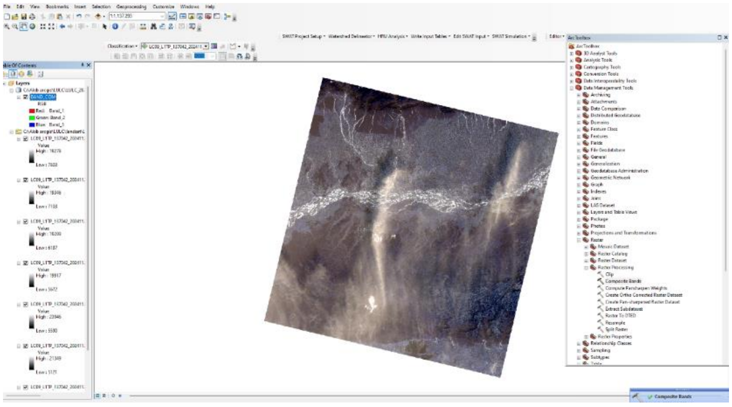


Fig 5.10 : Composition of bands of one Landsat image

Then False Colour Composite (FCC) has been done as shown below-

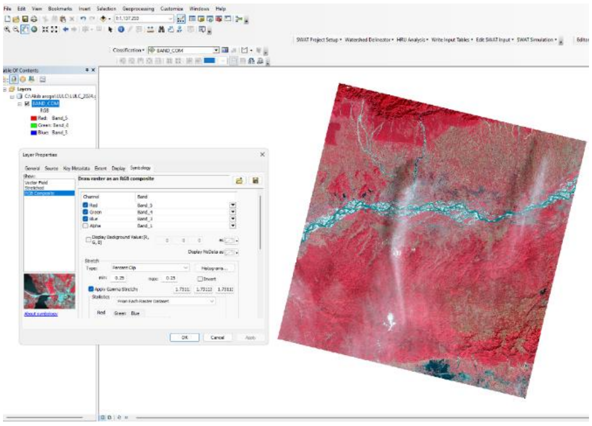


Fig 5.11: Figure Showing False Colour Composite band

After Composite band of the First landsat add the second bands of landsat.

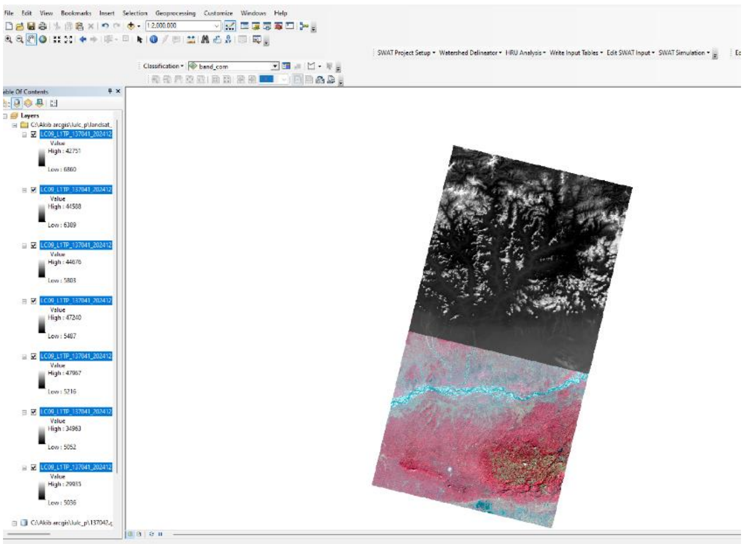


Fig 5.12: Adding of second landsat bands

After that mosaicing has been done.

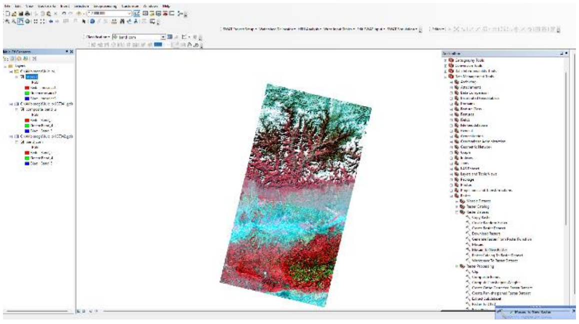


Fig 5.13 Mosaic of Landsat image

Extraction of mask has been done for extracting the study area watershed.

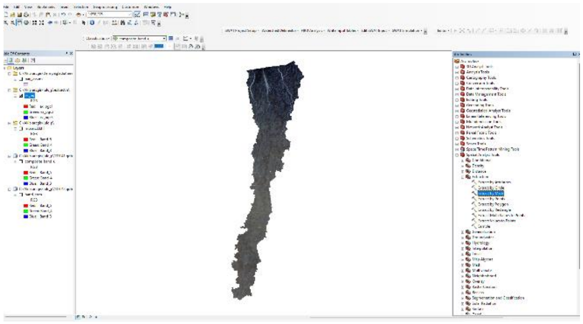


Fig 5.14 Extract by Mask

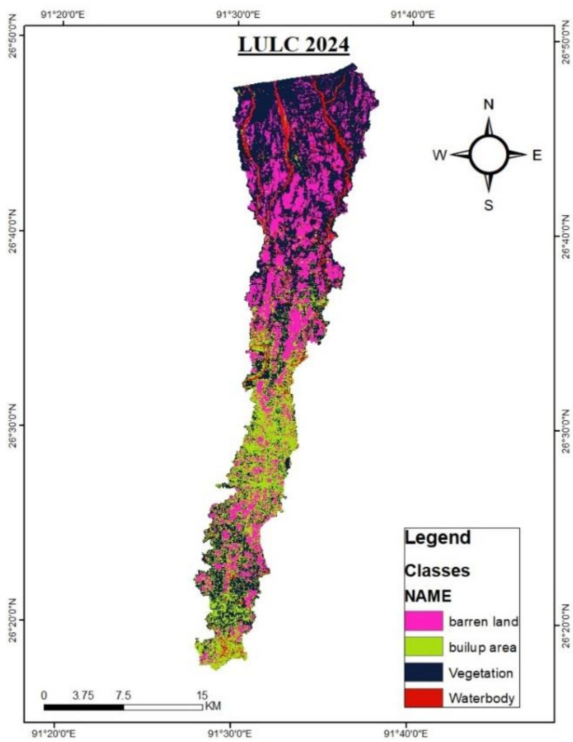


Fig 5.15 : Land use land cover map of Pagladia Watershed

After preparing LULC map Land use type has been classified and area of each type has been calculated in th study area. In the table below Land use type , area of the class and percentage of cover has been shown below-

Table 5.1: Approximate area under each land use type

Sl no	Land use type	Area (Km^2)	Percentage
1	barren land	106.1388736	27%
2	Builtup area	88.22640352	23%
3	Vegetation	170.9482356	44%
4	Waterbody	24.05900373	6%
	Grand Total	389.3725165	100%

5.3 Soil Erodibility Factor (K)

The ease with which soil is separated by splash during rainfall, by surface movement, or by both is referred to as soil erodibility. The soil-erodibility factor (K), also known as soil erodibility, measures the combined impact of rainfall, runoff, and infiltration on soil loss. The influence of soil characteristics on soil loss during storm occurrences on upland areas is taken into consideration by the soil-erodibility factor (K) in RUSLE.

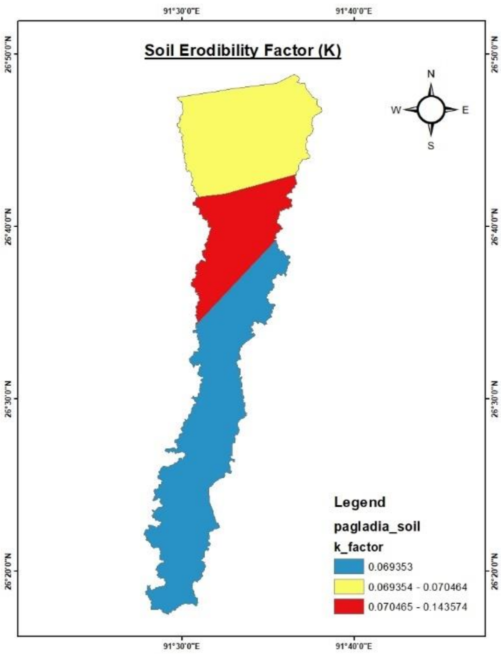


Fig 5.16 : Soil Erodibility Factor (K) map

5.4 Slope length and Steepness Factor (LS)

L factor and S factor are usually considered together to combine the effect of slope and slope length, which basically reflects the terrain on a given site. In this study an approach developed by Moore and Burch (1986) is used to compute LS factor. Moore and Burch (1986) proposed a unit stream power based physical LS factor.

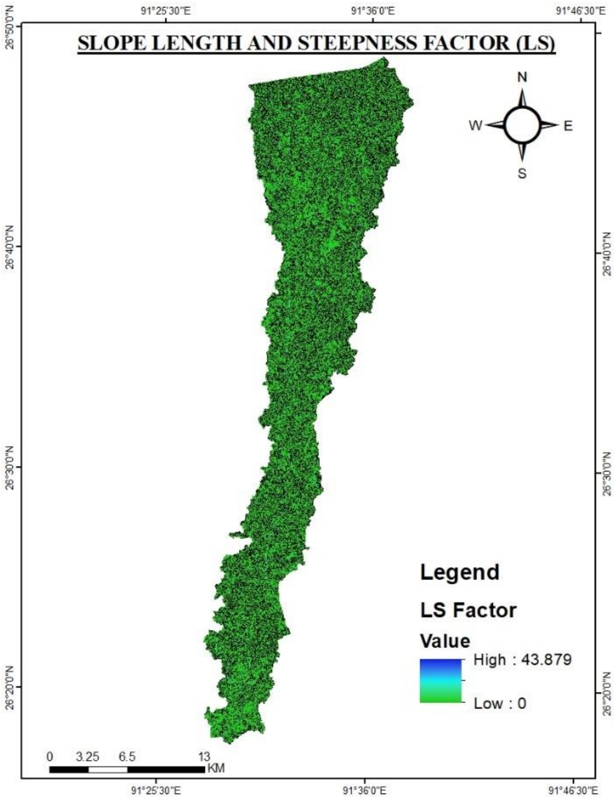


Fig 5.17 : Slope Length and Steepness Factor (LS Factor) Map

5.5 Cover Management Factor (C)

The cover management factor was first created by USDA-SCS (1972) using water bodies, agricultural land, sparse vegetation, dense vegetation, barren land, and built-up land (Table 5.2).

The USDA-SCS (1972) equation was updated by Wischmeier and Smith (1978a,b), who increased the variation in land cover for the C factor.

Table 5.2 : Land use-land cover class and respective C-factor Values

Sl no.	Classes	Apprrox area (km^2)	Percentage Distribution(%)	C factor
		2024	2024	
1)	barren land	106.1388736	27%	1
2)	Builtup area	88.22640352	23%	0.9
3)	Vegetation	170.9482356	44%	0.003
4)	Waterbody	24.05900373	6%	0

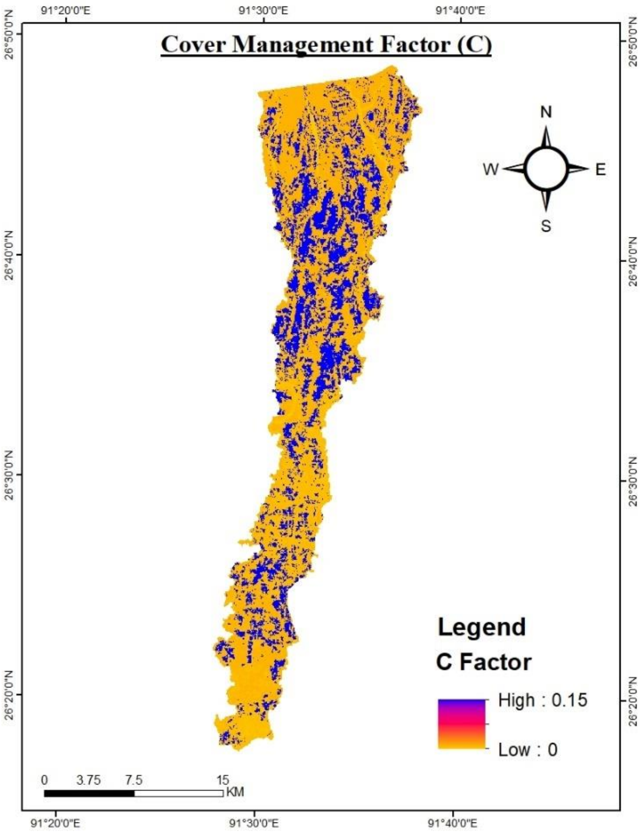


Fig 5.18 : Cover Management Factor (C) Map

According to Figure 4.11, the watershed's C Factor values range from 0 to 0.15 ..The study determined the C factor, results as thickly vegetated areas have low C values and are less likely to erode.

5.6 Support Practice Factor (P):

Support practice indicates the rate of soil loss according to the various cultivated lands on the earth. The table below shows the value of support practice factor according to the cultivation methods and slope (Wischmeier and Smith, 1978). P values range from 0 to 1, whereby the value 0 represents a very good manmade erosion resistance facility and the value 1 no manmade erosion resistance facility.

Table 5.3 : Support Practice factor (P) (Wischmeier and Smith, 1978).

Land use	Slope(%)	P-factor
Agricultural land	0-5	0.10
	5-10	0.12
	10-20	0.14
	20-30	0.19
Other land	all	1.00

For this study the maximum value of 1 was considered as there is no known conservation practice present in the watershed. Of all the factors, values for P are typically the most challenging to calculate and the least trustworthy. (Renard *et al*., 1994)

CHAPTER 6

CONCLUSION

- From the soil map, it can be found that the study area soil consists of three soil textures namely Sandy Clay Loam , Sandy Loam, Loam. From this soil map, the soil erodibility factor(K) map was also determined. The K-factor values were found to be the range of (0.069353-0.143574) t. ha.h./ha.MJ.mm. The low values of K indicates that the soil in the study area are less susceptible to erosion.
- The Land Use Land cover map for the year of 2024 shows that the class of forest occupies the largest area of 170.94 km^2 at a percentage distribution of 44% . And the class of waterbody occupies a very small area of 24.06 km2 at a percentage distribution of 6%.
- From the Slope length and Steepness (LS) factor map it can be seen the LS factor varies from 0 to 43.879 . Lower values appear to be scattered in the plain region of the basin where the slope length and steepness is low. It shows that the LS factor is large in hilly or places with high elevations and low in areas with low elevations.
- From the cover management factor(C) map, it can be seen that the C-factor values varies from 0 to 0.150 within the study area.

CHAPTER 7

FUTURE WORK

- R Factor have to be found for the study area.
- The annual soil loss of Pagladia watershed have to be found using RUSLE .
- Land use land cover map have to make for last 20 years at a interval of 5 year , then to find the impact of land cover change on sheet erosion of Pagladia watershed in Assam.
- To simulate the Runoff of Pagladiya river using HEC-HMS rainfall runoff model.

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